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**Advances in Transference of Technology at Small-Scale Agriculture**

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**Abstract.** Technology transference is widely considered as a very important factor to determinate growing at agriculture industry; this paper reviewed successful models to transfer technology to the agricultural sector to identify key factors that can determinate the success of their implementation. To do this, a systematic review of some examples with the objective of identifying characteristics was done. Finally, the analysis can support some recommendations and give more clear vision of situation of transference of technology at agriculture industry as a mean to invigorate the few existing relations between the field where science and technology are developed and the business industrial field where solutions will be commercialized.

**Keywords:** Agricultural industry, Transference Technology, Models

### Introduction

Nowadays, technological changes, the complexity of human interactions, changes in the environment and the rapid transformation of business models have made flexibility and adaptability translated as innovation in industries a daily task (López Mielgo et al., 2009).

Thus, given that an industry is permanently linked to its context, the instrument for accessing the technological assets that a company needs to remain competitive is technology transfer and, to obtain it, it will have to resort to the transfer mechanisms it considers most appropriate.

The right technologies to meet the challenges can be obtained in two ways: a) Through internal sources, our own research and technological development departments. b) From external sources, collaboration with entities outside the company for the acquisition of the technology when it is already available (Sabater, 2010).

It is when we talk about technology transfer as a mechanism by which the company has the possibility of incorporating the technology it needs to develop.

This paper focuses on the transfer of technology to the agricultural industry, because of its relevance to the economic and social development of the countries, it analyzes the most relevant factors that have a direct impact on the process of technology transfer.

This review, therefore, uses Okoli methodology to organize the literature. In so doing we isolate the specific issues of relevance and the findings with the objective of identify key factors capable to determinate the successful of transfer of technology to the agricultural industry.

The findings of this study can be helpful in guiding the development of the research agenda concerning the impact of transference of technology to agroindustry, because much research follow developing, and its necessary it would be aligned to real needs and expectations of farmers.

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### **Agricultural Industry**

Contributions from multiple disciplines have made major advances relevant to a wide range of agricultural system model applications at various spatial and temporal scales (Jones et al., 2017a).

Agriculture activities now are very different than it did many years ago, modern agricultural improvements allow farmer to adapt to new conditions in weather, transportation, conservation, and available resources (Bowers et al., 1984).

In 1933 synthetic pesticides were used at agricultural production, general purpose and diesel engine tractors were introduced and rapidly grew in use; the first widely recognized statistic support about weather was the Old Farmer's Almanac, that document provided weather forecast (Grigg, 1974).

After that, in 1980 the beginning of computers to track, monitor and improve farming operations grew up, in 2012 were designed some agriculture systems supported in informatics and now vast amounts of available data support decisions of farmers about their activities (Hill, 2018).

Newest tendencies as organic products connected consumer and omni presented, specialization, new channels of distribution and new product supply chains in the field (Reigada et al., 2017), as well as promoting circular economy models is one of the great challenges agreed by those responsible for the agri-food industry who must be able to face the challenges of climate change and energy efficiency.

### **Transference Technology**

The advance in economy development is closely related to innovation and transference of technology and knowledge, because of that, technology transfer maintains as a hot topic for researchers, managers, and entrepreneurs, who are searching for useful knowledge to improve enterprises (Bozeman et al., 2015).

Consequently, the relationship between science and productive activity has become less casual and more systemic, transfer of technology to industry involves a considerable number of activities, these mechanisms and activities are focused on general issues to guaranteed technology transfer effectiveness that would be traduced in a model to reuse and implement in newest situations. Indeed, the use of a model or other one depends on sector, circumstance, and type of technology to transfer.

United Nations defines Transfer technology as "*systematic transfer of knowledge for application in a process to manufacture a product or provide a service*" (Roffe, 1985). Moreover, Organization for Economic Cooperation and Development (OCDE) defines it as the process to "*identify and manage the organization's intellectual assets, including protecting intellectual property and transferring or licensing rights to other parties to enhance prospects for further development*" (OCDE, 2003).

Meanwhile, World Bank says, "*technology transfer means that local capabilities to understand, develop, produce, and use technologies are enhanced*", and mores specific, explains technology transfer "*means anything that facilitates the adoption, adaptation, diffusion, and dissemination of new technologies within a given country*" (World Bank, 2000).

