Geography matters for learning and innovation in natural resource-based activities: regional differences in technical linkages across Argentine agriculture

Article *in* Innovation and Development · April 2023

DOI: 10.1080/2157930X.2023.2194070

Andrés Niembro
Universidad Nacional de Río Negro

Jesica Sarmiento
Universidad Nacional de Río Negro

Agustín Rivas Bergant
Universidad Nacional de Río Negro

Routledge
Taylor & Francis Group

Innovation and Development

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/riad20

Geography matters for learning and innovation in natural resource-based activities: regional differences in technical linkages across Argentine agriculture

Andrés Niembro, Jesica Sarmiento, Gastón Blasquiz Landa & Agustín Rivas Bergant

To cite this article: Andrés Niembro, Jesica Sarmiento, Gastón Blasquiz Landa & Agustín Rivas Bergant (2023): Geography matters for learning and innovation in natural resource-based activities: regional differences in technical linkages across Argentine agriculture, Innovation and Development, DOI: 10.1080/2157930X.2023.2194070

To link to this article: https://doi.org/10.1080/2157930X.2023.2194070

Published online: 06 Apr 2023.

INNOVATION AND DEVELOPMENT
https://doi.org/10.1080/2157930X.2023.2194070

Geography matters for learning and innovation in natural resource-based activities: regional differences in technical linkages across Argentine agriculture

Andrés Niembro [a,c], Jesica Sarmiento [b,c], Gastón Blasquiz Landa [a,c] and Agustín Rivas Bergant [a]

[a]Universidad Nacional de Río Negro, Instituto de Estudios en Ciencia, Tecnología, Cultura y Desarrollo (CITECDE), Argentina; [b]Universidad Nacional de Río Negro, Centro Interdisciplinario de Estudios sobre Territorio, Economía y Sociedad (CIETES), Argentina; [c]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina

ABSTRACT

Although innovation is present in all economic sectors, innovation surveys and empirical research are biased towards high-tech activities. Meanwhile, quantitative studies on agricultural innovation systems (AIS) usually neglect the regional dimension. As in many developing countries, Argentine agriculture seems to have evolved towards a new techno-productive paradigm, but no study has yet analyzed its geographical scope. This article proposes a regional-structural approach to study where, how and with whom technical linkages and interactive learning processes are developed. Using under-explored data from the 2018 National Agricultural Census and multivariate analysis techniques, the results reveal significant regional differences in technical linkages and show that the new techno-productive paradigm is limited to the Pampean region. While private sources of knowledge are mainly concentrated in central areas, technical linkages with public agencies are geographically widespread. Acknowledging these regional heterogeneities poses different policy challenges for promoting AIS in developing countries with large and diverse territories.

ARTICLE HISTORY
Received 3 December 2021
Accepted 19 March 2023

KEYWORDS
Interactive learning; Knowledge transfer; Agricultural innovation systems; Developing countries; Multivariate analysis

1. Introduction

The idea that innovation and technological change are crucial for growth and development is widely accepted, regardless of the horizon of analysis, be it companies, sectors, countries or subnational regions (Fagerberg, Mowery, and Nelson 2005; Suárez, Erbes, and Barletta 2020). In this sense, the article lies at the intersection of three highly relevant topics, learning and innovation in natural resource-based activities (Pérez, Marin, and Navas-Alemán 2014; Andersen, Marin, and Simensen 2018) and specifically in agriculture (Läpple, Renwick, and Thorne 2015; Moschitz et al. 2015), innovation in developing countries (Lundvall et al. 2009; Lema, Kraemer-Mbula, and Rakas 2021), and the importance of addressing regional inequalities (Pradhan 2011; dos Santos and Mendes 2021)

CONTACT Andrés Niembro aniembro@unrn.edu.ar

for a better understanding of the geography of innovation, especially in these activities and countries (Mesquita, Luna, and Souza 2021).

Although the literature usually pays less attention to innovation and technological change in natural resource-based activities, innovation in many of these activities has intensified in recent decades –driven by new global trends and opportunities for the application of biotechnologies, nanotechnologies, digitalization and artificial intelligence, among other technologies–, which is particularly important for developing countries (Andersen, Marin, and Simensen 2018; Lema, Kraemer-Mbula, and Rakas 2021). Several authors argue that the Argentine agricultural sector is also undergoing a new techno-productive paradigm, based on the incorporation of new technologies and knowledge, in many cases provided by new agents, such as AgTech companies (Anlló, Bisang, and Campi 2013; Trigo, Mateo, and Falconi 2013; Lachman and López 2019; 2022). However, beyond isolated evidence or case studies, there are no quantitative studies that, based on nationwide data, have verified the geographic scope of this new paradigm. Therefore, where and how learning and innovation processes take place in Argentine agriculture are central questions for this article.

In this context, it is important to highlight at least three issues. First, innovation and technological change do not usually occur in isolation but are often the result of social and interactive processes of knowledge transfer between different agents. In other words, the transmission of knowledge usually depends on learning processes, which are predominantly interactive and take place in specific social and cultural environments (Lundvall 1992b). Interactive learning, innovation networks and systemic approaches are particularly relevant in agriculture (Nieuwenhuis 2002; Knickel et al. 2009; Moschitz et al. 2015), as the literature on agricultural innovation systems (AIS) has widely acknowledged (Hall, Mytelka, and Oyeyinka 2006; Onumah, Asante, and Osei 2021). Andersen, Marin, and Simensen (2018) also highlight the importance of interactive learning and linkages between natural resource producers and suppliers of equipment, services and solutions, since 'the generation, diffusion and use of knowledge via different forms of innovation is the pivotal issue in natural resource-based development' (Andersen, Marin, and Simensen 2018, 10). Therefore, what types of linkages are developed and with whom are also relevant questions.

Secondly, but linked to the above, these social and interactive processes are generally rooted in practices and characteristics specific to each region. This 'natural resource knowledge idiosyncrasy' makes that 'knowledge produced in a specific location might not always be useful to every other location' (Andersen, Marin, and Simensen 2018, 8). For example, Mesquita, Luna, and Souza (2021) show that the expansion of the agricultural frontier in Brazil towards peripheral regions is not followed by the movement of knowledge, which remains located in central regions. Likewise, a vast literature indicates that, in general, the benefits of innovation and technological change are not distributed symmetrically across the territory, generating winners and losers and widening regional inequalities (dos Santos and Mendes 2021). For these reasons, the geographic dimension should be incorporated into the analysis to avoid falling into homogeneous categories like Argentine agriculture (*el agro argentino*, as is often mentioned).

Thirdly, even though innovation and technological change take place in all economic sectors, innovation studies are conceptually and empirically biased towards high-tech industries or knowledge-intensive services, while natural resource-based activities are often considered low-tech activities (Anlló, Lugones, and Peirano 2007; Martin 2016; Lema, Kraemer-Mbula, and Rakas 2021). Despite the importance of agricultural production in Argentina, as in many other developing countries, the empirical evidence on innovation and technical linkages remains highly concentrated in the industrial sector, since innovation surveys have only covered manufacturing companies (ECLAC 2017). In the agricultural sector, the measurement of innovation is still incipient, both in conceptual and practical terms, and is limited to a few pilot tests (DNIC 2019). Another limitation of innovation surveys in Argentina is that they neglect the geographic dimension, since the location of companies is not published.

These research gaps are part of a more general context where 'the methodological toolkit employed in the study of developing-country agriculture remains fairly limited' and 'the favored methodology is the descriptive case study' (Spielman, Ekboir, and Davis 2009, 402). On the other hand, Minh (2019:, 268) highlights that even though the AIS approach has 'recently received considerable attention in academic and development circles, links between an AIS's regional specifications and structural-functional analysis have been neglected'. Like Minh (2019), we also propose an integrated regional-structural approach to analyze how regional and structural dimensions affect the functioning of regional AIS and, especially, where, how and with whom technical linkages and interactive learning processes are developed. However, instead of applying a qualitative analysis on a single region, we present a relatively simple quantitative analysis methodology using data from all Argentine regions. Paraphrasing Klerkx, van Mierlo, and Leeuwis (2012, 478), it is 'about recognizing diversity of [regional] subsystems within a [national] system, and getting a clearer view of how different system boundaries cut across each other'.

Given some of the mentioned limitations of the available data in Argentina, this article does not intend to (and cannot) contribute directly to the analysis of innovation results in regional AIS, but it can help to understand the geography of some crucial factors for innovation and technological change in natural resource-based activities, such as technical linkages, knowledge transfer or interactive learning. Using under-explored data from the 2018 National Agricultural Census (CNA 2018, in Spanish) and multivariate analysis techniques, the article shows significant regional[1] differences and heterogeneities in technical linkages across Argentine agriculture. The results relativize the geographic scope of the new techno-productive paradigm, in which private agents and service suppliers are considered central actors, and also emphasize the role of public organizations for knowledge transfer throughout the country. In this sense, it is shown that the Argentine agricultural innovation system comprises different agents –producers, suppliers, clients and knowledge organizations– (Andersen, Marin, and Simensen 2018), but they have different weights in technical linkages and interactive learning depending on the region. Therefore, policies that seek to promote knowledge transfer in natural resource-based activities must consider the geography of learning and the different types of technical linkages.

After this introduction, the article is organized into six sections. Section 2 briefly develops the theoretical framework and section 3 reviews several empirical studies related to the scope of the article. Then, section 4 details the data and the methodology employed. Turning to the results, section 5 begins with a preliminary descriptive analysis, followed by an in-depth presentation of the results of the multivariate analysis. These results are further discussed in section 6, along with their policy implications. Finally, section 7 presents some concluding remarks.

2. Conceptual framework

The importance of interactions, linkages and learning capabilities for knowledge transfer has given rise to a vast literature. Within different conceptual frameworks, this literature has also recognized the influence of regional characteristics on the evolution of innovation and development. One of the most recognized contributions of the evolutionary or neo-Schumpeterian school is the innovation system approach, which emphasizes the role of linkages and interactions between different agents, organizations and institutions. Although this approach initially focused on the study of national innovation systems (Freeman 1987; Lundvall 1992a; Nelson 1993), it quickly descended to the local or regional level (Cooke 1992; Asheim and Isaksen 1997; Autio 1998; Braczyk, Cooke, and Heidenreich 1998). Under a broad definition, the innovation system is composed of a diverse set of public and private agents whose actions and interactions contribute to the creation, transfer and exploitation of knowledge for innovation and technological change. Therefore, this approach highlights the interactive, social, cultural and historical nature of learning and innovation processes (Lundvall 1988; 1992b; Freeman 1995).

