Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.5327/fst.00323

An approach to the porcine health and production research structure in Brazil, 2010–2018

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Abstract

The research project described here sets out to identify and evaluate the topological features of the social structure underlying the porcine health and production system in Brazil between 2010 and 2018. To do this, a sample of the research carried out in the said system was delimited through a set of scientific documents written by several authors from different public and/or private Brazilian institutions. The unit examined was the co-authorship established in the said publications by the authors themselves. It used social network analysis to discover the dynamics that existed based on the cooperation occurring among the protagonists and the collaborative work done by the different research groups. It was observed that the main subjects of joint research were circovirus, porcine reproductive and respiratory syndrome, bacterial infections, innocuousness, animal welfare, sanitary management, reproduction, and genetics. An analysis of the network research structure revealed respective decreases of 5.8% and 52.3% in the communicative and connective capacity of the research network. This could suggest diminished research capacities that are limited to particular technological narratives, which might be linked to some of the animal health contradictions identified in the aforementioned system.

Keywords: Brazil; swine research system; swine production; animal health; social network analysis.

Practical Application: Monitoring and analyzing the innovation skills in the swine technical-scientific system; exploring the fortress or vulnerabilities in the swine research areas; and identifying innovation clusters within the swine research system.

1 INTRODUCTION

Around 120 million tons of pork are produced worldwide every year, 80% of which are produced by China, Europe, the United States, and Brazil, with the latter being the only global Latin American pork-producing country, accounting for 3% of the world total (Errea et al., 2013; FAO, 2023). According to the FAO (2023), while herd sizes in Brazil doubled from 8,000,700 to 14,000,000 swine between 1961 and 1980, from 1990 on, the Brazilian pork-producing system displayed an exceptional pattern of continuous growth, increasing by up to 253% in the year 2000 and by 376% in the year 2021, with China being one of the main and latest markets of the said production (PIC, 2019).

According to Guanziroli (2014), the growth pattern of the current agriculture and fishery section in Brazil comprehends three stages: between 1964 and 1985, the adoption of oriented toward providing support in the form of credits and investment in the development of technology aimed at increasing productivity, satisfying internal demand, and penetrating foreign markets, between 1985 and 2010 by the development of agrobusinesses leading to the creation of new instruments aimed at ensuring minimal prices, future markets, and different options for supporting agrobusiness, and starting in 2001, the inclusion of social policies aimed at generating jobs, reducing rural poverty, and promoting family farming. This three-step program drove the modernization of pork production in Brazil, leading to a clear increase in productivity and Brazil's conversion into one of the world's main pork-exporting countries, mainly due to low production costs, increased product quality, and competitive prices in global markets (Veites et al., 2000). This modernization of the Brazilian pork production system spanned all the links in the production and management chain, including construction models, production technology, progress in genetics, breeding methods, and feed and sanitary management, thus leading to a radical increase, from 9 kilos per capita in 1980 to 19 kilos per capita in 2001 (Brandt, 2023); and a professionalization of the production chain, resulting in the strengthening and increased specialization of the technical-scientific management of the aforesaid pork production system. One of the consequences of these processes is that, in the last few years, in the economic and productive sphere, Brazil has seen a 23% increase in the production of fresh and frozen pork, excluding pieces and substitutes, along with a 29% increase in the number of pigs slaughtered (FAO, 2023). All this growth implies an increase in the resources devoted to production systems, sanitary research, and specialized veterinary care for pigs.

Given the above, the Brazilian pork production system is currently the largest and most competitive one in Latin America.

Received: April 10, 2024.
Accepted: May 6, 2024.
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Conflict of interest: nothing to declare.
Funding: none.