Technology transfer usually includes several types of activities, which solve specific research problems, provide technical knowledge to companies seeking to develop new products or processes, help entrepreneurs in the creation of new companies, and provide patent services or technology licenses (Santoro, 2000).

Moreover, the growing international competition means that the competitiveness of companies depends more and more on their ability to apply new knowledge and technology in products and production processes. But accelerated technological development and the

increasing specialization of knowledge restrict the possibility that a company produces, by itself, all relevant knowledge.

At the same time, the company seeks to specialize with the objective of reducing risks and reducing the time of arrival to the market. In this way, the company becomes more dependent on the complementary knowledge and know-how of other organizations public and private.

On the other hand, in the field of companies there are also factors that facilitate or hinder their ability to innovate and cooperate with other actors in this process, not all companies are equally prepared to collaborate with other entities or willing to do so. The greater or lesser facility that companies must cooperate depends on characteristics such as size, sector, technical training, and attitude towards innovation.

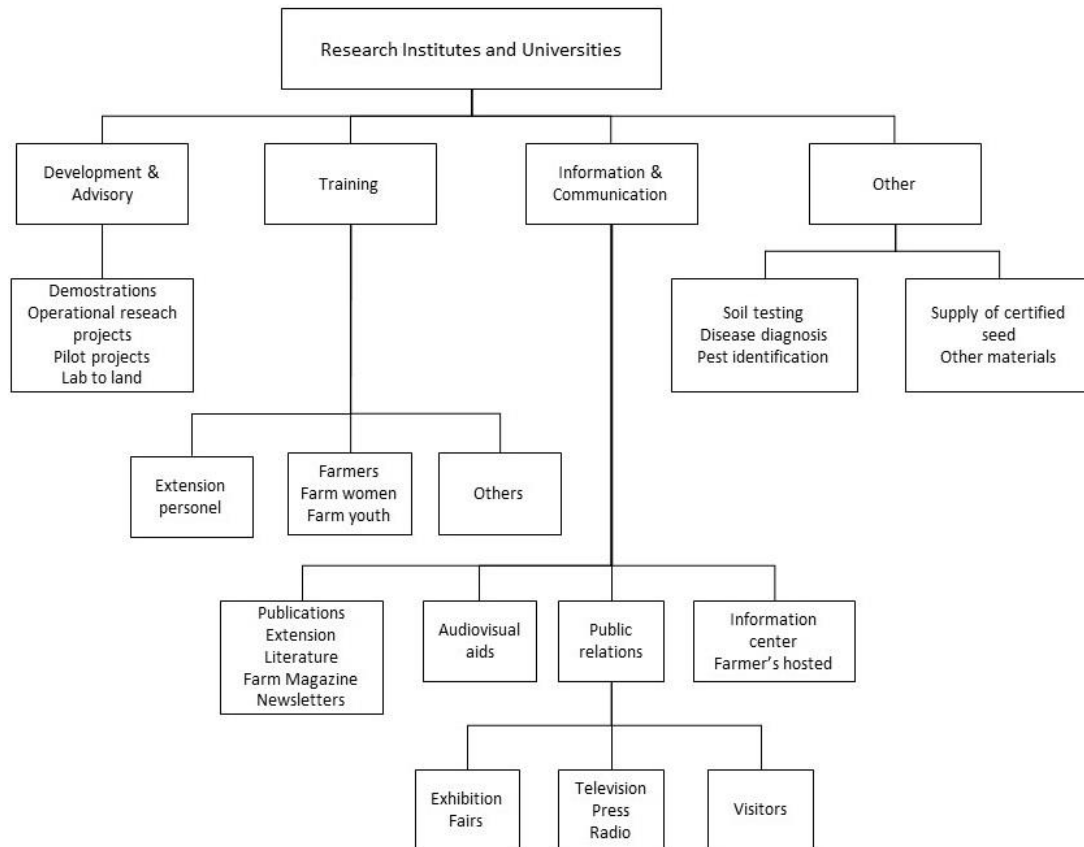
According to Feldman & Stewart (2006), most authors conclude that collaboration is the key element for newest industrial production strategies. Common interests, complementary experience, and goodwill are the important ingredients to define and manage agreement for collaboration with other organizations (Harrigan, 1988).