Several authors have pointed out that regional characteristics are crucial for innovation and development (Scott and Storper 2003; Doloreux and Parto 2005; Borello 2019), since many actions, interactions, capabilities and knowledge are rooted in the territory (Maskell et al. 1998; Maskell and Malmberg 1999). Tacit knowledge (Polanyi 1966), absorptive capacities (Cohen and Levinthal 1990) and different types of proximity (Boschma 2005) are some of the issues underlying the geography of interactive learning and innovation, as they depend to a large extent on the institutional, cultural, social and economic context of each region (Dosi 1988; Howells 2002; Gertler 2003; Morgan 2004; Storper and Venables 2004; Shearmur, Carrincazeaux, and Doloreux 2016).

Linked to the idea of sectoral innovation systems (Malerba 2002), the application of the innovation systems approach to understand and diagnose agricultural innovation processes gave way to the AIS concept (Hall, Mytelka, and Oyeyinka 2006; World Bank 2006). According to Spielman and Birner (2008), this framework involves:

> the study of sets of interrelated actors who interact in the generation, exchange, and use of agriculture-related knowledge in processes of social or economic relevance, and the institutional context that conditions their actions and interactions. (…) [The AIS] approach includes the farmer as part of a complex network of heterogeneous actors engaged in innovation processes, along with the formal and informal institutions and policies environments that influence these processes (…). The framework addresses novel issues such as the capacity of individuals and organizations to learn, change and innovate, the nature of iterative and interactive learning processes among innovation agents, and the types of interventions that enhance such capacities and processes (Spielman and Birner 2008, 1–2).

The AIS approach is usually applied at the level of countries or specific sectors, market niches or technologies (Klerkx, van Mierlo, and Leeuwis 2012; Pigford, Hickey, and Klerkx 2018; Toillier et al. 2018), and it is occasionally used for qualitative analysis of some regions (Minh 2019; Schmidt, Díaz-Puente, and Bettoni 2022). The different purposes, hypotheses and views on AIS generally involve the application of different methodologies (Toillier et al. 2018). In line with the infrastructural view of AIS outlined by Klerkx, van Mierlo, and Leeuwis (2012), the 'structural analysis of an AIS consists mainly of identifying its structural components, i.e. stakeholders and their networks' (Toillier et al. 2018, 5) or, in terms of the seminal work of the World Bank (2006), the key actors, their roles and characteristics of patterns of interaction.

Spielman and Kelemework (2009) offer an example of a structural analysis performed at the country level, based on the collection of more than 40 indicators to assess four domains: the knowledge and education domain, the bridging institutions domain (including advisory services), the business and enterprises domain (including farmers) and the enabling environment domain (including policies). They construct a synthetic index by assuming equal weights (simple average) and also by comparing the results with principal component analysis (PCA). Finally, they classify the countries into four groups and analyze their characteristics.

3. Empirical literature

Beyond the international literature already mentioned, this article is at the intersection between three previous lines of research in Argentina. First, several studies have partially addressed –often with case studies– the techno-productive situation of some agricultural chains, or the role of certain agents and public organizations in terms of technical linkages and knowledge transfer in Argentine agriculture. A second line has tried to achieve more holistic reflections on the evolution of agricultural activity in the country, based on data sources with a broad geographic scope, particularly the CNAs. Finally, some studies have sought to understand regional inequalities in Argentina through empirical typologies, often based on socioeconomic indicators and multivariate analysis techniques.

Partly due to the industrial bias of innovation studies and statistics in Argentina, different studies have focused on inputs or capital goods linked to agricultural production, such as seeds and agricultural machinery (Marin and Stubrin 2017; Sztulwark and Girard 2017; Lavarello et al. 2019; Marin, Stubrin, and Palacín Roitbarg 2022). In addition, other studies have analyzed the subsequent stages of transformation and value addition to natural resources, such as food production and biofuels (Bisang and Sztulwark 2010; Gutman, Lavarello, and Ríos 2010; Marin, Stubrin, and Kababe 2014; Marin and Petralia 2018).

Several authors have highlighted the emergence of a new techno-productive paradigm in Argentine agriculture in recent decades –although, as will be seen later, it would apply mainly to the Pampean region–. According to this view (Bisang, Anlló, and Campi 2010; Anlló, Bisang, and Campi 2013), hand in hand with the emergence of a new type of networked production organization, private professionals and service suppliers play a strategic role in the diffusion of knowledge and technologies in these networks (García and Lombardo 2016; Hernández and Muzlera 2016; Arza et al. 2018; Schiaffino 2020). In the same line, some studies have analyzed the strategies and technological evolution of knowledge-intensive service companies linked to agricultural production in Argentina (Anlló, Bisang, and Katz 2015; Marin, Stubrin, and da Silva 2015; Crespi, Katz, and Olivari 2017; Lachman and López 2019; Lachman et al. 2021; Lachman and López 2022).

Other studies have noted the historical role of agricultural and agro-industrial cooperatives for knowledge transfer and the introduction of productive and commercial innovations (Lattuada et al. 2011; Mateo 2011; Sili, Sanguinetti, and Meiller 2014), which is also relevant in other Latin American countries (Rodríguez-Miranda, Boza, and Núñez 2021). On the other hand, several authors have described the processes of concentration and integration between primary production and the agro-industrial sector in some traditional regional economies (Landriscini et al. 2007; Moscheni Bustos and Carrizo Muñoz 2015; Brignardello 2017). Other studies have emphasized the role of some public policies or agencies associated with extension services and knowledge transfer (Carballo 2002; Selis 2012; Landini 2013). It is worth noting that some of these public organizations, such as the National Institute of Agricultural Technology (INTA, in Spanish) or the National Universities with their respective agricultural departments, have a wide territorial distribution throughout the country (Linzer 2008; Gárgano and Souza 2013; Albornoz 2015; Iparraguirre 2017; Gárgano 2018).

Regarding the source of information, several studies have used National Agricultural Censuses (CNA 1988, 2002, 2008 and 2018) to describe the situation of agricultural producers in Argentina, either covering the whole country (Obschatko, Foti, and Román 2007; Azcuy Ameghino and Fernández 2019; Vértiz 2020) or focusing on some regions, especially the Pampean region (Basualdo 2010; Basualdo, Barrera, and Basualdo 2013; García and Lombardo 2016; Garay, Krapovickas, and Mikkelsen 2017; Azcuy Ameghino and Fernández 2019). These studies usually analyze the concentration of land tenure and the evolution of small producers. They also explore some changes in production organization under the agribusiness paradigm, the advance of agriculturalization and the growing influence of agricultural contractors, among other issues. For example, several of the chapters compiled by Lombardo and Tort (2018) analyze the figure of the contractor and its historical development in the Pampean region, based on data from CNAs between 1988 and 2008.

Finally, regarding regional classifications or typologies in Argentina, the seminal study by Nuñez Miñana (1972) represents a benchmark for later comparisons (e.g. Porto 1995). Cicowiez (2003) uses PCA to construct synthetic socioeconomic indicators and then compares the ranking of Argentine provinces with Nuñez Miñana (1972). Meanwhile, other authors (Figueras, Capello, and Arrufat 2007; Figueras, Capello, and Moncarz 2009) use hierarchical cluster analysis to elaborate and compare provincial typologies in different years (1970, 1991 and 2001). Other recent studies also employ hierarchical cluster analysis (Brida, Garrido, and London 2013; Sigal, Camusso, and Navarro 2020) or a combination of PCA and cluster analysis (Niembro 2017; Gómez and Pereyra 2019; Niembro and Sarmiento 2021) to classify Argentine provinces according to different dimensions and indicators.

As can be seen, the classification and elaboration of regional typologies in Argentina have usually focused on the 24 provinces due to the greater availability of data for this geographic scale. In contrast, some studies (ECLAC 2015; Borello et al. 2016) divide the country into 55 micro-regions and then define a regional typology, based on business and labour data and Ward's cluster analysis. Following the same method, Niembro, Calá, and Belmartino (2011) classify the 85 local economic areas[2] of the country according to their different production patterns.

4. Data and methodology

Compared to previous studies, this article takes departments as the unit of analysis, which allows us to work with a much larger number of observations than provinces, micro-regions or local economic areas. Of the 512 departments listed in the CNA 2018, 14 departments lack information, as they are urban areas. Likewise, other 14 departments with less than 20 agricultural holdings (EAPs, in Spanish)[3] have been excluded, as their results may show extreme values due to the small number of observations. Most of these 28 cases correspond to districts around the City of Buenos Aires or capital departments of some provinces. Therefore, we work with information from 484 departments, which have more than 20 EAPs.

Based on a personal interview with the agricultural producer or a qualified informant from each EAP, the CNA 2018 collects structural, productive, technological and socio-demographic information. This information is currently published in tables (*Excel* spreadsheets) presenting different dimensions of the overall results by province and department. Although it was planned that a geographic information system at EAP and parcel level and a user database –for external processing– would also be published, none of these sources is available yet.

In historical terms, Argentina has conducted agricultural censuses for more than a century, but with irregular intervals and different methodological changes. The first of the *modern censuses*, with conceptual definitions and methodologies aligned with international recommendations, was carried out in 1988, followed by the 2002, 2008 and 2018 censuses. Looking back, the latest complete data on the agricultural sector correspond to the 2002 census, since the 2008 census had major coverage failures and only some dimensions of analysis were published –excluding, for example, technical linkages, among other relevant indicators–. However, several methodological changes or differences in the definition of categories between censuses make the 2002 results not strictly comparable with those of 2018.

Having said that, and following the structural approach of some seminal studies (World Bank 2006; Spielman and Birner 2008; Spielman and Kelemework 2009), we select different indicators from the CNA 2018 to cover key dimensions or domains of regional AIS: the patterns of interaction and bridging institutions domain, the business and enterprise domain, the knowledge or education domain and the enabling environment domain –which includes policies and institutions–. Table 1 shows the indicators considered for each dimension, expressed as percentages of total EAPs in each department, and some descriptive statistics that provide a first overview of the level of regional inequalities. Some of these indicators reflect the technical-administrative conditions governing the management of the EAPs, the educational level of the producers or the use of public programmes.[4] Given the focus of this article, a central role is played by the indicators that cover the different technical linkages established by the EAPs, the different forms of association or interaction of the EAPs and the contractual integration or not with the agro-industrial sector. The categories used are not only aligned with the review of previous studies in Argentina but also with how AIS currently operate:

> Within this AIS framework, agricultural producers must be understood as crucial actors in the value chain that are not just assisted by agricultural research and education systems via bridging institutions that build capacities for agricultural innovation, but also by other

Table 1. Data from the CNA 2018 (as % of total EAPs in each department).

