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**KEY ELEMENTS
FOR A PROCESS OF
DISSEMINATING 4.0
TECHNOLOGIES IN
AGRIBUSINESS: A CASE
STUDY WITH PROJECTS
INVOLVING RURAL
PRODUCERS**

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Abstract: 4.0 technologies involve a set of technological equipment and applications that allow the fusion of the physical and digital world, such as artificial intelligence (AI), the internet of things (IOT), robotics, computer vision, among others. Currently, these technologies are already being adopted in several sectors, such as the agricultural sector, and represent a high potential to enable the development of the sector, significantly remodel value chains and contribute to more productive, resilient and transparent food systems. In Brazil, technology has played a fundamental role in agriculture and largely explains the evolution of productivity. However, expanding the adoption of 4.0 technologies in the field is still a challenge and depends on a series of factors and conditions. This article aimed to identify key elements in a process of disseminating 4.0 technologies in agribusiness. For its preparation, a bibliographical research was carried out, in addition to interviews with actors involved in projects to adopt 4.0 technologies of the Agro 4.0 Program, of the Brazilian Agency for Industrial Development – ABDI. Based on the information collected, it was possible to draw up a table with the main elements of inputs, stages and outputs for this process.

Keywords: 4.0 technologies; agro 4.0; diffusion of technologies; technology adoption.

INTRODUCTION

The 4.0 technologies involve a set of technological equipment and applications that allow the fusion of the physical and digital world, such as artificial intelligence (AI), the internet of things (IOT), robotics, computer vision, among others. Its application in the production sector began with the concept of Industry 4.0, a movement that originated in Germany around 2011, for the manufacturing industry. Currently, these technologies have already been adopted in several sectors, such

as the agricultural sector.

The 4.0 technologies have a high potential to enable the development of the agricultural sector, significantly reshape value chains and contribute greatly to more productive, resilient and transparent food systems (FAO, 2009).

The agricultural sector has great economic relevance for Brazil, representing almost 30% of the Gross Domestic Product – GDP in 2021 (CEPEA/CNA, 2022). Despite Brazil's relevance in the global food market, there are still great opportunities to increase the efficiency of the production process through productivity, ensuring its sustainability. According to data from FAO (2009), it is estimated that global demand for food will increase by up to 70% by 2050, which brings even more challenges to the country.

Technology has played a fundamental role in agriculture and largely explains the evolution of productivity. In the period between 1975 and 2015, technological advances were responsible for 59% of the growth in the gross value of agricultural production, while work accounted for 25% and land for 16% (EMBRAPA1, 2018).

However, with regard to precision agriculture technologies, a recent survey showed that around 50% of farmers adopt or are willing to adopt agricultural technologies for their operations (McKinsey1, 2022), showing that there is still a large audience that has not yet adopted or considered this type of technology in its production process.

The expansion of the adoption of 4.0 technologies in the agricultural sector depends on a series of factors and conditions, with some of the main bottlenecks being the high cost of implementation, the lack of infrastructure and the lack of understanding and knowledge of the tool's potential (EMBRAPA2, 2020; ABDI1, 2021; McKinsey2, 2021).

Another important aspect for expanding

the adoption of these technologies is the diffusion process. According to Rogers (2003), technology diffusion is “the process by which an innovation is communicated through certain channels over time to members of a social system”.

This article aims to share the results of a research carried out to identify key elements in a process of disseminating 4.0 technologies in agribusiness, considering a bibliographical research, in addition to interviews carried out with actors involved in projects to adopt 4.0 technologies of the Agro Program 4.0, from the Brazilian Industrial Development Agency – ABDI.

LITERATURE REVIEW

DIFFUSION OF TECHNOLOGIES

According to Rogers (2003), diffusion is the process by which an innovation is communicated through certain channels over time among members of a social network system. The definition implies communication events in which a convergence develops, based on the exchange of information between individuals.

With regard to technological innovation, it creates a type of uncertainty for potential adopters (about its expected consequences), however, it represents an opportunity for gains by obtaining improvements and/or developing new products, processes and business models. business, which can lead to the resolution of a perceived need or problem.

It turns out that these opportunities and advantages provide a motivation to experiment and undertake innovation efforts. Since the information necessary to develop the innovation is expanded, uncertainty in its adoption and expected consequences is reduced, depending on the level of tolerance of an individual and an organization. The innovation decision process is an activity that involves the search

and processing of information in which the individual or organization is motivated to reduce uncertainty about the advantages and disadvantages of its adoption.