Moreover, as is the case with all the other intensive mass-confinement pork production systems in the world, innovative organizational dynamics are generated, comprehending marketing, production, scientific research, and research into animal health, resulting in solid academic research and management structures in the pig farming sector. In this way, the said technical-scientific system has gradually augmented its ability to monitor, prevent, and mitigate the pandemic, enzootic, and zoonotic problems that tend to arise in such large systems. For example, the porcine reproductive and respiratory syndrome virus, one of the sicknesses that do most harm in pork production systems all over the world, has been controlled in Brazil to the point where it can be deemed an "exotic" illness (Masson et al., 2010). Another example of Brazil's success is the eradication of the African swine fever virus, commonly referred to as ASFV (Freitas and Lyra, 2016). However, the characteristics and complexity of the global industrial pork production system of which Brazil forms a part imply homogeneous production conditions, massive confinement in reduced spaces, and the limiting of genetic diversity, leading to the more immediate rotation of animals, which in turn creates conditions that favor the appearance of cross-border systems that tend to foster the transmission and spreading of porcine sicknesses (Giudice et al., 2020; FAO, 2020; Mora, 2022; OIRSA, 2020), outstripping the technical-scientific capacity to control such contradictions—a problem that the Brazilian system is not exempt from. Given the latest, the extension of the aforesaid pork production system has led to certain contradictions in the latter's management: in the more productive areas where costs are lowest, pig farms have violated their own management and protocol systems, resulting in a complex symptomatology of coinfections and sicknesses in the Brazilian herd and hence important biosecurity breaches (Gatto et al., 2014; Machado & Pinheiro, 2014; Maia, 2007). For example, sicknesses such as porcine rotavirus are circulating either unassociated with other illnesses or accompanied by different infections, something that, according to Lorenzetti et al. (2012), has become a common problem in conventional Brazilian pork production systems due to the mismanagement of the said systems, which constitutes 98% of all pig farm infections. For its part, porcine parvovirus, which constitutes 98% of all pig farm infections, has been observed to be associated with a significant abortion rate, leading to significant economic losses for the entire Brazilian pork production system—a phenomenon explained by the wide distribution of the said sickness in regions such as Minas Gerais, Paraná, Santa Catarina, and Rio Grande do Sul (Dias et al., 2012; Rodriguez-Ballarà et al., 2012b; Rodriguez-Ballarà & Ibanez, 2016).

Furthermore, the defective management of local herds, as part of efforts to lower costs and maximize profits and lower costs, has been associated with various outbreaks of porcine circovirus, even in vaccinated herds (Machado & Pinheiro, 2014). The aforementioned sicknesses have been circulating in Brazil at least since 1998 (Sato et al., 2014), mainly in that country's Northwest, South, and Southwest regions (Barbosa et al., 2010; Castro et al., 2010a; Henriques et al., 2014), but also in wild pig systems (Sato et al., 2014). According to some authors, this phenomenon might be due to the mismanagement of pork production systems, given that, despite the health measures implemented in local pork production systems, the spread of circovirus has been associated with the presence of wild rodents such as rats and their access to food on the said farms (Ferrari et al., 2012). In turn, according to Castro et al. (2010b), this sickness has been observed in coinfections with Torque teno virus (TTV-2), mainly on commercial farms in some of Brazil's pork-producing states (Sao Paulo, Paraná, Goías, Sta. Catarina, Matta Grosso del Sur), and for the first time in pig fetuses (Favero et al., 2010a; Favero et al., 2010b; Leme et al., 2012). One enzootic sickness that is widely distributed on Brazilian pig farms and associated with the inadequate observance of biosecurity norms is bovine viral diarrhea virus or BVDV (Gatto et al., 2014; Gatto et al., 2018). Some other illnesses with which Brazilian pig farmers are all too familiar, given the economic losses that they cause, are *Mycoplasma hyopneumoniae*, one of the most important widespread agents associated with chronic sicknesses on Brazilian pig farms, being present in at least 59% of all local pig farming systems (Bordin et al., 2010); another widespread virus is Senecavirus A, which has been associated with several outbreaks of vesicular diseases, among other ailments, and with neonatal mortality (Gava et al., 2016).

The increase in the number of Brazilian industrial pig farming systems has also given rise to various zoonotic scenarios. For example, the swine flu virus (H1N1) has been reported in Brazil since 2006 (with an outbreak occurring in 2009), although other studies assert that it has been present there since 1996. The aforementioned sickness regularly goes hand-in-hand with another illness called *M. hyopneumoniae* (Rodriguez-Ballarà et al., 2012a; Zanella et al., 2012) and, according to Almeida et al. (2016) is present throughout Brazil's entire intensive pork production system, as well as in wild-peccary (Pecari tajacu) herds. The presence and spread of both of the aforementioned sicknesses directly correlate with the growth in the number of industrialized pork production systems (Baraldi et al., 2018; Vanderlei et al., 2018). Another sickness associated with the increased number of pork production systems and the mismanagement of the latter is porcine salmonellosis (Schwarz et al., 2010). Between 2013 and 2015, an outbreak of the aforementioned sickness occurred in Minas Gerais, Paraná, Santa Catarina, and Rio Grande do Sul, Brazil's main pork production zones (Vanucci et al., 2014).