Dimensions and indicators			Variable name	Country Total	Departmental values			
					Mean	Standard deviation	Minimum	Maximum
Patterns of interaction and bridging institutions	Technical linkages, by type of agent	Individual professionals	indiv	23.0	24.7	19.5	0	74.3
		National agencies	nat_ag	5.6	7.2	7.5	0	56.6
		Provincial agencies	prov_ag	4.4	5.2	8.0	0	56.8
		Cooperatives	coop	7.3	5.6	9.3	0	67.4
		Service provider companies	serv	7.1	7.0	8.4	0	46.8
		Agro-industrial companies	agroind	1.8	1.7	2.2	0	16.7
	Type of association, by entity	Cooperatives	assoc_coop	14.0	11.6	15.4	0	82.3
		Technical	assoc_tecn	1.7	1.8	2.6	0	21.8
	Contractual integration with industry		integr_ind	3.2	2.9	5.1	0	43.4
Business and enterprises, and education	Technical-administrative management	Production records	prod_rec	43.7	47.1	23.1	0.1	113.3
		Accounting records	acco_rec	44.4	46.9	32.1	0	96.5
		Use of banks or other financial institutions	banks	38.8	41.1	31.6	0	96.7
		Use of computer	compu	34.2	36.9	26.3	0	95.6
		Use of internet	intern	34.4	36.9	26.4	0	92.7
	Producer's educational level	University (incomplete or complete)	univer	17.0	20.7	11.5	1.0	61.7
Enabling environment (policies)	Use of public programmes	National	nat_prog	2.9	4.0	7.4	0	73.3
		Provincial or municipal	prov_prog	2.8	3.2	6.5	0	52.8

Source: Own elaboration based on CNA 2018.

> actors in the value chains such as the input suppliers and seed producers in agribusiness that provide valuable technical assistance, as well as retailers and their demands in order to comply with the standards of good agricultural practices (Aerni et al. 2015, 833).

In innovation surveys in developing countries, especially in Latin America, a small proportion of companies report having innovated or having made efforts to innovate. In the case of the CNA 2018, it is also evident that a low percentage of EAPs have established technical linkages to access new knowledge and technologies. About a quarter of the EAPs interacted with individual professionals, while linkages with the other agents usually range between 5% and 7%. However, the descriptive statistics also show considerable regional differences. According to the maximum values, there are departments where 75% of the EAPs established technical linkages with individual professionals. In addition, linkages with most of the other agents also reached 50% or 60% of the EAPs in some departments. At the opposite extreme, there are several departments in which no producer interacted with the different agents under consideration. On the other hand, in some departments more than 80% of the EAPs were part of cooperatives – the national figure was 14%–, while in others more than 40% were contractually integrated with agro-industrial companies.

Regarding the methodology, this article combines two multivariate analysis techniques commonly used in regional studies, PCA and cluster analysis (Quadrado, Loman, and Folmer 2001; Rasic 2005; Del Campo, Monteiro, and Soares 2008; Argüelles, Benavides, and Fernández 2014; Jindrová 2015; Alberdi, Gibaja, and Parrilli 2016). First, PCA helps to synthesize the information contained in a set of original variables –with a certain degree of correlation between them– into a smaller number of common dimensions. These dimensions or principal components are linear combinations of those variables and have the attribute of being uncorrelated, which is desirable for the subsequent cluster analysis (Johnson and Wichern 2008; Hair et al. 2010). Given that both PCA and cluster analysis are sensitive to using different scales, it is necessary to employ standardized variables. One of the most traditional forms of standardization is Z scores, which are obtained by subtracting the mean and then dividing by the standard deviation –so that they have mean 0 and deviation 1–.

Secondly, cluster analysis seeks to classify the objects of study –the departments– according to their similarity or proximity in terms of the different variables analyzed –in this case, the principal components previously estimated–. The objective of cluster analysis is to include in each cluster the most homogeneous and similar cases while maximizing the heterogeneity among the different clusters (Johnson and Wichern 2008; Hair et al. 2010; Härdle and Simar 2015). In regional studies, one of the most widely used hierarchical techniques is Ward's method (Quadrado, Loman, and Folmer 2001; Kronthaler 2005; Yang and Hu 2008; Jindrová 2015; Alberdi, Gibaja, and Parrilli 2016; Borello et al. 2016). It usually produces more balanced solutions than other methods in terms of the number of objects included in the different clusters. However, given that the use of different methods often leads to different results, we compared them with the non-hierarchical K-Means method (as argued by Del Campo, Monteiro, and Soares 2008; Hollanders et al. 2012; Argüelles, Benavides, and Fernández 2014; Niembro 2017) to verify the consistency of the results obtained (Johnson and Wichern 2008; Hair et al. 2010).

Hierarchical methods, which consist of a series of combinations or agglomerations of objects according to the degree of similarity between them, have the advantage of offering some statistical criteria to define the final number of clusters. One of the most common rules is to analyze the changes in heterogeneity –specifically, the within-cluster sum of squares provided by Ward's method– for the different stages of this agglomeration process (Hair et al. 2010). By combining objects and reducing the number of clusters, the differences within them tend to increase. If joining two clusters produces a sudden jump in heterogeneity, one option is not to take that step and assume the previous number of clusters as a solution.

5. Results

5.1. Preliminary descriptive analysis

As mentioned above, the relative importance of the different technical linkages and sources of knowledge is highly variable in regional terms. In the maps in Figure 1, the colour scale ranges from the departments with the highest percentages of technical linkages –maximum values in Table 1– for each type of agent, in dark green, to the departments in which no EAP interacted with the different agents, in dark red. Technical linkages with individual professionals and, especially, with public agencies are relatively widespread throughout the country. In contrast, it is more common to identify several departments in dark red on the other maps, representing the absence of technical linkages with cooperatives, service providers or agro-industrial companies.

In addition, different areas in dark green can be identified in all maps, showing departments with a higher intensity of linkages with each type of agent. For example, interactions with individual professionals and service providers are prominent in the provinces of Buenos Aires, Córdoba and Santa Fe, the core of the Pampean region. The role of cooperatives is notorious in Santa Fe, as well as in parts of Córdoba, Buenos Aires, Entre Ríos, Misiones or the Cuyo region. Beyond the central area, technical linkages with service providers or agro-industrial companies seem to be concentrated in a few departments.

The Patagonian region and most of the North and the Cuyo region stand out in technical linkages with public agencies. In the particular case of provincial agencies, the provinces of Neuquén, Santa Cruz and Formosa are noteworthy. In general, in those departments where technical linkages with individual professionals are relatively lower, the relative importance of national or provincial agencies is usually higher, and *vice versa*. This could indicate a greater weight of small-scale agriculture, family farming or other alternative practices (García et al. 2008; Gisclard, Allaire, and Cittadini 2015).

The relationships between the variables that account for technical linkages and the other dimensions and indicators can be partially explored from the correlation matrix (Table 2). For example, there is a strong relationship between the linkages with individual professionals and service providers, which are also related to the professional management of the EAPs –production and accounting records, use of computers and internet– and a higher educational level of the producer. In other words, in those departments where producers have a higher level of education, there is usually a more professional

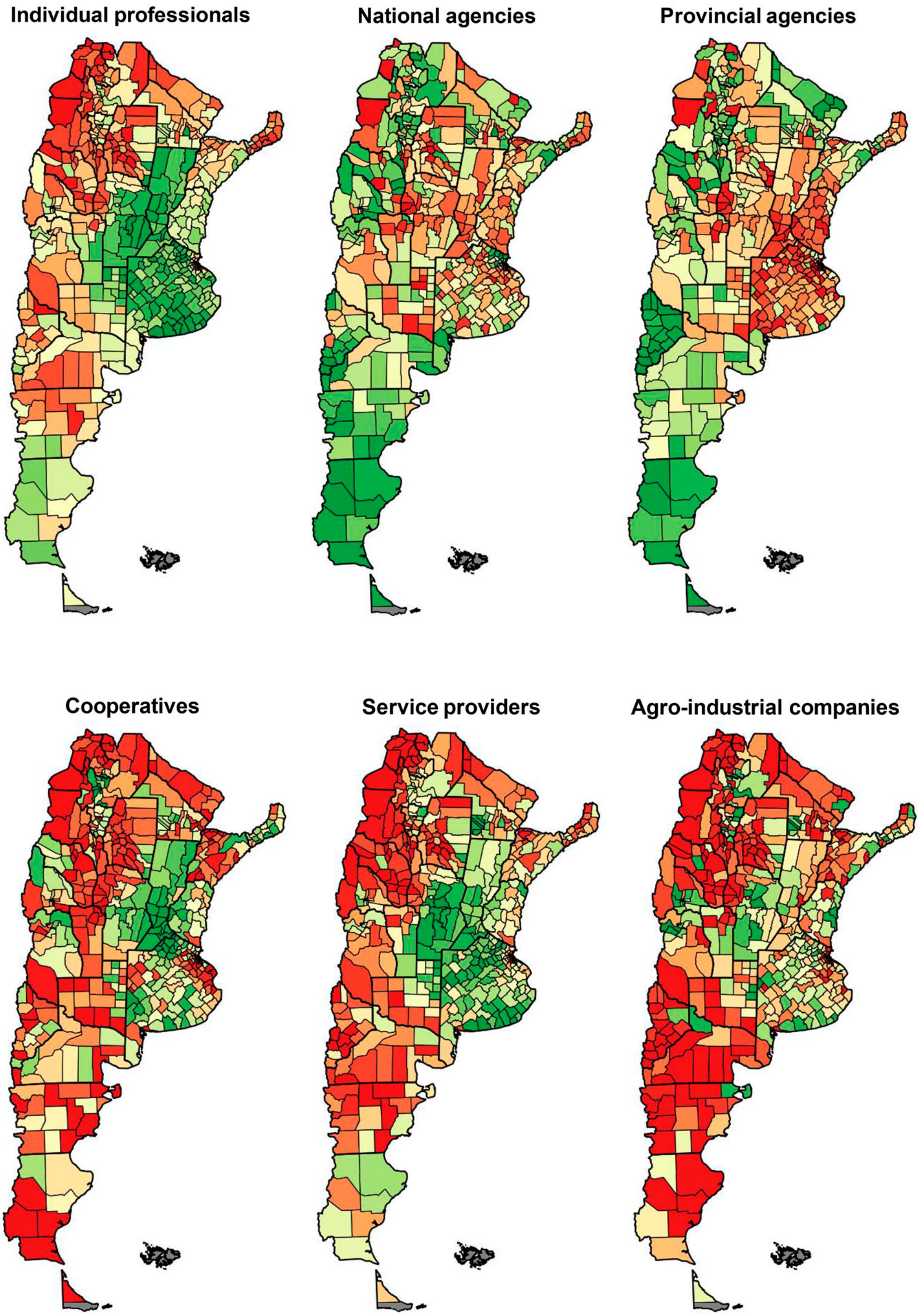

Figure 1. Intensity of technical linkages by type of agent.
Source: Own elaboration based on CNA 2018.