Thus, Rogers (2003) conceptualized the technology diffusion process (innovation) in five steps, namely: a) knowledge, b) persuasion, c) decision, d) implementation and e) confirmation, in which an individual (or other unit decision-making) moves from the first knowledge of an innovation to the formation of an attitude towards the innovation, to a decision to adopt or reject, followed by the implementation of the new idea and confirmation of that decision.

It is worth mentioning that different profiles of individuals and organizations adopt different behaviors in relation to the adoption of new technologies. According to Moore (2021), he describes a model for the entry of any new technology product into the market, based on the types of consumers it attracts during its useful life, which are a) innovators, b) visionaries, c) initial majority, d) late majority and e) latecomers.

According to the author, some consumers are pioneers and want to be the first to acquire something new, others are more fearful and prefer to wait for the product to be used on a large scale before deciding to use it, in addition to there being more traditional consumers who only adopt the technology if There really is no escape. Therefore, these profiles must be evaluated, within the technology diffusion and adoption strategy.

CONDITIONS FOR THE ADOPTION OF TECHNOLOGIES

Technology has historically played an important role in increasing productivity in agriculture and has been an important factor in determining the performance of organizations. However, the diffusion of technology does not occur at the same speed

and intensity between different producers and regions. The conditions for the adoption of technologies have been a discussed issue and a research problem for several authors for some years.

Griliches (1957) studied a model that describes the adoption and diffusion of hybrid corn among producers in the United States. The central idea of his study was that the speed of adoption of hybrid corn would essentially depend on economic variables and very little on social variables. He identified that the main determinant of the diffusion of hybrid corn among producers was the expectation of profitability with the incorporation of the innovation.

Souza et. al (2011) presented a literature review identifying four sets of factors that are related to the decision and adoption of technology: a) socioeconomic conditions and characteristics of the producer; b) characteristics of production and rural property; c) characteristics of the technology; d) systemic factors. The authors highlight the importance of understanding and designing actions that consider the different technical, social and economic configurations of communities.

Ihring (2020), carried out a study that sought to assess the digital readiness of Hungarian food companies, taking into consideration, subsectors and company size. He listed a set of dimensions for evaluation, such as: connectivity, human capital, use of internet services, integration of digital technologies and access to public digital services. He identified that the network connectivity rate of Hungarian food companies has a significant impact on the digitalization of companies and the integration of digital technology within the company.

The World Bank (2021) carried out an analysis of the adoption of technologies by companies in Ceará. In addition to

mapping bottlenecks in some sectors, such as Agriculture, they related the degree of use of technologies to some environmental factors, such as company size, sector, services and employees.

As described previously, some studies have been carried out in the agricultural sector in Brazil to also identify some of the main bottlenecks for the adoption of digital technologies, with the findings leading to issues such as lack of culture, high implementation costs and lack of infrastructure (EMBRAPA 2, 2021; ABDI1, 2021; McKinsey2, 2021).

MARKET SEGMENTATION

Market segmentation has been defined as a strategy of fundamental importance for the success of companies, to better identify the target audience for their actions. According to Kotler (2002), a market segment consists of a large group that is identified based on their preferences, purchasing power, geographic location, purchasing attitudes and similar purchasing habits. The process of dividing a market into meaningful, relatively homogeneous and identifiable segments or groups is called market segmentation.

For Lamb (2004), a market segment is a subgroup of people or organizations that share one or more characteristics and that have the same product needs.

Market segmentation is a tool that can help institutions identify their different types of customer profiles and develop a strategy considering the different characteristics of the groups, understanding that there is an opportunity to take different actions, based on the needs and challenges of each profile.

According to Kotler (2002), market segmentation is carried out in the following ways: a) geographic segmentation, which requires dividing the market into different geographic units, such as nations, states, regions, counties, cities or neighborhoods;

b) demographic segmentation, in which the market is divided into groups of basic variables, such as age, family size, family life cycle, gender, income, occupation, level of education, religion, race, generation, nationality and social class ; c) psychographic segmentation, considering that customers are divided into different groups, based on their lifestyle, personality and values; and d) behavioral segmentation, in which customers are divided into groups based on their knowledge of a product, their attitude towards it, their use of it or their response to it.

According to the author, market analysis must be multi-attribute, in which not just one market segment must be taken into consideration, but rather a combination of several variables, to try to identify small and more defined target groups.

