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Is there a "Made in Mexico" model for innovation transfer or diffusion among farmers?

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ABSTRACT

Objective: To determine the existence or absence of a model or several models for the transfer of innovations that have been developed and evaluated in Mexico.

Design/methodology/approach: Using the SCOPUS® metadatabase, a search was conducted with the words innovation AND farmer AND Mexico. It resulted in 70 articles, of which only 35 met the selection criteria.

Results: The articles used concepts, frames of reference, and, to a lesser degree, theories to support their research. The highest number of published cases dealt with the MasAgro technological hub model in maize and the GGAVATT model for group-oriented work in livestock.

Limitations on study/implications: Using a metadata base that is not open access limits the results, since technical reports, books, and other documents that might otherwise enrich the discussion are left aside.

Findings/conclusions: There is still much to be theorized in order to create new models adapted to other product systems that could promote technology transfer from the institutions of the sector and researchers to farmers.

Keywords: Agriculture Innovation Systems, extensionist, technological model.

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INTRODUCTION

One of the greatest challenges that researchers face when developing new technologies, varieties, products, or services for the agri-food sector is achieving the adoption of the technology by users. Studies on the adoption of agricultural technology have their beginnings in the United States during the seventies. The researchers who made the most significant contributions were sociologists interested in distinguishing the characteristics of possible adopters of technology, opinion leaders, as well as their perspectives, adoption rates, and the communication channels they used (Marra *et al.*, 2003).

The concept of innovation has been widely used in science, as governments, companies, or organizations that finance science seek to ensure that the technologies they support have an innovative component. In the agricultural sector, innovation has also played an important role among researchers. In relation to innovations and their transfer, the focus has gone from studying innovation per se (technology-oriented approach), to understanding its users, taking into account the combination of technological and non-technological aspects (systemic, holistic, user-based approaches) (Schut *et al.*, 2014). The aim of the present study was to understand, in the case of Mexico, how research related to innovations that have focused on farmers has been addressed, whether the focus has been on innovation, or on more complex approaches, and whether these have been proposals developed in Mexico or models imported from abroad.

Theoretical and conceptual framework

Farmer-level reasons for the adoption of innovations

After the initial studies, there is a wide range of research that has established that the adoption of innovations is affected by various factors. For example, in a literature review on the factors that affect the adoption of innovations in small farmers in Africa (Fadeyi *et al.*, 2022), the authors found 29 factors that could be classified into five groups: farmer characteristics, production unit characteristics, technology characteristics, as well as institutional and financial factors. Of these, the most commonly mentioned factors were finance, gender, age, education, size of the production unit, and access to extension. One case is the adoption of agricultural innovations in Ethiopia, where farmers with the following characteristics were more likely to adopt innovations: higher level of education, larger families, more participation in activities outside their production unit, more livestock, access to extension services, advisory services, credit, optimal roads, production units close to their homes, and less income from remittances (Zegeye *et al.*, 2022). In another study carried out in China, the authors found an increase in the adoption rate of innovations for precision fertilization when extension services based on information and communication technologies were used (Li *et al.*, 2022); in a study on adoption of irrigation systems in Lebanon, the authors found that an increase in risk perception reduced the adoption of innovations (Sabbagh and Gutierrez, 2022). Another factor is the level of knowledge that the farmer has about a given innovation, which has been positively correlated with the adoption of that innovation (Khan *et al.*, 2022); as well as the farmer's ability to process information, which is correlated to his or her age (Wu *et al.*, 2022), and whether or not they belong to a cooperative (Adebayo *et al.*, 2022).

Systemic-level reasons for the adoption of innovations

Other studies have stressed the role of the State, as well as of the institutions. For example, they become critical for facilitating the collaboration and participation of diverse actors in the value chains when digital innovations are adopted. The State, the institutions, as well as the context surrounding the users, have contributed to a situation in which the process of diffusion and adoption of innovations not only focuses on the user, nor on the innovation to be transferred, but rather it has been reported that the adoption of innovations must be addressed under a systematic approach (Schut, Rodenburg *et al.*, 2014).

Agricultural innovation systems, which analyze technological, economic, and institutional changes in agriculture, represent one of the existing approaches from a systematic perspective (Klerkx *et al.*, 2010).

This approach has been and continues to be used to analyze agricultural systems around the world (Klerkx *et al.*, 2023). In one study, the authors found that each country has agricultural innovation systems that are unique and that suffer from problems which, although they might seem common, are not actually common for everyone (Hermans *et al.*, 2015).