administration of the EAPs, and it is more common to obtain technical assistance *in the market* through individual professionals or service providers. On the other hand, technical linkages with public agencies or associative forms such as cooperatives are much less

Table 2. Correlation matrix.

	indiv	nat_ ag	prov_ ag	coop	serv	agroind	prod_ rec	acco_ rec	banks	compu	intern	assoc_coop	assoc_tecn	integr_ind	nat_ prog	prov_ prog	univer
indiv	1																
nat_ag	0.000	1															
prov_ag	−0.175	0.544	1														
coop	0.356	−0.040	−0.092	1													
serv	0.739	−0.040	−0.165	0.352	1												
agroind	0.367	0.042	−0.049	0.217	0.513	1											
prod_rec	0.693	0.057	−0.099	0.292	0.523	0.295	1										
acco_rec	0.853	−0.076	−0.248	0.381	0.685	0.400	0.825	1									
banks	0.856	−0.068	−0.254	0.408	0.697	0.385	0.806	0.971	1								
compu	0.874	−0.033	−0.227	0.358	0.693	0.388	0.788	0.941	0.953	1							
intern	0.875	−0.040	−0.233	0.365	0.697	0.390	0.783	0.938	0.951	0.997	1						
assoc_coop	0.390	0.005	−0.097	0.888	0.335	0.161	0.278	0.369	0.399	0.366	0.374	1					
assoc_tecn	0.391	0.311	0.144	0.129	0.356	0.150	0.243	0.259	0.280	0.318	0.323	0.192	1				
integr_ind	0.003	0.133	0.062	0.052	−0.004	0.390	0.104	0.118	0.111	0.114	0.107	0.037	−0.069	1			
nat_prog	−0.052	0.497	0.388	−0.088	−0.102	0.038	0.136	0.033	0.042	0.037	0.020	−0.075	0.025	0.246	1		
prov_prog	−0.065	0.256	0.637	−0.092	−0.106	−0.009	−0.003	−0.091	−0.090	−0.093	−0.094	−0.086	0.021	0.043	0.513	1	
univer	0.667	0.051	−0.179	0.097	0.487	0.326	0.581	0.692	0.688	0.745	0.736	0.104	0.268	0.216	0.043	−0.088	1

Source: Own elaboration based on CNA 2018.

frequent. As a counterpoint, there are strong relationships between the linkages with national and provincial agencies and the participation in public programmes, or the association with cooperatives and the reception of their technical assistance.

Instead of analyzing by pairs, the underlying structure of relationships between these multiple variables is better understood through the multivariate analysis in the following subsection. Indeed, the presence of high and significant correlations between these indicators is a precondition for using PCA.

5.2. Multivariate analysis

In addition to the correlations mentioned above, the application of PCA is technically viable since Bartlett's test of sphericity is satisfied, the KMO sampling adequacy measure is greater than 0.50 (in this case, 0.84) and all variables show (Table 3) high communalities (Hair et al. 2010). According to the Kaiser criterion, it is convenient to extract the first five principal components with eigenvalues greater than one. Altogether, these five principal components account for almost 81% of the total variability.

After applying the varimax orthogonal rotation, the analysis of the factor loadings reveals the structure of relationships between the different indicators (Table 3). For example, the first component contains the technical linkages with individual professionals and service providers, along with variables that account for the techno-productive management of the EAPs and the educational level of the producer. Therefore, we call this component *private-to-private professional linkages*. In contrast, component 2 includes the *linkages with public agencies*, both national and provincial, and the participation in public programmes. While the third component reflects the *linkages with cooperatives*, the fourth component shows the contractual integration and *technical linkages with agro-industrial companies*. Finally, the distinctive aspect of component 5 is the *participation in technical associations*, which is also related to the interaction with national agencies –Locher and Guibert (2015) also observe this relationship–.

Table 3. Factor loadings and communalities.

Variable name	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Communality
compu	0.962	−0.040	0.142	0.072	0.065	0.956
intern	0.958	−0.051	0.151	0.067	0.070	0.952
acco_rec	0.953	−0.046	0.168	0.078	−0.008	0.945
banks	0.952	−0.044	0.199	0.065	0.008	0.951
indiv	0.879	−0.067	0.179	−0.016	0.223	0.858
prod_rec	0.847	0.124	0.104	0.023	−0.021	0.744
univer	0.782	−0.042	−0.159	0.205	0.112	0.693
serv	0.686	−0.176	0.210	0.123	0.338	0.675
prov_prog	−0.027	0.818	−0.029	−0.076	−0.084	0.684
nat_prog	0.084	0.800	−0.092	0.184	−0.112	0.703
prov_ag	−0.232	0.777	−0.003	−0.012	0.281	0.736
nat_ag	−0.066	0.621	−0.022	0.153	0.516	0.679
coop	0.231	−0.046	0.938	0.053	0.006	0.938
assoc_coop	0.233	−0.029	0.932	0.008	0.060	0.927
integr_ind	0.053	0.150	0.008	0.871	−0.151	0.807
agroind	0.335	−0.084	0.116	0.717	0.221	0.695
assoc_tecn	0.270	0.065	0.069	−0.080	0.838	0.790

Source: Own elaboration.

Based on the estimation of these five principal components, a cluster analysis is performed using Ward's method. During the agglomeration process, the change in heterogeneity shows a first peak in 8 clusters, then drops, and shows a new break in 6 clusters (Figure 2). The analysis of variance (ANOVA) verifies that these six groups of departments are significantly different from each other (Table 4).

Table 5 shows the mean value of the principal components for each cluster, which allows us to distinguish the characteristics of these different groups of departments. Additionally, the map in Figure 3 illustrates the geographic scope of the different clusters. Cluster 2 shows the highest values for *private-to-private professional linkages* (component 1) and the lowest values for the *linkages with public agencies* (component 2). This cluster comprises several departments in the provinces of Buenos Aires, Córdoba, La Pampa and, to a lesser extent, Corrientes and San Luis. Cluster 1, which covers the provinces of Santa Fe and Entre Ríos, part of Córdoba and Buenos Aires and some departments in the North, stands out for the *linkages with cooperatives* (component 3), along with *private-to-private professional linkages.* In some way, both clusters are the most visible expression of the new techno-productive paradigm that several authors highlight as *the model* of Argentine agriculture. However, far from being geographically spread throughout the country, these clusters are mainly limited to the Pampean region.[5]

On the other hand, clusters 4 and 5 show positive values –above the general mean– in terms of the integration and *technical linkages with agro-industrial companies* (component 4). These values are higher in cluster 5, which covers some departments in the provinces of San Juan, Mendoza, La Rioja, Tucumán, Misiones, Entre Ríos and some specific areas in the Patagonia region. This situation is consistent with the historical trajectory of concentration and integration of food and beverage production in these territories (Bocco et al. 2007; Landriscini et al. 2007; Moscheni Bustos and Carrizo Muñoz 2015; Brignardello 2017). Meanwhile, cluster 4 combines *agro-industrial linkages* with *private-to-private linkages*, as well as the *participation in technical associations*

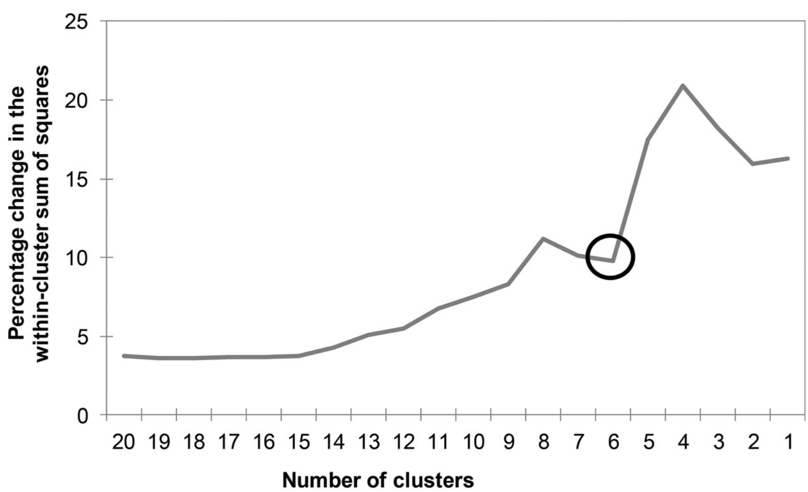

Figure 2. Change in heterogeneity in the agglomeration process.
Source: Own elaboration.

Table 4. Analysis of variance (ANOVA).

	Sum of squares	Degrees of freedom	Mean square	F
Comp. 1	293.003	5	58.601	147,429***
Comp. 2	279.755	5	55.951	131,587***
Comp. 3	258.759	5	51.752	110,316***
Comp. 4	298.693	5	59.739	154,932***
Comp. 5	218.658	5	43.732	79,078***

Source: Own elaboration. Significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

(component 5). This cluster also shows a very diverse regional pattern, with some departments in the central, northern and southern parts of the country.

In contrast to the previous groups, cluster 6 –which includes only 13 departments, mainly in the Patagonia region– shows extreme values of *technical linkages with public agencies* (component 2). These public organizations are also the most relevant source of knowledge in cluster 3. In addition to being the most numerous and geographically widespread, cluster 3 shows the lowest values for *private-to-private professional linkages*. Therefore, this cluster is the opposite of cluster 2 and, to some extent, the most evident exception of a new techno-productive paradigm in Argentine agriculture led by the transfer of knowledge among private agents.

6. Discussion and policy implications

Using under-explored data from the CNA 2018 and multivariate analysis techniques, the article addresses different limitations of the previous empirical literature. On the one hand, even though agricultural production is very important in Argentina, as in other developing countries, the available surveys and statistics on innovation and technological change are generally limited to the industrial sector. For this reason, the measurement and understanding of learning and innovation in the agricultural sector are still incipient. On the other hand, innovation surveys of the industrial sector, as well as part of the literature on the agricultural sector, do not usually consider the geographic dimension. This can lead to simplistic or homogenizing views, such as the idea of a dominant techno-productive paradigm in Argentine agriculture.