### **Models to Transfer Technology at Agricultural Industry**

FAO (1986) diffused a "*Role of research institutes and agricultural universities in transfer of technology*", where they describe:

- *Operational research project.* The institution can apply some operational research projects (one or two), based on validated farm technology, to demonstrate its impact directly under farmers' field conditions, and study constraints to its adoption.
- *Minikit trials.* On farmers' fields scientist could implement trials, with small amounts of seed and other inputs.
- *Working with local extension workers.* Scientists work with local farm workers, to experimenting with actual field conditions and providing technical advice and information.
- *Subject-matter specialists.* Teams of agricultural specialists from research centers and universities advise farmers and extension agents on the use of new agricultural technologies.
- *Formulate packages of practices.* Institutions configure practical packages with recent research results to disseminate them as alternatives to meet farmers' needs.
- *Advice to visiting farmers or through correspondence.* Institutions should have an office or center with technical staff where farmers can ask for free technical advice.
- *Training.* Training programs are important to share knowledge and skills of practical nature to farmers and extension workers to learn by doing about new agricultural technologies.

Information communication, other activities related in Figure 1.



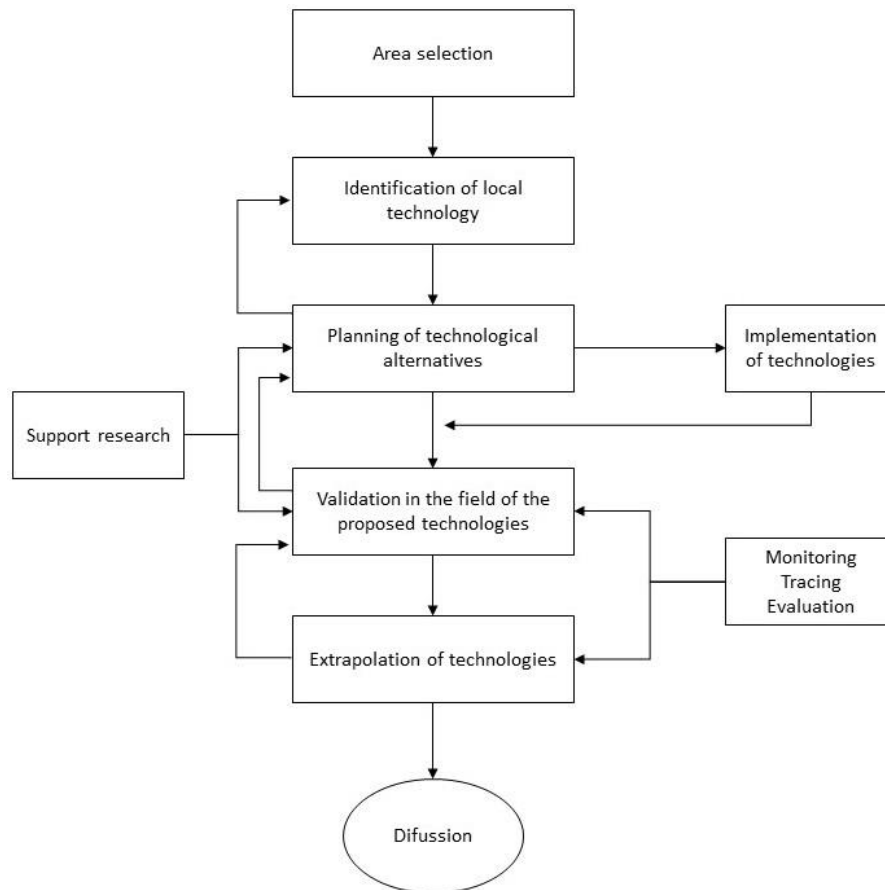
**Figure 1. Technology transfer from research centers and universities**

Source: FAO (1986).

According Jolly et al. (1998), some models of technology transfer on the farm and village level were:

- *Community Development*. Focuses on village-level efforts to organize and implement new technologies through the community development here farmer participation is viewed as a key intervening process.
- *Adoption-Diffusion*. In this model, the development is assumed in terms of the spread or uptake of new technology in a social system. The demand for, as well as the supply of, the innovations are two complementary aspects of this perspective.
- *Training and Visit Extension*. The Training and Visit model of technology transfer emphasizes an invigorated and focused extension service as an apparatus for fostering agricultural development, successful depends on a well-organized team.
- *Farming Systems Research*. It was intended as much to influence the kind of research done as simply to transmit technology.

In other hand, European, Asiatic agriculture industry, has developed their own methodologies, by example, Hernández (1999) propose the model at Figure 2.



**Figure 2. Methodologic model to transfer technology in manage of seed with farmers**

Source: Hernández (1999).