Market research can be one of the instruments to help with market analysis, as it can identify customer characteristics and needs, helping to incorporate differentiated products and services. Nowadays, there are methodologies that help in this research, for example, evaluating the addressable market (total market for the idea at a national or global level), usable (e.g. market with viable geographic and logistics reach) and achievable (e.g. market size). : accessible market, considering competition, distribution and viable sales channels).

STEPS TO CUSTOMER DEVELOPMENT

The *Customer Development* – Customer Development is a methodology currently discussed and applied by companies, especially startups, and advocates the development of business models focused on the customer's real needs, reducing the risk of the product not being accepted on the market (Blank, 2015). According to the author, the process is divided into four stages: a) customer

discovery, b) customer validation, c) demand generation and d) business structuring.

In the customer discovery process, the focus is on identifying the consumers of the product and verifying the problem by the customer. In the validation stage, the purpose is to build a replicable sales map and make the first sales. From then on, the stage of generating demand from end users takes place, leading them to the company's sales channel, and the business structuring stage, in which the company's formal departments are structured.

Here it is worth highlighting the step-by-step process of customer discovery, which includes actions such as defining and validating problem and solution hypotheses, in relation to the product you intend to sell. It is also worth highlighting the importance of defining and defining the product's distribution channels.

Distribution channels are the trajectory followed by the product from its origin until it reaches the final consumer. To select a sales channel, it is important to consider whether it adds value to the sale, the prices and complexity of the project and whether it is already part of the customer's practice and custom.

To evolve into a channel plan, it is important to identify the actors and the structure that exists between a company and customers (chain), to understand how the product can reach the consumer, identify the product distribution costs, considering the structure and actors mapped and the management format of this channel. A distribution channel plan can help create repeatable and scalable sales processes (Blank, 2015).

METHODOLOGY

The objective of the article was to identify key elements in a process of disseminating 4.0 technologies in agribusiness. To achieve this, the research was carried out in a few

stages. Initially, a bibliographical research was carried out to map references, themes and elements related to the technology diffusion process. The main information is described in the “Literature Review” section.

The mapping was carried out considering five main themes: a) the technology diffusion process, in order to identify the main steps for this process in the literature; b) the life cycle of technology adoption, in order to identify consumer profiles and target audiences for the adoption process; c) the conditions for the adoption of technologies, as critical factors to be considered in a diffusion process, as well as the d) main difficulties in adopting digital technologies in Brazil, in addition to the identification of e) market segmentation and development methodologies customers, who can support the diffusion process.

Below, the key elements of the main themes identified were consolidated (table 1):

| Themes | Identified elements | Sources |
|--|--|----------------------|
| a) technology diffusion process | a) knowledge, b) persuasion, c) decision, de) implementation d e) confirmation. | Rogers (2003) |
| b) technology adoption life cycle (profiles) | a) innovators, b) visionaries, c) early majority, d) late majority and e) laggards. | Moore (2021) |
| c) conditions for the adoption of technologies | expectation of profitability with the incorporation of innovation. | Griliches (1957) |
| | a) socioeconomic conditions and characteristics of the producer; b) characteristics of production and rural property; c) characteristics of the technology; d) systemic factors. | Souza et. al (2011) |
| | a) connectivity, b) human capital, c) use of internet services, d) integration of digital technologies and e) access to public digital services. | Ihring (2020) |
| | a) such as company size, b) sector, c) services and d) employees. | Banco Mundial (2021) |

| | | |
|---|--|------------------|
| d) main difficulties in adopting digital technologies in Brazil | a) value of investment in the acquisition of machines, equipment and applications; b) problems or lack of connection in rural areas; c) value for hiring specialized service providers; d) lack of knowledge about which technologies are most appropriate (40.9% of respondents). | Embrapa2 (2020) |
| | a) lack of infrastructure; b) lack of financial resources by the producer; c) difficulty in calculating the return on investment of solutions; d) lack of technical training of the farm/industrial operation workforce; e) lack of management culture on the farm/agribusiness; f) difficulty in accessing simple, affordable solutions that meet needs; g) significant changes in the production process; h) change cookies. | ABDI1 (2021) |
| | a) high costs; b) lack of infrastructure; c) lack of understanding; d) lack of understanding on the subject; e) lack of alternatives; f) longer negotiation deadlines. | McKinsey2 (2021) |
| e1) market segmentation | a) geographic; b) demographic; c) psychographic; d) behavioral | Kotler (2002) |
| e2) customer development | a) customer discovery (which involves validating problem and solution/product hypotheses and defining a distribution channel plan)), b) customer validation, c) demand generation and d) business structuring. | Blank (2015) |

Table 1: elements identified in the literature.