More generally, the literature on agricultural systems in developing countries is dominated by case studies and qualitative methodologies (Spielman, Ekboir, and Davis 2009; Minh 2019), while quantitative analyses are often used to compare the national AIS in different countries (Spielman and Kelemework 2009; Wang et al. 2018). None of these approaches can provide a complete and holistic view of the possible diversity of regional

Table 5. Number of departments and mean value of components by cluster (Z scores).

	Comp. 1 Private-to-private professional linkages	Comp. 3 Linkages with coope-ratives	Comp. 4 Linkages with agro-industrial companies	Comp. 2 Linkages with public agencies	Comp. 5 Technical associations	Number of depart-ments
Cluster 2	**1.24**	−0.68	−0.43	**−0.38**	−0.06	87
Cluster 1	**0.57**	**1.62**	−0.25	−0.19	−0.29	78
Cluster 5	−0.22	−0.20	**2.20**	0.03	−0.29	52
Cluster 4	**0.40**	−0.05	**0.33**	0.02	**2.19**	39
Cluster 6	**0.47**	−0.21	−0.32	**4.50**	−1.12	13
Cluster 3	**−0.76**	−0.24	−0.31	**−0.06**	−0.13	215

Source: Own elaboration. Note: components and clusters are reordered to facilitate their description.

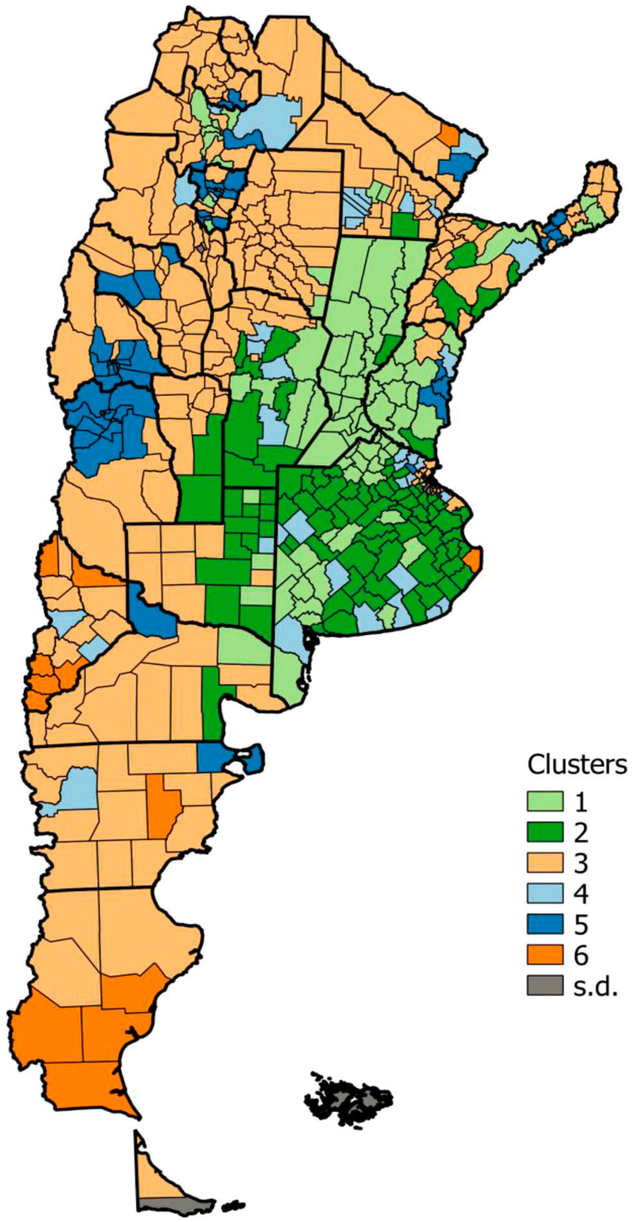

Figure 3. Map of departments, provinces, and clusters.
Source: Own elaboration. Note: Thin lines indicate the departments, while thick lines show the provinces.

contexts within each country, which is especially relevant in developing countries with large territories, such as Argentina.

In this context, the article shows how a set of multivariate analysis techniques can be used to explore regional data from agricultural censuses and help to answer where, how and with whom technical linkages and learning and innovation processes are developed. This exercise is not only relevant in academic or analytical terms but also for decision-making processes and the generation of new or improved policies. Minh (2019, 269) also highlights 'the importance of looking into structural and regional interactions and interconnections when identifying blocking mechanisms in order to design strong mutually reinforcing sets of systemic instruments'.

Based on a regional-structural approach of AIS, the results highlight that technical linkages and interactive learning differ significantly across Argentine regions. In particular, private sources of knowledge tend to maintain an uneven pattern of localization and reproduction in central regions –like Mesquita, Luna, and Souza (2021) show in Brazil–, even though modern agricultural production has advanced towards peripheral areas in recent decades (Bisang et al. 2018; Lódola, Morra, and Picón 2019). In other words, the predominance of *private-to-private professional linkages*, one of the pillars of the new techno-productive paradigm, is limited to the Pampean region –where the cooperative tradition is also relevant–.

In other regions with a long-standing agro-industrial tradition, linkages with individual professionals or service providers coexist with *intra-group technical linkages*. But perhaps the most important result of this article is the broad geographic scope of *technical linkages with public agencies* throughout the country. In short, Argentine agriculture is notoriously complex and heterogeneous.

Some authors (e.g. Anlló, Bisang, and Campi 2013; Trigo and Elverdin 2020) argue that the privatization of knowledge and technologies is increasing in the agricultural sector. However, it seems that in many areas –not only in the less profitable ones for the market– the role of the public sector in research and knowledge transfer is still very relevant. The evidence from Argentina shows that in the departments where the percentage of EAPs interacting with private professionals is lower, the relative importance of public agencies is usually higher. This is in line with and re-emphasizes the empirical findings highlighted by Hall (2007):

> Lack of interaction weakens innovation capacity and is a reflection of deep-rooted habits and practices in both public and private sector organisations.
>
> The market is not sufficient to promote interaction; the public sector has a central role to play (Hall 2007, 18–19).

According to Andersen, Marin, and Simensen (2018), one of the challenges for natural resource-based development is building and sustaining a natural resource innovation system. In other words, 'creating and supporting the institutions and organizations that generate, diffuse and use new knowledge and capabilities in the production and use of natural resources' (Andersen, Marin, and Simensen 2018, 10). The other challenge is that this innovation system 'must be locally anchored to address local specificity of knowledge needed to succeed' (Andersen, Marin, and Simensen 2018, 10) or, in terms of Toillier et al. (2018, 24), 'innovation policies must be adapted to each national and possibly sub-national context'.

This represents a significant challenge for public policy, bearing in mind that the Argentine science and technology system is highly concentrated territorially, not surprisingly in the metropolitan and the central-Pampean region (Niembro and Starobinsky 2021; Abeles, Villafañe, and 2022). The case of Brazil can also be illustrative and shows that this situation transcends many developing and Latin American countries. As Mesquita (2022) notes:

> Differences in the production capacity of science and technology have constituted vectors of regional inequalities within the context of globalization. It is true that agriculture has had a

> historic role as a force for productive deconcentration in Brazil. However, the core STIA [territorial system of agricultural innovation] segments are still concentrated in certain points close to the traditional production zones (Mesquita 2022, 20).

As mentioned above, some public agencies and organizations, such as INTA or public universities, have a wide presence throughout the country. Beyond possible initiatives to promote the generation and diffusion of agricultural knowledge from *new* actors and private sources –e.g. Lachman and López (2022) note that linkages with the local ecosystem allowed the development of AgTech companies–, the evidence seems to indicate the relevance of reinforcing the role of public agencies, especially outside the Pampean region. This supports the idea of sustaining and deepening the policy of federalization –or territorial deconcentration– of science and technology in Argentina (Niembro 2020).

7. Concluding remarks

This article aims to provide a quantitative analysis of the geography of learning and innovation in natural resource-based activities in developing countries, focusing on technical linkages in Argentine agriculture. Like Minh (2019), we highlight the importance of including the regional dimension in AIS studies and suggest that using a regional-structural approach 'allows the design of integrated coherent sets of systemic instruments for a regional AIS' (Minh 2019, 268).

Therefore, when designing technological and innovation policies for natural resource-based activities, it is necessary to identify the strategies, objectives, forms of organization and degree of consolidation of the different production chains in each region. Given the heterogeneity of Argentine agriculture, the production and learning processes respond to specific practices and realities of each region, which leads to different techno-productive profiles. From this perspective, the construction of public policies, understood as social processes, must consider the regional characteristics in which the different production and innovation networks are rooted. In terms of Schmidt, Díaz-Puente, and Bettoni (2022, 2597), 'more attention needs to be paid to this local context when aiming to enable interactive innovation'.

Beyond the quantitative evidence provided in this article, the last comments highlight the possibility –and perhaps the need in the future– to complement the analysis with qualitative case studies. Another pending task is to study more explicitly the innovation results in the Argentine agricultural sector and not only the factors or inputs that contribute to learning and innovation. Finally, it would be valuable to move from static analyses to dynamic studies showing the evolution of these phenomena over time. Unfortunately, the application –and publication– of different categories of analysis in the CNA 2018 concerning previous censuses did not allow us to perform comparative exercises between these surveys. In the future, it would be desirable to maintain similar census methodologies to study the temporal and regional dynamics of knowledge transfer and technological change in Argentine agriculture.

Notes

1. The geographic unit of analysis will be the departments. At the subnational level in Argentina, there are two political-administrative figures, the provinces and, on a much smaller

scale, the municipalities or local governments. Likewise, the provincial territory is divided into departments –called *partidos* in the case of the province of Buenos Aires–, which generally include different localities and also rural areas. Only in 4 of the 24 provinces, departments coincide with local governments. On the other hand, and mainly for analytical purposes, the provinces are usually grouped into macro-regions (Pampean, Northeast, Northwest, Cuyo and Patagonia).

2. Local economic areas include a city or central node and a group of other localities linked by workers' commuting between their workplace and their home.
3. *Explotación agro-pecuaria* or EAP in Spanish is the production unit surveyed by the CNA. It should be noted that the term *agro-pecuario* in Spanish or agro-livestock covers both agricultural and livestock activities. For the sake of simplicity, we use only the term agriculture in the article.
4. Some of these dimensions have been analyzed descriptively in a recent study from Brazil (Mesquita 2021).
5. When comparing the results with the K-Means method, 80% of the departments are classified in the same clusters. More importantly, if clusters 1 and 2 are taken together, 94% of the departments still belong to these groups. In the case of cluster 3, the most numerous (Table 5), the coincidence is 90%.