Later, are widely used models to transfer technology named lineal and dynamic. The Linear model according to Siegel et al. (2004) refers to the scientific discoveries that are generated and that must be patented having as actors the university, research center, results transfer office (OTRI) and the companies, the process in Figure 3, basically seeking to patent and exploit the discovery made.



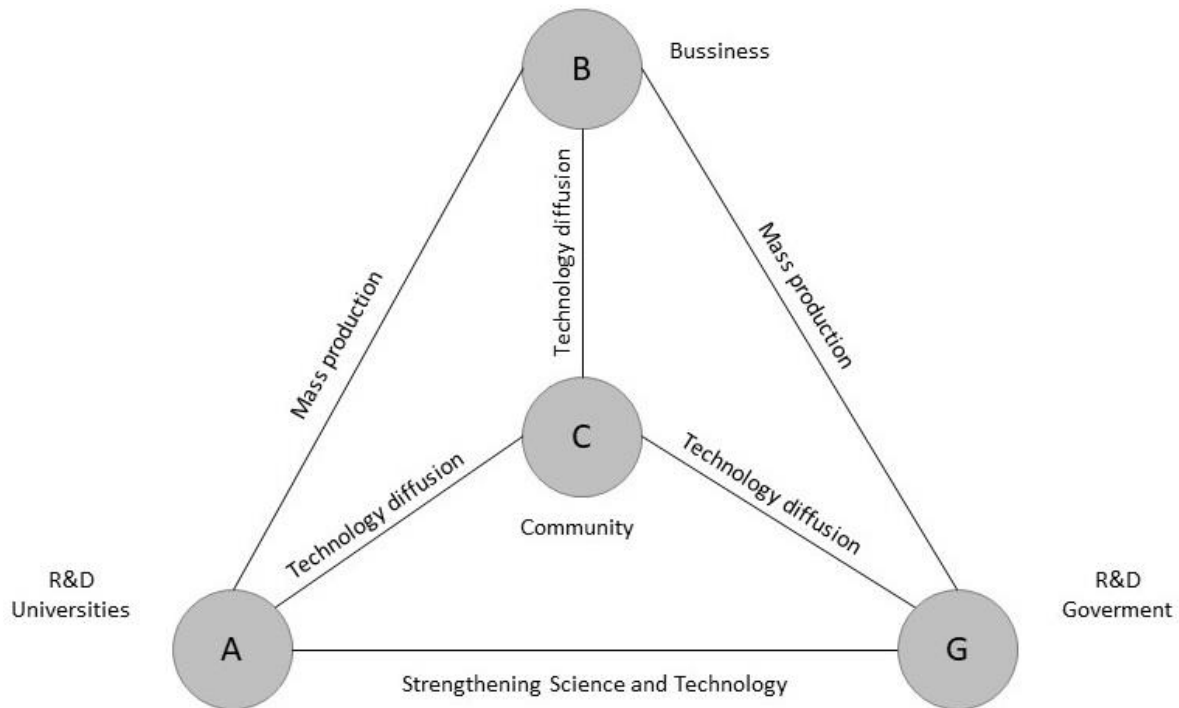
**Figure 3. Lineal Model to transfer technology.**

Source: Siegel et al. (2004).

The dynamic model, which is a linear improvement, aims to transfer knowledge through marketing or dissemination using variables that are critical to this process:

- Intercultural understanding.
- Negotiation skills.
- Incentives for negotiation.