From then on, field research was carried out with actors involved in the eight projects for the adoption and dissemination of 4.0 technologies in agribusiness under the Agro 4.0 Program.

The Agro 4.0 Program is an initiative of the Brazilian Agency for Industrial Development - ABDI and partners and aims to stimulate and promote the use of 4.0 technologies in agribusiness, through notices, events, meetings, information and other actions focused on increasing efficiency, productivity and cost reduction.

The Program's second notice selected 8 projects with the purpose of monitoring the implementation of 4.0 technologies in the production process. The selection process followed the criteria in the notice and was carried out by a panel of experts in Brazil.

The projects were made up of at least one producer whose role was to adopt 4.0 technology in its production process, one or more technology suppliers with the role of implementing the solution and an innovation environment to integrate actors and dissemination of knowledge obtained with the implementation of technology, in practice.

The projects were carried out in Brazilian territory, all of which involved the adoption of at least one 4.0 technology in their production process, and the main technologies chosen by the projects developed were: Remote Sensing (38%), Computer Vision (25%), IOT, AI and Analytics (13%).

Semi-structured interviews were carried out with the main actors involved in these projects, with the purpose of identifying whether the elements identified for the diffusion process made sense for the sector, considering its realities and possible strategies for carrying out diffusion in the projects. The information collected was consolidated and the suggestions considered in the next stage.

ANALYSIS

Based on bibliographical research and interviews carried out with actors involved in projects to adopt 4.0 technologies in agribusiness, it was possible to consolidate a table representing some of the key elements in the technology diffusion process, as shown below (figure 1).

Some inputs and requirements were identified that are key elements for a technology diffusion process, they are:

- information on conditions for the adoption of technologies (e.g.: socioeconomic

conditions of producers, characteristics of production and property, characteristics of technology, systemic factors, expected profitability) (Griliches (1957), Souza et. al (2011), Ihring (2020), World Bank (2021)).

- technology adoption profiles (innovators, visionaries, early majority, late majority and laggards) (MOORE, 2021).

- main difficulties in adopting digital technologies (e.g.: EMBPAPA2 (2021), ABDI1 (2021) and McKinsey2 (2021) surveys).

- market segmentation methodologies and data (demographic - age, family size, family life cycle, gender, income, occupation, level of education, religion, race, generation, nationality and social class; behavioral - knowledge about the product, attitudes, use and response; geographic - nations, states, regions, counties, cities or neighborhoods; psychographic - based on lifestyle, your personality and your values;), customer development and market research, distribution channels, among others (e.g. Kotler (2002) and Blank (2015)).

- journey of adopting 4.0 technologies (considering the solution implementation trajectory, which can range from diagnosis, process optimization, prospecting, customization, piloting, scaling, maintenance and monitoring (ABDI2, 2022).

- other sectoral information and prospecting, analysis and implementation methodologies/tools.

In the technology diffusion stages, the processes recommended by Rogers (2003) were taken into consideration, including suggestions discussed in the interviews carried out. Are they:

- knowledge: at this stage, it is the moment when rural producers learn about 4.0 solutions and technologies in a brief and quick way.

- evaluation/persuasion: this is the persuasion phase for the purchase. It is understood that, at this moment, the rural