Acknowledgments

We appreciate the valuable comments and suggestions of two anonymous reviewers. The usual disclaimers apply.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Agencia Nacional de Promoción de la Investigación, el Desarrollo Tecnológico y la Innovación: grant no PICT 2019-1162; Universidad Nacional de Río Negro: grant no PI 40-B-888.

ORCID

Andrés Niembro http://orcid.org/0000-0003-1449-6361
Jesica Sarmiento http://orcid.org/0000-0002-5459-1702
Gastón Blasquiz Landa http://orcid.org/0000-0001-8504-5336
Agustín Rivas Bergant http://orcid.org/0000-0002-5630-6098

References

Abeles, M., and S. Villafañe, eds. 2022. *El sistema de ciencia, tecnología e innovación argentino en clave federal*. Santiago, Chile: ECLAC, United Nations.

Aerni, P., K. Nichterlein, S. Rudgard, and A. Sonnino. 2015. "Making Agricultural Innovation Systems (AIS) Work for Development in Tropical Countries." *Sustainability* 7 (1): 831–850. doi:10.3390/su7010831

Alberdi, X., J. J. Gibaja, M. Parrilli, et al. 2016. "Innovation Gaps: A Typology for Spain." In *Innovation Drivers and Regional Innovation Strategies*, edited by M. Parrilli. New York: Routledge.

Albornoz, M. 2015. “Cambio tecnológico y cultura institucional: el caso del INTA.” *CTS - Revista Iberoamericana de Ciencia, Tecnología y Sociedad* 10 (29): 41–64.

Andersen, A. D., A. Marin, and E. Simensen. 2018. “Innovation in Natural Resource-Based Industries: A Pathway to Development? Introduction to Special Issue.” *Innovation and Development* 8 (1): 1–27. doi:10.1080/2157930X.2018.1439293

Anlló, G., R. Bisang, and M. Campi. eds. 2013. *Claves para repensar el agro argentino*. Buenos Aires: Eudeba.

Anlló, G., R. Bisang, and J. Katz. 2015. “Aprendiendo con el agro argentino: De la ventaja comparativa a la ventaja competitiva. El rol de las KIBs.” Documento para Discusión No. IDB-DP-379. Washington DC: Inter-American Development Bank.

Anlló, G., G. Lugones, and F. Peirano. 2007. “La innovación en la Argentina postdevaluación. Antecedentes previos y tendencias a futuro.” In *Crisis, recuperación y nuevos dilemas. La economía argentina 2002-2007*, edited by B. Kosacoff. Santiago, Chile: ECLAC, United Nations.

Argüelles, M., C. Benavides, and I. Fernández. 2014. “A new Approach to the Identification of Regional Clusters: Hierarchical Clustering on Principal Components.” *Applied Economics* 46 (21): 2511–2519. doi:10.1080/00036846.2014.904491

Arza, V., A. Marin, E. López, and L. Stubrin. 2018. “Knowledge Networks Associated with the Production of Natural Resources in Latin America: A Comparative Analysis.” *CEPAL Review* 125: 93–118.

Asheim, B., and A. Isaksen. 1997. “Location, Agglomeration and Innovation: Towards Regional Innovation Systems in Norway?” *European Planning Studies* 5 (3): 299–330. doi:10.1080/09654319708720402

Autio, E. 1998. “Evaluation of RTD in Regional Systems of Innovation.” *European Planning Studies* 6 (2): 131–140. doi:10.1080/09654319808720451

Azcuy Ameghino, E., and D. Fernández. 2019. “El Censo Nacional Agropecuario 2018: visión general y aproximación a la región pampeana.” *Revista Interdisciplinaria de Estudios Agrarios* 51: 5–36.

Basualdo, E. 2010. “Los propietarios de la tierra y las economías de escala, sustentos del paradigma sojero en la Argentina.” *Desarrollo Económico* 50 (197): 3–31.

Basualdo, F., M. Barrera, and E. Basualdo. 2013. *Las producciones primarias en la Argentina reciente: Minería, petróleo y agro pampeano*. Buenos Aires: Cara o Ceca.

Bisang, R., G. Anlló, M. Campi, 2010. “La organización del agro en la Argentina. La transición de un modelo de integración vertical a las redes de producción agrícolas.” In *El crecimiento de la agricultura argentina. Medio siglo de logros y desafíos*, edited by L. Reca. et al. Buenos Aires: EFA-UBA.

Bisang, R., R. Brigo, A. Lódola, and F. Morra. 2018. *Cadenas de valor agroalimentarias: Evolución y cambios estructurales en el Siglo XXI*. Buenos Aires: Secretaría de Gobierno de Agroindustria, Dirección General de Programas y Proyectos Sectoriales y Especiales (DIPROSE).

Bisang, R., S. Sztulwark, 2010. “Rentas económicas e inserción en cadenas globales de valor. El caso de la agroindustria argentina.” In *Redes globales de producción, rentas económicas y estrategias de desarrollo. El papel de América Latina*, edited by A. Dabat. et al. Mexico, DF: UNAM.

Bocco, A., L. Alturria, J. Gudiño, J. Oliva, A. M. Ruiz, G. Salvarredi, H. Vila, et al. 2007. “La trama vitivinícola en la provincia de Mendoza.” In *Innovación y empleo en tramas productivas de Argentina*, edited by M. Delfini. Buenos Aires: Prometeo.

Borello, J., 2019. “El desarrollo reciente de una geografía económica evolucionista: Características de su emergencia y breve aplicación al análisis de la geografía económica de América Latina.” In *Tópicos de la teoría evolucionista neoschumpeteriana de la innovación y el cambio tecnológico, Volumen 2*, edited by F. Barletta. et al. Los Polvorines: Universidad Nacional de General Sarmiento.

Borello, J., L. González, M. Pereira, and V. Robert. 2016. “Evolución de la actividad económica argentina desde una perspectiva territorial, 2004-2012.” Serie Estudios y Perspectivas No. 50. Santiago, Chile: ECLAC, United Nations.

Boschma, R. 2005. “Proximity and Innovation: A Critical Assessment.” *Regional Studies* 39 (1): 61–74. doi:10.1080/0034340052000320887

Braczyk, H. J., P. Cooke, and M. Heidenreich, eds. 1998. *Regional Innovation Systems: The Role of Governance in a Globalized World*. London: UCL Press.

Brida, J. G., N. Garrido, and S. London. 2013. "Estudio del desempeño económico regional: el caso argentino." *Cuadernos de Economía* 32 (60): 437–466.

Brignardello, M. 2017. "¿Cómo entender la organización de la producción en el agro actual? Vinculación agroindustrial y producción de calidad en la vitivinicultura mendocina en las primeras décadas del siglo XXI." *Mundo Agrario* 18 (37): e042. doi:10.24215/15155994e042

Carballo, C. 2002. *Extensión y transferencia de tecnología en el sector agrario argentino*. Buenos Aires: Facultad de Agronomía, Universidad de Buenos Aires.

Cicowiez, M. 2003. "Caracterización económico-social de las provincias argentinas." Documento de Federalismo Fiscal No. 5. Universidad Nacional de La Plata, Facultad de Ciencias Económicas, Departamento de Economía.

Cohen, W., and D. Levinthal. 1990. "Absorptive Capacity: A new Perspective on Learning and Innovation." *Administrative Science Quarterly* 35 (1): 128–152. doi:10.2307/2393553

Cooke, P. 1992. "Regional Innovation Systems: Competitive Regulation in the new Europe." *Geoforum; Journal of Physical, Human, and Regional Geosciences* 23 (3): 365–382. doi:10.1016/0016-7185(92)90048-9.

Crespi, G., J. Katz, and J. Olivari. 2017. "Innovation, Natural Resource-Based Activities and Growth in Emerging Economies: The Formation and Role of Knowledge-Intensive Service Firms." *Innovation and Development* 8 (1): 79–101. doi:10.1080/2157930X.2017.1377387

Del Campo, C., C.Mand Monteiro, and J. O. Soares. 2008. "The European Regional Policy and the Socio-Economic Diversity of European Regions: A Multivariate Analysis." *European Journal of Operational Research* 187 (2): 600–612. doi:10.1016/j.ejor.2007.03.024

DNIC. 2019. *Medición de la Innovación en el sector agropecuario: Experiencia Argentina*. Buenos Aires: Dirección Nacional de Investigación Científica (DNIC), Secretaría de Gobierno de Ciencia, Tecnología e Innovación Productiva.

Doloreux, D., and S. Parto. 2005. "Regional Innovation Systems: Current Discourse and Unresolved Issues." *Technology in Society* 27 (2): 133–153. doi:10.1016/j.techsoc.2005.01.002

Dosi, G., 1988. "The Nature of the Innovative Process." In *Technical Change and Economic Theory*, edited by G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete, 221–238. London: Pinter.

dos Santos, U. P., and P. S. Mendes. 2021. "Regional Spillovers of Knowledge in Brazil: Evidence from Science and Technology Municipal Indicators." *Innovation and Development* in press. doi:10.1080/2157930X.2021.1978723.

ECLAC. 2015. *Complejos productivos y territorio en la Argentina: Aportes para el estudio de la geografía económica del país*. Santiago, Chile: ECLAC, United Nations.

ECLAC. 2017. *La Encuesta Nacional de Dinámica de Empleo e Innovación (ENDEI) como herramienta de análisis. La innovación y el empleo en la industria manufacturera argentina*. Santiago, Chile: ECLAC, United Nations.

Fagerberg, J., D. Mowery, and R. Nelson, eds. 2005. *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Figueras, A. J., M. Capello, and J. L. Arrufat. 2007. "Regionalización: Una posibilidad de territorialización por proximidad." *Actualidad Económica* 17 (61): 21–32.

Figueras, A. J., M. Capello, and P. Moncarz. 2009. "Un ejercicio de agrupación territorial: Ensayo académico con vistas a salvar problemas." *Ensayos de Política Económica* 3: 65–84.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

Freeman, C. 1995. "The National System of Innovation in Historical Perspective." *Cambridge Journal of Economics* 19 (1): 5–24. doi:10.1093/oxfordjournals.cje.a035309.

Garay, A., J. Krapovickas, and C. Mikkelsen. 2017. "Transformaciones territoriales en ámbitos rurales del Noroeste Argentino y la Región Pampeana hacia finales del siglo XX e inicios del XXI." *Mundo Agrario* 18 (38): e054. doi:10.24215/15155994e054

García, I. L., A. García, E. Rodríguez, and A. Rofman. 2008. "Los dos "campos" en el territorio argentino. Análisis crítico y estrategias de desarrollo rural." *Revista de Estudios Regionales* 4: 167–200.