Other approaches are: 1) farming systems (FS), which emerged in the eighties and nineties and focuses on the production unit. FSs require experts and technologies that are specific to a specific context; and 2) agricultural knowledge and information systems (AKISs), which emerged in the nineties and seek to empower producers with a value chain approach, joint production, and joint learning. It employs a participatory approach but does not consider the power relations between the actors or their inequalities (Schut, Rodenburg *et al.*, 2014).

As mentioned above, the transfer of innovations and their adoption by users has been analyzed at various levels: the innovation by itself, the individual, and at a systemic level that can even reach the national scale. In the case of Mexico, there are several studies that address technology innovation processes; however, the level of their analysis has not been explored to date, nor whether they have a systemic vision or whether they have proposed models to understand and promote innovation transfer processes in the sector. The objective of this systematic literature review was to determine the existence or absence of a model or several models for the transfer of innovations that have been developed in Mexico.

MATERIALS AND METHODS

Search

The articles that were included in the study were obtained through a search performed in the SCOPUS database on February 17, 2023, using innovation AND farmer AND Mexico as search words, resulting in 70 articles. The search was limited to these terms because we wanted to investigate experiences with technology transfer models in farmers and not specific experiences of “diffusion” or “extensionism” since these concepts could have limited the search or might have already been part of a technology transfer model.

Data analysis

The research question became the framework under which the literature was analyzed, categorized, and coded to highlight the way in which the innovation was approached and whether it had been transferred under a model. And if it had, establish the characteristics of the model. Articles were coded and organized by topic using an inductive approach.

Scope

To be included in the study, the articles had to show evidence of processes of innovation transfer to farmers. An important restriction was that the studies should not have an anthropological/historical focus that could refer to ancient Mexico. The articles could be published in English or Spanish, and could address agricultural, livestock, or fishing components. Based on the above criteria, only 35 of the 70 articles were retained for analysis.

RESULTS AND DISCUSSION

The oldest publications that address the topic of innovations, farmers, and Mexico begin in 2006 with a growing trend until 2022, 71.4% of the publications being concentrated in the last six years. They focused on several agri-food products (Figure 1), but mainly on two product systems: maize (seed, cultivation, or combinations with other crops); and livestock (in dual-purpose systems, for meat or milk).

Geographically, the studies were located at various levels, from those that made comparisons at the binational level (Mexico-Peru or Thailand-Mexico), at the Latin American level, at the National level, or those that covered various locations in several states (Guanajuato and Michoacán; 10 states of Mexico), regions (the Mexican tropics, the Central Valleys of Oaxaca, or the Purépecha region). In total, experiences were documented in 16 states of the republic (Figure 2).

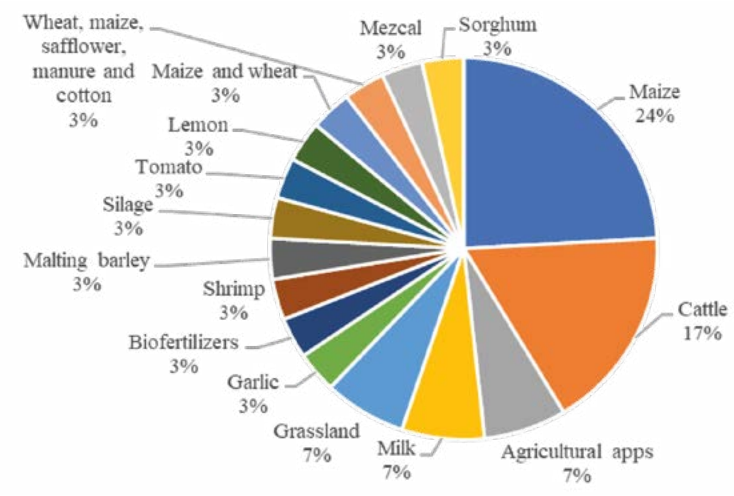

Figure 1. Studied products in publications referring to innovation, farmers, and Mexico.

Figure 2. States where publications referring to innovation, producers, and Mexico were located.