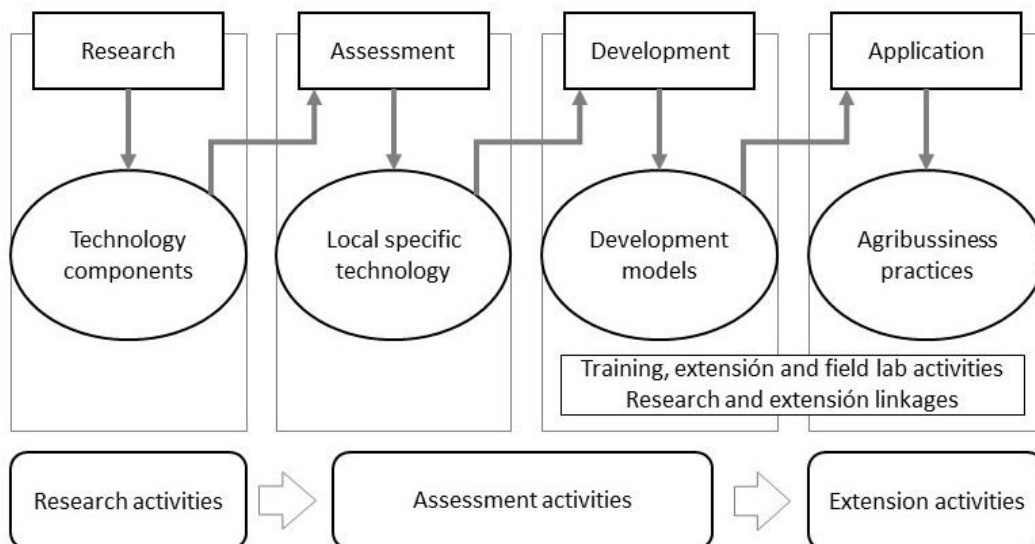
Nowadays, triple and quattro helix model as show in Figure 4, are the most diffused to generate in the intersection sector of all four structural elements, the "zone" generating innovative effects during operation of the agroindustry because of a seamless interaction and mutual complementarity of concerned structural elements (Bondarenko et al., 2016; Tan et al., 2016).



**Figure 4. Quatro helix model**

Source: Tan et al. (2016).

Other case, Indonesia uses this one like a base, and develop their own procedures. It shows in Figure 5.



**Figure 5. Stages of agriculture technology transfer**

Source: Tan et al. (2016).

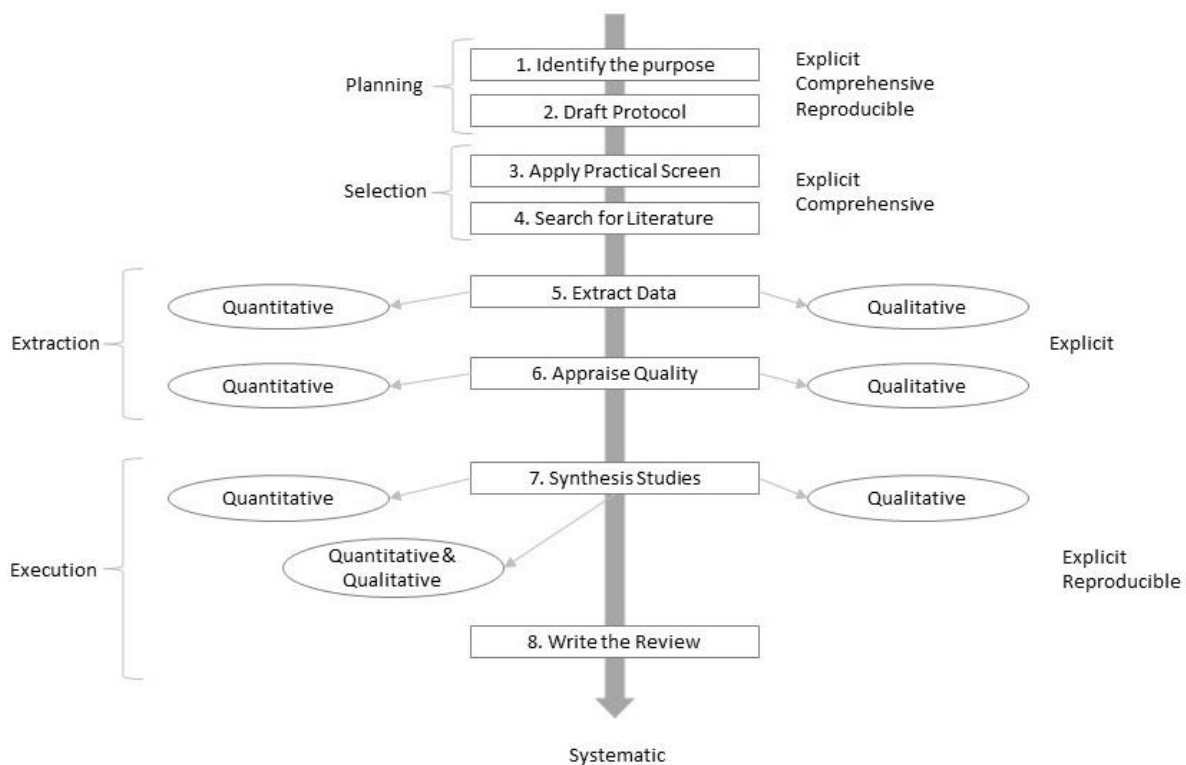
This paper is intended to review and synthesize previous experiences of the technology transfer system, and to develop a conceptual framework that considers technology characteristics, the capability of a nations institutions and governmental structures, as well as the farmer's perspective about technology supporting to agricultural activities.