García, M., and P. Lombardo. 2016. "Contratistas rurales y cambios en la estructura agraria pampeana." *Revista Interdisciplinaria de Estudios Agrarios* 44: 101–127.

Gárgano, C. 2018. “Ciencia, tecnología y mercado: investigaciones en arroz en el INTA argentino.” *Journal of Technology Management & Innovation* 13 (1): 75–83. doi:10.4067/S0718-27242018000100075

Gárgano, C., and P. Souza. 2013. “Investigación pública orientada al agro en Argentina: apropiación, trayectorias y disputas.” *Voces en el Fénix* 24: 126–133.

Gertler, M. 2003. “Tacit Knowledge and the Economic Geography of Context, or the Undefinable Tacitness of Being (There).” *Journal of Economic Geography* 3 (1): 75–99. doi:10.1093/jeg/3.1.75

Gisclard, M., G. Allaire, and R. Cittadini. 2015. “Proceso de institucionalización de la agricultura familiar y nuevo referencial para el desarrollo rural en Argentina.” *Mundo Agrario* 16 (31).

Gómez, M., and L. Pereyra. 2019. “Los territorios de la exclusión social en Argentina. Evidencia empírica sobre las décadas 1990-2010.” *Investigaciones Regionales - Journal of Regional Research* 43: 103–127.

Gutman, G., P. Lavarello, and P. Ríos. 2010. “Oportunidades biotecnológicas y estrategias innovativas en las industrias lácteas en Argentina.” *Revista Interdisciplinaria de Estudios Agrarios* 33: 5–45.

Hair, J., W. Black, B. Babin, and R. Anderson. 2010. *Multivariate Data Analysis*. 7th Edition. London: Pearson.

Hall, A. 2007. “Challenges to Strengthening Agricultural Innovation Systems: Where do we go from Here?.” Working Paper No. 2007-038. Maastricht: UNU-MERIT.

Hall, A., L. Mytelka, and B. Oyeyinka. 2006. “Concepts and Guidelines for Diagnostic Assessments of Agricultural Innovation Capacity.” Working Paper No. 2006-017. Maastricht: UNU-MERIT.

Härdle, W., and L. Simar. 2015. *Applied Multivariate Statistical Analysis*. New York: Springer.

Hernández, V., and J. Muzlera. 2016. “El contratismo y su integración al modelo de agronegocios: producción y servicios en la región pampeana.” *Mundo Agrario* 17 (34): e005.

Hollanders, H., J. Derbyshire, R. Lewney, R. Tijssen, S. Tarantola, and L. Rivera. 2012. *Regional Innovation Scoreboard 2012-Methodology Report*. Brussels: European Commission.

Howells, J. 2002. “Tacit Knowledge, Innovation and Economic Geography.” *Urban Studies* 39 (5-6): 871–884. doi:10.1080/00420980220128354

Iparraguirre, G. 2017. *Imaginarios del desarrollo: Gestión política y científica de la cultura*. Buenos Aires: Biblos.

Jindrová, A. 2015. “Application of Multivariate Statistical Methods in the Analysis of Czech Population Life Quality with Attention to Regional Differentiation.” *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 63 (5): 1671–1678. doi:10.11118/actaun201563051671

Johnson, R., and D. Wichern. 2008. *Applied Multivariate Statistical Analysis*. 6th Edition. London: Pearson.

Klerkx, L., B. van Mierlo, and C. Leeuwis. 2012. “Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions.” In *Farming Systems Research Into Twenty-first Century: The new Dynamic*, edited by I. Darnhofer, D. Gibbon, and B. Dedieu. Dordrecht: Springer Science, Business Media.

Knickel, K., G. Brunori, S. Rand, and J. Proost. 2009. “Towards a Better Conceptual Framework for Innovation Processes in Agriculture and Rural Development: From Linear Models to Systemic Approaches.” *The Journal of Agricultural Education and Extension* 15 (2): 131–146. doi:10.1080/13892240902909064

Kronthaler, F. 2005. “Economic Capability of East German Regions: Results of a Cluster Analysis.” *Regional Studies* 39 (6): 739–750. doi:10.1080/00343400500213630

Lachman, J., and A. López. 2019. “Las empresas de servicios basados en conocimiento para producciones de base biológica: el caso de la agricultura y ganadería de precisión.” *Revista de Economía Política de Buenos Aires* 19: 67–100.

Lachman, J., and A. López. 2022. “The Nurturing Role of the Local Support Ecosystem in the Development of the Agtech Sector in Argentina.” *Journal of Agribusiness in Developing and Emerging Economies* 12 (4): 714–729. doi:10.1108/JADEE-10-2021-0264

Lachman, J., A. López, G. Tinghitella, and S. Gómez-Roca. 2021. “Las Agtech en Argentina: desarrollo reciente, situación actual y perspectivas.” Documento de Trabajo No. 57. Buenos Aires: Instituto Interdisciplinario de Economía Política (IIEP-BAIRES).

Landini, F. 2013. “Perfil de los extensionistas rurales argentinos del sistema público.” *Mundo Agrario* 14 (27).

Landriscini, G., O. Preiss, F. López Raggi, V. Rama, I. Rivero, 2007. “La trama frutícola en el Alto Valle de Río Negro y Neuquén. Evolución histórica y situación actual.” In *Innovación y empleo en tramas productivas de la Argentina*, edited by M. Delfini. et al. Buenos Aires: Prometeo.

Läpple, D., A. Renwick, and F. Thorne. 2015. “Measuring and Understanding the Drivers of Agricultural Innovation: Evidence from Ireland.” *Food Policy* 51: 1–8. doi:10.1016/j.foodpol.2014.11.003

Lattuada, M., M. E. Nogueira, J. M. Renold, and M. Urcola. 2011. “El cooperativismo agropecuario argentino en la actualidad: Presentación y análisis de tres casos desde la perspectiva del capital social.” *Mundo Agrario* 12 (23).

Lavarello, P., D. Bil, R. Vidosa, and F. Langard. 2019. “Reconfiguración del oligopolio mundial y cambio tecnológico frente a la agricultura 4.0: implicancias para la trayectoria de la maquinaria agrícola en Argentina.” *Ciclos en la Historia, la Economía y la Sociedad* 53: 163–193.

Lema, R., E. Kraemer-Mbula, and M. Rakas. 2021. “Innovation in Developing Countries: Examining two Decades of Research.” *Innovation and Development* 11 (2–3): 189–210. doi:10.1080/2157930X.2021.1989647.

Linzer, G. 2008. “Devenir de la generación y transferencia de conocimientos en el Instituto Nacional de Tecnología Agropecuaria de la Argentina.” *ARBOR Ciencia, Pensamiento y Cultura* 184 (732): 701–717. doi:10.3989/arbor.2008.i732.216.

Locher, M. V., and M. Guibert. 2015. “Organizaciones interprofesionales e innovación agrícola: entre lógicas globales y territoriales. El rol de ACSOJA, ASAGIR y PROARROZ en Argentina.” *GEOgraphia* 17 (35): 172–196. doi:10.22409/GEOgraphia2015.v17i35.a13733

Lódola, A., F. Morra, and N. Picón. 2019. *Cadenas de valor agroalimentarias. Evolución en el nuevo contexto macroeconómico 2016/2019*. Buenos Aires: Ministerio de Agricultura, Ganadería y Pesca de la Nación.

Lombardo, P., and M. I. Tort. Eds. 2018. *Contratismo de servicios de maquinaria en el agro pampeano. Heterogeneidad de actores y vínculos*. Buenos Aires: Orientación Gráfica Editora.

Lundvall, B-Å, 1988. “Innovation as an Interactive Process: From User-Producer Interaction to the National Systems of Innovation.” In *Technical Change and Economic Theory*, edited by G. Dosi. et al. London: Pinter.

Lundvall, B-Å, ed. 1992a. *National systems of innovation. Towards a theory of innovation and interactive learning*. London: Pinter.

Lundvall, B-Å. 1992b. “User-producer Relationships, National Systems of Innovation and Internationalisation.” In *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning*, edited by B-Å Lundvall. London: Pinter.

Lundvall, B-Å, K. J. Joseph, C. Chaminade, and J. Vang, eds. 2009. *Handbook of Innovation Systems and Developing Countries*. Cheltenham: Edward Elgar.

Malerba, F. 2002. “Sectoral Systems of Innovation and Production.” *Research Policy* 31: 247–264. doi:10.1016/S0048-7333(01)00139-1

Marin, A., and S. Petralia. 2018. “Sources and Contexts of Inter-Industry Differences in Technological Opportunities: The Cases of Argentina and Brazil.” *Innovation and Development* 8 (1): 29–57. doi:10.1080/2157930X.2018.1429191

Marin, A., and L. Stubrin. 2017. “Oportunidades y desafíos para convertirse en un innovador mundial en recursos naturales. El caso de las empresas de semillas en Argentina.” *Desarrollo Económico* 56 (220): 471–497.

Marin, A., L. Stubrin, and J. J. da Silva. 2015. “KIBS Associated to Natural Based Industries: Seeds Innovation and Regional Providers of the Technology Services Embodied in Seeds in Argentina and Brazil, 2000-2014.” Discussion Paper No. IDB-DP-375. Washington DC: Inter-American Development Bank.

Marin, A., L. Stubrin, and Y. Kababe. 2014. “La industria de biodiesel en Argentina: capacidades de innovación y sostenibilidad futura.” *Desarrollo Económico* 54 (212): 131–160.

Marin, A., L. Stubrin, and R. Palacín Roitbarg. 2022. “Growing from the South in the Seed Market: Grupo Don Mario.” *Journal of Agribusiness in Developing and Emerging Economies* 12 (4): 656–672. doi:10.1108/JADEE-11-2021-0307

Martin, B. 2016. "Twenty Challenges for Innovation Studies." *Science and Public Policy* 43 (3): 432–450. doi:10.1093/scipol/scv077

Maskell, P., H. Eskelinen, I. Hannibalsson, A. Malmberg, and E. Varne. 1998. *Competitiveness, Localised Learning and Regional Development: Specialisation and Prosperity in Small Open Economies*. London: Routledge.

Maskell, P., and A. Malmberg. 1999. "Localised Learning and Industrial Competitiveness." *Cambridge Journal of Economics* 23 (2): 167–185. doi:10.1093/cje/23.2.167

Mateo, G. 2011. "La Cooperativa Arroceros Villa Elisa, un buen ejemplo de la tradición cooperativista de Entre Ríos (Argentina)." *Mundo Agrario* 11 (22).