Of the total of articles, 62.8% of the studies focused on: farmers (28.5%), ranchers (25.7%), heads of household (2.9%), mezcalilleras —the woman who produces and likes mezcal— (2.9%), and stakeholders (2.9%). The rest of the studies focused on institutions such as foundations or innovation centers. Most of the articles based their research on concepts (51.4%), followed by frameworks (37.1%) and theories (11.5%); the most frequent concept was that of technology adoption, while the most common framework was social network analysis. The theories used were the Theory of Reasoned Action (TRA), the Theory of Goal Orientation, the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Unified Theory of Acceptance and Use of Technology Modified (UTAUT2).

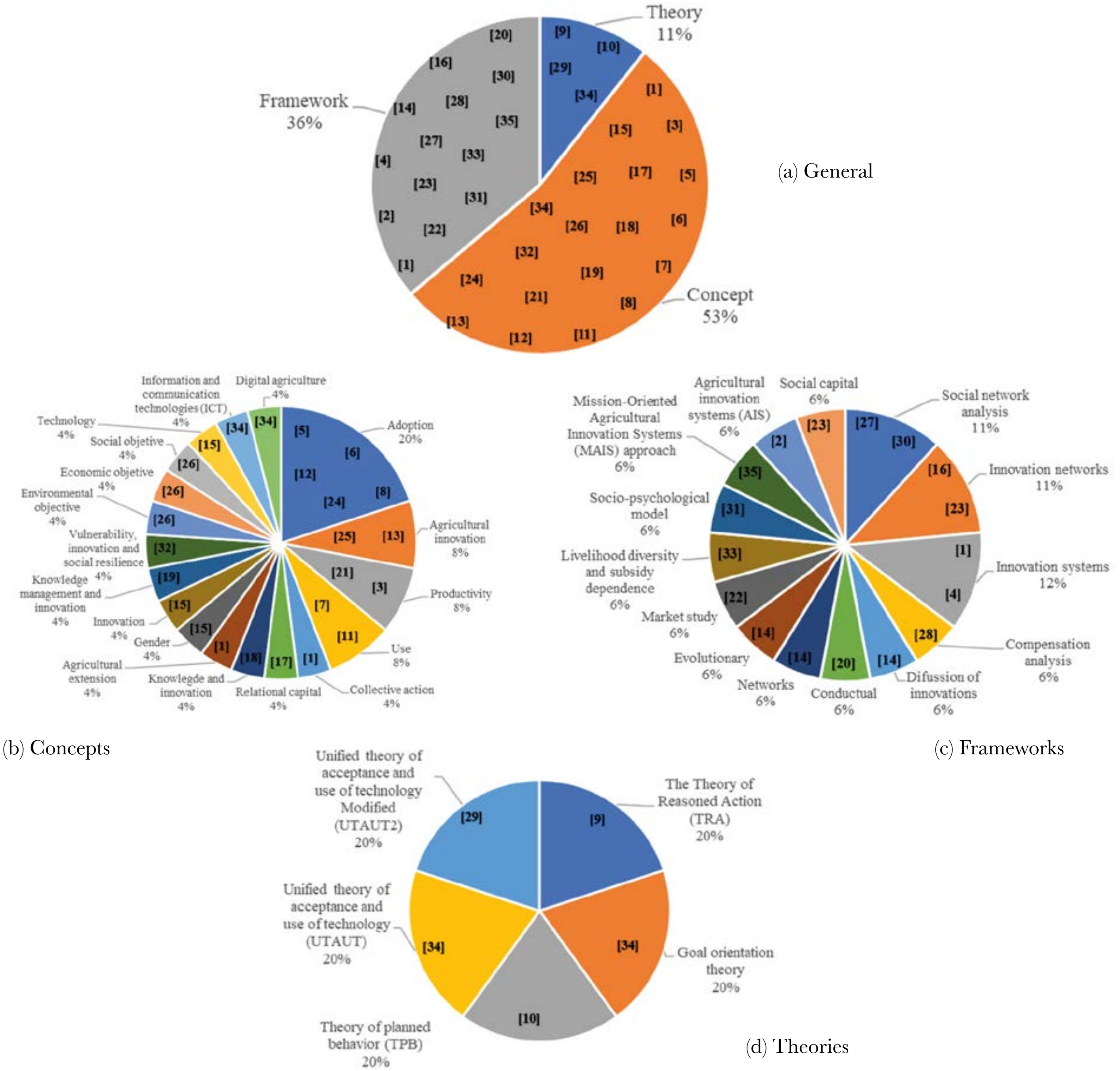

Figure 3. Distribution of articles according to the basis of their research (theories, concepts, or frameworks).