### Methodology

The scope of the research is qualitative and quantitative, to understand the implications of transfer technology at agroindustry enterprises. Consequently, was done exploratory research, because the Transference Technology in Agricultural Industry is an important and unsolved theme. In other hand this is an empirical study based on cases of literacy review, as a sampling technique that is used in qualitative and quantitative research, where the objective is the richness, depth, and quality of the information (Hernández et al., 2010).

Following, was defined a protocol to make a systematic review of selected cases, was used Okoli (2015) methodology to literacy review displayed in Figure 6. This methodology is widely used in academic work as an efficiently tool to solve research hitches (Reyes, 2016).

To implement it, was followed four steps as described:



**Figure 6. Okoli Methodology**

Source: Okoli (2015).

**Step I.** Corresponding to planning; for the research it was decided to use the keywords “Technology Transfer AND Agricultural”; selected from the topics of interest from the last five years published papers in international journals, related to technology and agroindustry from different countries.

**Step II.** From literacy review, selected these cases because of their relevance and interesting, they address studies related to technology transfer and the results obtained show the essential issues to be taken care of when implementing technology to support the agricultural industry. It was decided to use a total of 34 articles from 19 different journals focusing on the relation with the topic of interest, to have a diverse sample.

**Step III.** Following Okoli methodology, in this step extract relevant data from papers selected as show in Table 1.

**Table 1. Article set reviewed**

| No | Reference                                | Components                              | Contribution                                                                                                                                                                                                                                    |
|----|------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Ankrah & Al-tabbaa (2015)<br>* (C)       | Effectiveness of UIC                    | To leverage the competitive advantages of companies, it is necessary to objectively measure the effectiveness of UIC, as well as the impact of academic participation.                                                                          |
| 2  | Berbegal-Mirabent et al. (2015)<br>* (C) | University-Industry Partnership         | The drivers of successful university-industry partnerships are organizational and institutional. Success depends on the characteristics of the universities.                                                                                    |
| 3  | Rambe & Khaola (2022)<br>(K)             | Technology transfer and productivity    | Technology transfer and productivity as well as innovation and firm competitiveness are supported by relevant direct trajectories.                                                                                                              |
| 4  | Jones et al. (2017b)<br>(K)              | New farming systems                     | Advances in agricultural systems science are enabling the development of new models, databases, knowledge products, and data-driven decision making.                                                                                            |
| 5  | Shu & Zheng (2018)<br>(C)                | Opportunity discovery                   | Agri-food chain capabilities and management skills of agricultural entrepreneurs have a positive relationship in enhancing opportunity discovery for food production systems.                                                                   |
| 6  | Smart & Benaroya (2016)<br>(C)           | Effectiveness of transfers              | The use of the Contingent Effectiveness Model allows the formalization of comparative analysis of technology transfer effectiveness.                                                                                                            |
| 7  | Hsu et al. (2015)<br>* (K)               | Technology transfer-oriented start-ups. | The drivers for improving university technology transfer are institutional cultural and managerial resources coupled with the skills and capabilities of human capital.                                                                         |
| 8  | Vlăduț et al. (2015)<br>* (D)            | Responsibility of a country             | Technology transfer requires that countries take responsibility for generating a favorable framework through public policies and financing.                                                                                                     |
| 9  | Sum et al. (2017)<br>* (K)               | Technology transfer office efficiency   | The efficiency of the university technology transfer office is related to the attraction and training of staff with the right skills and capabilities.                                                                                          |
| 10 | Rossi et al. (2017)<br>* (C)             | Knowledge co-production                 | Academic engagement is strengthened through knowledge co-production and university staff are incentivized by generating impacts beyond academia.                                                                                                |
| 11 | Botchie et al. (2017)<br>(K)             | Hard and soft components                | In the context of a developing economy the process of technology transfer must include both hard and soft components of agricultural technology.                                                                                                |
| 12 | Verma & Sinha (2018)<br>(C)              | Reliable and valid constructs           | The interaction of the conditions of the transfer process are related in different ways. Social influence is an important factor in the adoption of new technology, while perceived economic welfare is related to users' perceived usefulness. |
| 13 | Machikita et al. (2016)<br>(C)           | Continuous improvement strategies       | Continuous improvement practices, such as Kaisen, contribute to process efficiency and favor the transfer of knowledge from consumers to suppliers. This strengthens the co-design of products and services.                                    |
| 14 | Far & Rezaei-Moghaddam (2017)            | Adoption promoters                      | Factors such as innovativeness, confidence, perceived ease of use, and perceived usefulness directly influence the                                                                                                                              |