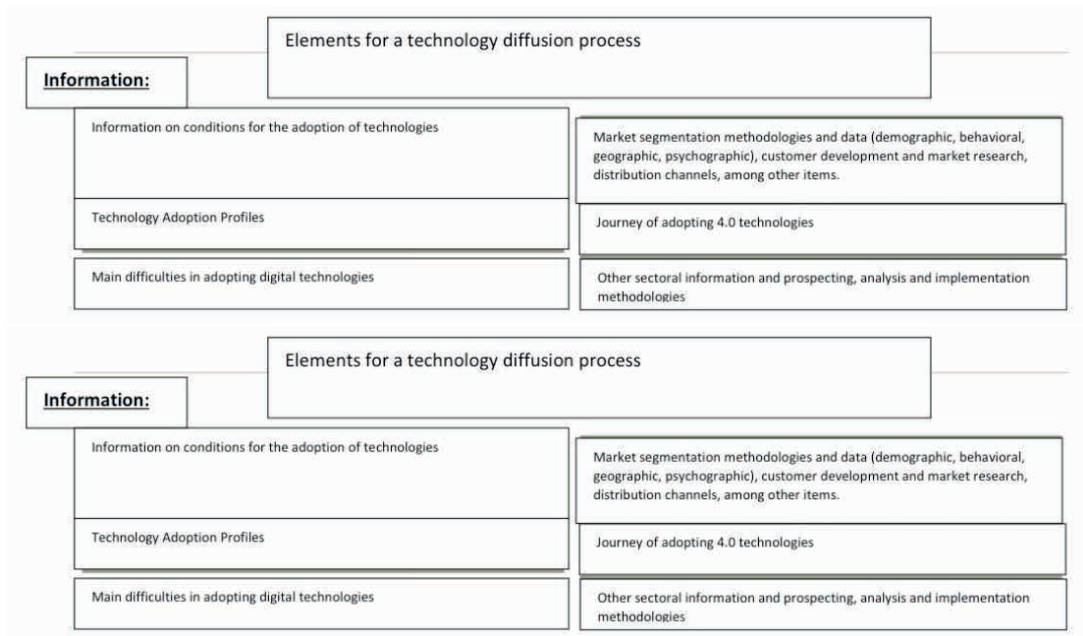


Figure 1: elements for a 4.0 technology diffusion process.

producer has more detailed information about the identified solution, making contacts with potential partners.

- decision: this is the moment of conviction. Thus, it is understood that the producer needs to have all the information about the justification, scope, requirements and benefits of the solution, adoption journey, prices, access channels, among other information.

- implementation/customization: this is the technology adoption stage. The importance of monitoring the implementation journey is understood, as well as evaluating whether the solution is solving the producer's needs.

- confirmation: at this stage, the assessment of achievement of expected results is carried out, in which the producer evaluates a scale plan and shares the innovation.

As process outputs, information from the processes recommended by Rogers (2003) was also considered, including suggestions discussed within the scope of the interviews carried out. Thus, we have:

- knowledge about digital technologies (e.g. training, publications, events, demonstrations, exhibitions): this knowledge is generally obtained through the events mentioned. An assessment of distribution channels is important to assess the best strategy for reaching rural producers.

- information about detailed solutions and partners: coming from the process of evaluating solutions by producers. In many cases, it may involve visiting suppliers, sharing data between producers and cooperatives, and testing demonstrations.

- solution evaluated and partnerships implemented: by obtaining detailed information on the justification, scope, requirements and benefits of the solution, adoption journey, prices, access channels, among other information, the producer assesses the innovation, decides and implements the partnership(s) for implementation.

- 4.0 technology adoption journey completed: the main output here is the adopted technology, from the implementation journey, with result indicators and lessons learned from the adoption process.

- dissemination and scale plan: once the solution meets initial expectations, the innovation is shared with other producers and institutions, in addition to the discussion of a scale plan.

Thus, some of the main elements identified from the bibliographic survey and interviews carried out with actors in projects adopting 4.0 technologies were listed.

From the rural producer's point of view, the process sheds light on a step-by-step process that can assist in their process of prospecting, analyzing and implementing new technologies. From the point of view of institutions and suppliers, it brings up points that must be considered when thinking about a dissemination strategy, given the interest in expanding adoptions.

It must be noted that these are instruments that can also be taken into consideration by cooperatives and associations, in addition to government institutions, in defining their action plans, considering the benefits that can be brought in terms of increased productivity, efficiency and sustainability, with the expansion of the use of digital technologies in the field.

CONCLUSION

This article aimed to identify key elements in a process of disseminating 4.0 technologies in agribusiness. For its preparation, a bibliographical research was carried out, in addition to interviews with actors involved in projects to adopt 4.0 technologies of the Agro 4.0 Program, of the Brazilian Agency for Industrial Development – ABDI. Based on the information collected, it was possible to draw up a table with the main elements of inputs,

stages and outputs for this process.

As suggestions for future work, we suggest greater detail on the identified elements, breaking down the framework into more specific activities, with definitions of roles and responsibilities.

The process of adopting and disseminating 4.0 technologies in agribusiness can increasingly contribute to increasing efficiency, productivity and sustainability in Brazilian agribusiness, contributing to the country's competitiveness, and requires well-defined strategies and processes for advances in the chain productive.

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