Technologies, systems, and technology transfer systems were documented. The technologies were biofertilizers, silage, improved maize, new varieties, improved grass, crop residues, improved seeds, and technological applications. The systems were agroforestry, conservation agriculture, technological kits, aquaculture parks, sowing in double row and piled furrows (SSDHP, Spanish initials), and technology for milk production; the technology transfer systems analyzed were MasAgro, GGAVATTs, and MAIS.

With regard to the developers of the technology, systems, and/or technology transfer systems, CIMMYT (International Maize and Wheat Improvement Center, Spanish initials) developed MasAgro and is responsible for 8 of the 35 articles. The second most important is INIFAP with 7 of the 35 and one co-authored between CIMMYT and INIFAP. The following institutions had one development: CONANP (National Commission of Protected Natural Areas, Spanish initials), FIRA, CINVESTAV Mérida in collaboration with the Kellogg Foundation, and a private company, the rest made no indication in this regard, so they were attributed to the authors but not to an institution.

Finally, in the global analysis of the articles, the approach followed by the authors was determined in terms of whether they were descriptive, theoretical, explanatory, or predictive. Most of the articles were descriptive and only one was theoretical. In the greatest number of cases, the authors' aim was that their contributions be explanatory, and to a lesser extent predictive. Descriptive articles focused on descriptions of the technologies, the adoption made by users, and the results found in the field; that is, they concentrated on the technology, while explanatory articles tended to establish the characteristics of the farmers that cause a technology to be adopted or not. Finally, predictive articles were those that make it possible to establish how the adoption of the technology or the technology might behave in other cases (Table 1).

The adoption of technology is relevant to the achievement of changes in rural areas. This systematic literature review seeks to present elements to discuss the existence of a "made in Mexico" model. The results show three models in particular: MasAgro, MAIS, and GGAVATT. We shall begin with the first: MasAgro is a sustainable modernization of a traditional agriculture program developed jointly between CIMMYT and the Mexican government that began in 2010 and aims to contribute to the country's food self-sufficiency (Camacho-Villa, Almekinders *et al.*, 2016).

In particular, it focuses on traditional maize farmers who can transition to a more commercial and profitable production through the use of more modern practices such as improved varieties, comprehensive soil fertilization, improved tillage methods, and their integration into more profitable markets (Donnet, Becerril *et al.*, 2017). In order to attain this, they establish "hubs" or innovation platforms, under the principles of agricultural innovation systems (AISs, which were developed by researchers from The Netherlands). This program initially focused on technology, and later transitioned to a more system-oriented approach (Camacho-Villa, Almekinders *et al.*, 2016).

MasAgro, although it has been replicated in various parts of the country, has not produced the expected impact. Furthermore, the program was not developed in Mexico, but rather contains elements of other CIMMYT experiences in various places around the world. The international focus of the program, which can be considered its strength, shows

Table 1. Focus of the articles on innovation, farmer, and Mexico.

No.	Author(s) (year)	Descriptive	Theoretical	Explanatory	Predictive
[1]	Hellin (2012)	✓			
[2]	Hellin and Camacho (2017)		✓		
[3]	Cuanalo de la Cerda and Siniarska (2006)	✓			✓
[4]	Speratti *et al.* (2015)	✓		✓	
[5]	Cuevas-Reyes (2019)	✓		✓	✓
[6]	Sánchez-Toledano *et al.* (2018)	✓		✓	✓
[7]	Cuevas-Reyes *et al.* (2021)	✓		✓	✓
[8]	Martínez-Garcia *et al.* (2020)	✓		✓	✓
[9]	Martínez-García *et al.* (2013)	✓		✓	✓
[10]	Juárez-Morales *et al.* (2017)	✓		✓	✓
[11]	Reyes Cuevas *et al.* (2013)	✓		✓	✓
[12]	García *et al.* (2012)	✓		✓	✓
[13]	Dutrénit *et al.* (2012)	✓		✓	
[14]	Díaz-José *et al.* (2016)	✓		✓	
[15]	Contreras-medina *et al.* (2021)	✓		✓	
[16]	Monsalvo-Velázquez *et al.* (2014)	✓		✓	
[17]	Roldán-Suárez *et al.* (2018)	✓		✓	
[18]	Lebel *et al.* (2016)	✓			
]19]	Lopez *et al.* (2020)	✓		✓	
[20]	Sánchez-Toledano *et al.* (2021)	✓		✓	✓
[21]	Donnet *et al.* (2017)			✓	
[22]	Barragán-Ocaña and del-Valle-Rivera (2016)				
[23]	Zarazúa *et al.* (2012)	✓		✓	
[24]	Sánchez-Toledano *et al.* (2017b)			✓	✓
[25]	Camacho-Villa *et al.* (2016)	✓			
[26]	Sánchez-Toledano *et al.* (2017a)			✓	✓
[27]	Oriana *et al.* (2021)			✓	✓
[28]	Speelman *et al.* (2006)	✓			
[29]	Molina-Maturano *et al.* (2021)			✓	✓
[30]	Villarroel-Molina *et al.* (2021)			✓	✓
[31]	Martínez-García *et al.* (2018)			✓	
[32]	Díaz-José *et al.* (2018)	✓			
[33]	Zabala *et al.* (2022)			✓	✓
[34]	Molina-Maturano *et al.* (2022)			✓	
[35]	Castillo-Martínez *et al.* (2022)	✓		✓	