Mesquita, F. 2021. "Divisão regional do conhecimento na produção agropecuária brasileira." Presented at 59 Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural, Brasilia, August 2-6.

Mesquita, F. 2022. "Urban Centrality in a Territorial System of Agricultural Innovation." *Revista Brasileira de Estudos Urbanos e Regionais* 24 (e202202en): 1–26. doi:10.22296/2317-1529.rbeur.202202en

Mesquita, F., I. Luna, and R. F. Souza. 2021. "The Uneven Geography of Knowledge in Agriculture: Regional Inequalities in Brazilian Sugarcane Production." *Revista Brasileira de Inovação* 20 (e021009): 1–30. doi:10.20396/rbi.v20i00.8663825.

Minh, T. T. 2019. "Unpacking the Systemic Problems and Blocking Mechanisms of a Regional Agricultural Innovation System: An Integrated Regional-Functional-Structural Analysis." *Agricultural Systems* 173: 268–280. doi:10.1016/j.agsy.2019.03.009

Morgan, K. 2004. "The Exaggerated Death of Geography: Learning, Proximity and Territorial Innovation Systems." *Journal of Economic Geography* 4 (1): 3–21. doi:10.1093/jeg/4.1.3

Moscheni Bustos, M., and C. Carrizo Muñoz. 2015. "Vitivinicultura sanjuanina: El caso de los pequeños productores, la subsunción y la reproducción del capital." *Mundo Agrario* 16 (31).

Moschitz, H., D. Roep, G. Brunori, and T. Tisenkopfs. 2015. "Learning and Innovation Networks for Sustainable Agriculture: Processes of co-Evolution, Joint Reflection and Facilitation." *The Journal of Agricultural Education and Extension* 21 (1): 1–11. doi:10.1080/1389224X.2014.991111

Nelson, R. ed. 1993. *National Innovation Systems. A Comparative Analysis*. New York: Oxford University Press.

Niembro, A. 2017. "Hacia una primera tipología de los sistemas regionales de innovación en Argentina." *Investigaciones Regionales - Journal of Regional Research* 38: 117–149.

Niembro, A. 2020. "¿Qué significa la federalización de la ciencia y tecnología en Argentina?." *Ciencia, Tecnología y Política* 3 (4): 1–11. doi:10.24215/26183188e036.

Niembro, A., D. Calá, and A. Belmartino. 2011. "Una tipología de las áreas económicas locales de Argentina en base a perfiles sectoriales de coaglomeración territorial (2011–2018)." *Investigaciones Regionales - Journal of Regional Research* 50: 169–203.

Niembro, A., and J. Sarmiento. 2021. "Regional Development Gaps in Argentina: A Multidimensional Approach to Identify the Location of Policy Priorities." *Regional Science Policy and Practice* 13 (4): 1297–1327. doi:10.1111/rsp3.12322.

Niembro, A., and G. Starobinsky. 2021. "Sistemas regionales de ciencia, tecnología e innovación en la periferia de la periferia: Un análisis de las provincias argentinas (2010–2017)." *Estudios Socioterritoriales – Revista de Geografía* 30: 1–22. doi:10.37838/unicen/est.30-311.

Nieuwenhuis, L. F. 2002. "Innovation and Learning in Agriculture." *Journal of European Industrial Training* 26 (6): 283–291. doi:10.1108/03090590210431256

Nuñez Miñana, H. 1972. "Indicadores de desarrollo regional en la República Argentina: Resultados preliminares." Documento Interno No. 10. Universidad Nacional de La Plata, Facultad de Ciencias Económicas.

Obschatko, E., P. Foti, and M. Román. 2007. *Los pequeños productores en Argentina. Importancia en la producción agropecuaria y en el empleo en base al Censo Nacional Agropecuario* 2002. 2a. Edición. Buenos Aires: Secretaría de Agricultura, Ganadería y Pesca.

Onumah, J. A., F. A. Asante, and R. D. Osei. 2021. "Actor roles and linkages in the agricultural innovation system: options for establishing a cocoa innovation platform in Ghana." *Innovation and Development* in Press. doi:10.1080/2157930X.2021.1965752.

Pérez, C., A. Marin, and L. Navas-Alemán. 2014. "The Possible Dynamic Role of Natural Resource-Based Networks in Latin American Development Strategies." In *National Innovation Systems, Social Inclusion and Development: The Latin American Experience*, edited by G. Dutrénit, and J. Sutz. Cheltenham: Edward Elgar.

Pigford, A.-A., G. Hickey, and L. Klerkx. 2018. "Beyond Agricultural Innovation Systems? Exploring an Agricultural Innovation Ecosystems Approach for Niche Design and Development in Sustainability Transitions." *Agricultural Systems* 164: 116–121. doi:10.1016/j.agsy.2018.04.007

Polanyi, M. 1966. *The Tacit Dimension*. London: Routledge.

Porto, G. 1995. "Convergencia entre regiones. Algunos resultados empíricos para la Argentina, 1953-1980." In *Finanzas públicas y economía espacial*, edited by A. Porto. La Plata: Universidad Nacional de La Plata.

Pradhan, J. P. 2011. "Regional Heterogeneity and Firms' R&D in India." *Innovation and Development* 1 (2): 259–282. doi:10.1080/2157930X.2011.614797

Quadrado, L., S. Loman, and H. Folmer. 2001. "Multi-dimensional Analysis of Regional Inequality: The Case of Higher Educational Facilities in Spain." *Papers in Regional Science* 80 (2): 189–209. doi:10.1007/PL00013621

Rasic, I. 2005. "Uncovering Regional Disparities – the use of Factor and Cluster Analysis." *Economic Trends and Economic Policy* 15 (105): 52–77.

Rodríguez-Miranda, A., S. Boza, and A. Núñez. 2021. "La contribución del cooperativismo agrario al desarrollo territorial: hallazgos a partir de casos en Chile y Uruguay." *Iberoamerican Journal of Development Studies* 10 (2): 34–60. doi:10.26754/ojs_ried/ijds.554.

Schiaffino, G. N. 2020. "Fenómeno técnico y modernización del campo en el área concentrada de Argentina: las empresas de agricultura de precisión." *Estudios Socioterritoriales* 28: 058. doi:10.37838//unicen/est.28-058

Schmidt, P. G., J. M. Díaz-Puente, and M. Bettoni. 2022. "How Rurality Influences Interactive Innovation Processes: Lessons Learnt from 15 Case Studies in 12 Countries." *European Planning Studies* 30 (12): 2595–2617. doi:10.1080/09654313.2022.2043832

Scott, A., and M. Storper. 2003. "Regions, Globalization, Development." *Regional Studies* 37 (6-7): 549–578. doi:10.1080/0034340032000108697a

Selis, D. 2012. "Análisis de la institucionalidad asociada a los procesos de innovación tecnológica en el sector hortícola del Gran La Plata." *Mundo Agrario* 12 (24).

Shearmur, R., C. Carrincazeaux, and D. Doloreux, eds. 2016. *Handbook on the Geographies of Innovation*. Cheltenham: Edward Elgar.

Sigal, F., J. E. Camusso, and A. I. Navarro. 2020. "Beyond the Political or Administrative Definition of the Argentinean Economic Regions, do Their Provinces Have a Common Economic Cycle?" *Anales de la LV Reunión Anual de la AAEP*.

Sili, M. E., J. Sanguinetti, and A. Meiller. 2014. "El cooperativismo agrario y su contribución al desarrollo rural. La experiencia de la Unión Agrícola de Avellaneda, Argentina." *CIRIEC-España, Revista de Economía Pública, Social y Cooperativa* 82: 155–177.

Spielman, D., and R. Birner. 2008. "How Innovative is Your Agriculture? Using Innovation Indicators and Benchmarks to Strengthen National Agricultural Innovation Systems." Agriculture and Rural Development Discussion Paper No. 41. Washington DC: The World Bank.

Spielman, D., J. Ekboir, and K. Davis. 2009. "The art and Science of Innovation Systems Inquiry: Applications to Sub-Saharan African Agriculture." *Technology in Society* 31 (4): 399–405. doi:10.1016/j.techsoc.2009.10.004

Spielman, D., and D. Kelemework. 2009. "Measuring Agricultural Innovation System Properties and Performance: Illustrations from Ethiopia and Vietnam." IFPRI Discussion Paper No. 00851. Washington DC: IFPRI.

Storper, M., and A. Venables. 2004. "Buzz: Face-to-Face Contact and the Urban Economy." *Journal of Economic Geography* 4 (4): 351–370. doi:10.1093/jnlecg/lbh027

Suárez, D., A. Erbes, and F. Barletta, eds. 2020. *Teoría de la innovación: evolución, tendencias y desafíos. Herramientas conceptuales para la enseñanza y el aprendizaje*. Madrid: Ediciones Complutense.

Sztulwark, S., and M. Girard. 2017. “El desarrollo de la agro-biotecnología en Argentina desde una perspectiva de cambio estructural.” *Revista Yura: Relaciones Internacionales* 9: 132–150.
Toillier, A., G. Faure, S. Audouin, S. Mathé, B. Triomphe, and L. Temple. 2018. “Literature Review of Methodologies for the Diagnosis of Agricultural Innovation Systems (AIS).” Working Paper No. 4. Montpellier: CIRAD.
Trigo, E., and P. Elverdin. 2020. “Los sistemas de investigación y transferencia de tecnología agropecuaria de América Latina y el Caribe en el marco de los nuevos escenarios de ciencia y tecnología.” *Revista Compromiso Social* 3: 116–127. doi:10.5377/recoso.v2i3.13437
Trigo, E., N. Mateo, and C. Falconi. 2013. “Innovación Agropecuaria en América Latina y el Caribe: escenarios y mecanismos institucionales.” Nota Técnica No. IDB-TN-528. Washington DC: Inter-American Development Bank.
Vértiz, P. 2020. “El agro argentino: modelo tecnológico, dependencia y soberanía.” *Ciencia, Tecnología y Política* 3 (5): 044. doi:10.24215/26183188e044
Wang, D., X. Du, J. Sun, X. Guo, and Y. Chen. 2018. “Synergy of National Agricultural Innovation Systems.” *Sustainability* 10 (3385): 1–20. doi:10.3390/su10103385.
World Bank. 2006. *Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems*. Washington, DC: The World Bank.
Yang, Y., and A. Hu. 2008. “Investigating Regional Disparities of China’s Human Development with Cluster Analysis: A Historical Perspective.” *Social Indicators Research* 86 (3): 417–432. doi:10.1007/s11205-007-9177-4