|    |                                       |                                    |                                                                                                                                                                                                                                                                                                                                                                       |
|----|---------------------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | (C)                                   |                                    | attitude and behavioral intention of both agricultural staff and consultants to use agricultural technologies.                                                                                                                                                                                                                                                        |
| 15 | Ravi & Janodia (2022)<br>* (C)        | Barriers to technology transfer    | Knowledge, experience, and skills of university personnel directly influence the effectiveness of technology transfer processes. On the other hand, the sensitivity of researchers to the fact that research activities generate products and services focused on commercialization is relevant.                                                                      |
| 16 | Van Norman & Eisenkot (2017)<br>* (D) | Intellectual property (IP)         | Agricultural technology transfer involves legal processes to protect and transfer Intellectual Property (IP). Universities regularly license their IP, while companies sell their IP.                                                                                                                                                                                 |
| 17 | Osabutey & Jin (2016)<br>(C)          | Transfer quality                   | Achieving a high level of quality in technology transfer processes requires different components. This group includes governmental policy incentives, efficient industrial enterprises and educational institutions with effective processes.                                                                                                                         |
| 18 | Novickis et al. (2017)<br>* (D)       | Innovation models                  | Technology transfer models serve to formalize and build an effective link between university research centers and business sectors. They allow the prototypes developed to be used by companies.                                                                                                                                                                      |
| 19 | Emil et al. (2014)<br>(C)             | Dimensions of the transfer process | Technology transfer is a multidimensional process in which inter-firm cooperation, labor mobility, and social ties are directly involved in shaping the collaborative environments that relate to the level and quality of outcomes.                                                                                                                                  |
| 20 | Huang & Chen (2017)<br>* (C)          | Academic Innovation                | Formal management mechanisms serve to shape university innovation environments that positively impact academic innovation performance.                                                                                                                                                                                                                                |
| 21 | Chen (2018)<br>* (K)                  | Impact of technology transfer      | International transfer of technology is encouraged with the participation of countries whose expectations and demands are regulated through public policies. In this way, opportunities and challenges for the transfer of capital and labor assets, skills, knowledge, and experiences depend on the different actors that generate variations in transfer patterns. |
| 22 | Antle et al. (2017)<br>(K)            | Modern agricultural models         | Modern agricultural models will take advantage of major advances in data technologies, media, and processing tools to support agricultural production systems through data, models, and knowledge products.                                                                                                                                                           |
| 23 | Battaglia et al. (2017)<br>* (K)      | Organizational structures          | The organizational structures adopted by university technology transfer offices are related to the dynamics, formalization and results achieved by the collaboration between office staff, policy makers and consumers.                                                                                                                                               |
| 24 | Jones et al. (2017a)<br>(D)           | Agricultural systems models        | Agricultural systems models have a wide number of applications at different spatial and temporal scales. For best results it will be necessary to enable accurate and timely data sets and improve opportunities for the open data paradigm.                                                                                                                          |
| 25 | Al-Tabbaa & Ankrah (2016)<br>* (C)    | Value creation framework           | The creation of value for the social capital of the organizations involved in technology transfer processes is achieved with the interaction between different dimensions                                                                                                                                                                                             |