that it is not a purely "made in Mexico" product. The transition from programs focused on technology to those with a holistic vision in the program is evident, yet the primary orientation of the program continues to be toward technology (improved varieties of maize and conservation tillage).

The second case is MAIS, a model that focuses on the evaluation of different aspects from a holistic perspective in order to establish an agenda for research and innovation, as well as for the production system. This approach was developed as an extension of the principles of agricultural innovation systems (AISs) by the same group of researchers in the Netherlands. It remains as a methodological guide to understand a reality in order to propose public policies (Castillo-Martínez, Díaz-José *et al.*, 2022), but it does not constitute a tested or pilot model.

Finally, the GGAVATTs are Livestock Farmers' Groups for the Validation and Transfer of Technologies, which conform to a model developed several decades ago by the INIFAP (National Institute for Forestry, Agriculture, and Livestock Research, Spanish acronym) in which livestock farmers were organized into groups with a common interest, that of adopting technology (reproduction, feeding, management, health, quality, management, and use of agricultural lands). The studies show that the GGAVATTs have been constituted as homogeneous groups with well-defined structures and with higher levels of technology adoption than livestock farmers that did not belong to them (Villarroel-Molina, De-Pablos-Heredero *et al.*, 2021). The greatest limitations of this model are that it has only been used in livestock farming and that a central axis is to group farmers. This becomes complex for other cases in which organization among farmers has been a historical problem.

The GGAVATT model has components that are like those of MasAgro, which is to have a clear innovation, a technological package to transfer and disseminate, as well as technical support (technicians and researchers) to monitor the processes. This is similar to the innovation ecosystem (Fursov and Linton, 2022). Although the two differ in their objectives, GGAVATT seeks to improve the standard of living of the livestock farmers and MasAgro originally sought to increase competitiveness; then they focused on food sovereignty and poverty reduction, adapting the justification of the impact of their models to the prevailing government discourse. Half of the rest of the research focuses on the factors that determine the adoption of innovations by farmers. These can be divided into those that focus on innovation and the rest on testing various concepts mentioned in the results section. This makes it possible to demonstrate that the focus of research has been on technology as well as on technological and non-technological aspects (Schut, Rodenburg *et al.*, 2014), with few models that have been evaluated or adopted by companies, institutions, or NGOs outside the institutions that created them.

CONCLUSIONS

This systematic literature review aimed to determine whether there is a "made in Mexico" technology transfer model. The answer to that question could be said to be yes, if we consider the GGAVATTs as a model to validate and transfer innovations as well as to organize livestock farmers. However, it remains to be determined whether this model is reproducible for other non-livestock farmers and in contexts where farmer organization is a complex issue. In conclusion, there remains much to be theorized in order to create new models adapted to other product systems that could promote technology transfer from institutions, companies, and NGOs to farmers.

It should also be noted that, except for one publication, the rest are not theoretical in nature; that is, the level of discussion does not reach the point of rejecting or improving existing models such as the Agricultural Innovation System (AIS) or social networks. Or perhaps proposing a tropicalized version of them, in order to use them as research frameworks to characterize or validate what was implemented in the field, especially with regard to the publications associated with MasAgro.

One of the limitations of this review is that it was restricted by the keywords used during the search, hindering the ability to include other publications that might have shed light on other models for the transfer and diffusion dissemination of innovations to farmers. Likewise, the use of a metadata base that was not open access also limited the results, since technical reports, books, and other documents that might have enriched the discussion were left out of the analysis.

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