|    |                                  |                                      |                                                                                                                                                                                                                                                                                                                               |
|----|----------------------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                  |                                      | and the dynamics between them is related to impacts and results.                                                                                                                                                                                                                                                              |
| 26 | Patel et al. (2018)<br>(K)       | Human resource management            | Hybridization approach to human resources management at local headquarters proposes the merger of headquarters practices and policies with local management practices to improve management and collaboration processes.                                                                                                      |
| 27 | Chen & Li (2022)<br>(D)          | Technological diffusion              | Consolidation of technology and science parks in the agricultural sector is achieved through the spatial grouping of organizations and industry dedicated to technological innovation in order to favor the temporal and spatial processes of technological diffusion.                                                        |
| 28 | Janssen et al. (2017)<br>(D)     | Modeling of agricultural systems     | Possibilities provided by the interoperability of data sources, open models, reference datasets, and analysis methodology will be exploited by the next generation of models and decision support tools for agricultural production systems.                                                                                  |
| 29 | Bozeman et al. (2015)<br>(D)     | Effectiveness model                  | Approaches to measuring the effectiveness of technology transfer are aimed at estimating the social and public value generated in the actors involved in the process.                                                                                                                                                         |
| 30 | Bonfim et al. (2018)<br>(D)      | Indigenous technological development | In order to reduce technological dependence on developed economies, emerging economies need to develop and implement a new generation of public policies that strengthen indigenous technological development through public-private partnerships and the transfer of knowledge and technology.                               |
| 31 | Swinnen & Kuijpers (2017)<br>(C) | Institutional innovations            | One mechanism for supporting the agricultural sector to improve the productivity of production systems and reduce poverty among farmers is the adoption of modern technologies. However, to achieve this requires that the organization and innovation of value chains contribute to the transfer of agricultural technology. |
| 32 | Carter et al. (2016)<br>(D)      | Property Rights                      | The technology transfer process involves risk structures that are covered by traditional and credit contracts to formalize environments in which property rights are guaranteed.                                                                                                                                              |
| 33 | Nguyen et al. (2022)<br>(K)      | Transfer of green technologies       | Green technology adoption processes generate increased competitive advantages and improvements in green operations. However, technical risks, operational test results, old technologies, and lack of knowledge transfer must be considered.                                                                                  |
| 34 | Bondarenko et al. (2016)<br>(C)  | Agribusiness clusters                | Agribusiness cluster models offer innovative development prospects and potential opportunities. To promote cluster efficiency, it is important for business entities to have information on financial market products and effective collaboration mechanisms.                                                                 |

Note: \*Universities as key factor. (K) Knowledge. (C) Collaboration and networks. (D) Development  
Source: Authors

**Step IV.** In 13 of the analyzed papers, transfer technology was focused on Universities as source of technology and leader to promote transference.

Some of the common topics about transference of technology to agroindustry are Innovation, Development (9), Collaboration and networks (15), Knowledge (10).

Additionally, some determinants for success of transference presents in the papers were: Technology Transfer Office (12), Data Systems (11), Acceptance of technology (10), Evaluation of process (6), Economy as a factor to implementation (4).

### Conclusions

According to the analysis, the following aspects should be considered when technology will be transfer to agroindustry:

- a) *Technology Transfer Office*: It seems a mechanism that is widely used to ask for support and options in technology.
- b) *Data Systems*: According to literacy review, it is a tendency because would strongly improve the performance in agricultural industries.
- c) *Acceptance of technology*: It is the objective for conquer papers high spot relevance of obtain the adoption through the alignment of offer and demand of the most suitable technology.
- d) *Evaluation of process*: It is not possible to improve what is not measured, and to achieve the transfer it is important to measure the results of the efforts made, among other things to systematize processes that will increase the chances of success.
- e) *Economy as a factor to implementation*: In several cases of the literature reviewed, the economic factor is highlighted as a determinant of the possibilities of technology transfer, this is relevant given that in many cases small enterprises is at a disadvantage, which is why policies to promote technology transfer require the provision of this element.

It has also been concluded that, although there is still a tendency to conceive of universities as the main source of innovation and technology transfer, it is very important that companies themselves invest in research and technological development for their own use and potential exploitation.

The triple and quadruple helix model is found as a reference for technology transfer between agricultural industries, however, there is no clear systematization of the process, it seems that in each latitude isolated efforts are implemented to achieve their purposes, such a situation suggests the absence of an appropriate model for the specific conditions of the agricultural sector.

In other hand, the common topics found in the analysis dictate the following practices as current technology transfer models:

Innovation, Research & Development, it's a source and the base of technology transfer, without them it's impossible to have any model or success. In addition, collaboration and networks are especially relevant for successfully addressing the challenges of technology transfer in the agricultural sector, human capital, technical skills, and mobilization to acquire experiences and then share them in a network, is identified as a highly relevant factor.

Finally, knowledge is a hot topic, in many cases was found knowledge transfer as a key to make possible the success of technological transfer into agriculture industry; without this element, the mere acquisition of technology equipment' without the possibility of efficient exploitation has no impact on the competitiveness of the sector.

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