Based on the above data, it is safe to assume that certain breaches of biosecurity have occurred mainly because some of the aforementioned zoonotic and epizootic problems have tended to get worse in Brazil and to associate the different areas of pork production, animal production, and commercialization with each other as part of a structural behavioral network at the social level, thus assuming the existence of a close structural relationship between the growth, in this case, of the pork production systems on the one hand and the growth of the veterinary pharmaceutical production systems on the other hand (AHE, 2019; Corrégé et al., 2014; Dupont et al., 2016; Mikulic, 2021). In this context, it bears pointing out that production models in Brazil are transmitted not only via official technology-transfer mechanisms but also via informal community mechanisms as well as through the spreading of diseases throughout that country's pork production system (Cespedes et al., 2018; Costa et al., 2012).

All these latest facts lead us to ask which organizational patterns prevail in Brazil's techno-scientific and porcine health sectors in order to characterize the socio-structural dynamics that prevail in that country's pork production research system. While the enormous size of the said system certainly transcends the boundaries of this research, it does not invalidate our proposal that the phenomenon in question be further explored so as to propose more secure systems for the management of pork production.

2 MATERIALS AND METHODS

The exponential growth of livestock systems such as pig farming entails a need to try and understand the dynamics underlying the interlinkage and management of specialized knowledge that accompany such growth. In the present case, this analysis was carried out by implementing a mixed approach that uses the following reference tools: Historical Memoirs of the international congresses held by the International Pig Veterinary Society (IPVS) between 2010 and 2018 (IPVS, 2010, 2012, 2014, 2016, 2018a, 2018b)—mainly everything having to do with the pig farming system in Brazil. The said sample consisted of 237 documents written by 645 authors from 111 public and/or private institutions. While the IPVS is not the only forum of this type, given its historical antecedents since 1969 (IPVS, 2018b), it is a space for the exchange and amalgamation of technical knowledge through dialogue and scientific discussion (Fistetti, 2004); furthermore, the fact that most of the aforesaid scientific research has been methodologically confirmed in the laboratory makes it possible to replicate them methodologically (Soria, 2003) and to ensure the quality of the type of collaborative networks that have been built around the livestock system in Brazil. Based on this, social and historical patterns of integration in Brazilian pig veterinary research are suggested, making it possible to analyze them via the social network approach. Social network analysis is an analytical tool focused on the particularity of relationships that makes it possible to analyze the network of links generated by the different relationships established among social individuals, institutional or organizational protagonists, and so on (Molina, 2001). In this case, the relationships studied were those established via the joint authorship of specialized articles on pork production and pig health in Brazil. The topology of the said structure was analyzed using measures of the centrality of communication (i.e., nodal degree), linkage (i.e., intermediation), and structural efficiency in managing information (social density). The first measure gauges the ability to access the information circulating on the social network, while the second gauges the efficacy of managing information via its bridge-node roles (Ramos-Vidal & Ricaurte, 2015). According to Freeman (1979) and Wasserman and Faust (1994), the node degree (1) and betweenness (2) are calculated based on the Equations 1 and 2:

$$d = \sum_{j \in V} A_{ij} \tag{1}$$

$$C_I(n_i) = \Sigma g_{jk}(n_i) \;/\; g_{jk} \forall j < k \tag{2}$$

Degree = *di*;

A_{ij} = matrix that links the nodes "*i*" and "*j*".

Betweenness.

$C_I\,(n_i)$ = degree of intermediation;

$g_{jk}(n_i)$ = number of geodesics between the *j* and *k* nodes passing through the *i* node;

g_{jk} = number of geodesics connecting the *j* and *k* nodes.

Social density (3) = percentage of relationships existing between the possible relationships is calculated using Equation 3 (Mamani et al., 2013):

$$\Delta = \frac{L}{g\,(g-1)} \tag{3}$$

where:

L = number of existing arcs and (−1) 0 possible number of arcs.

Using this set of formulae, it was possible to analyze structural skills in the Brazilian pork production research along the indicated periods and identify the possible strengths and weaknesses of the said research. The software used to carry out the study described here was UCINET 6.587 (Borgatti et al., 2002).

3 ANALYSIS

In accordance with the analysis carried out, 64.28% of all pig farming research in Brazil is concentrated in six public and private institutions in 111 institutional entities (Table 1), which suggests a proxy indicator of the concentration of the financial resources that are available for research in the pork production systems.

Moreover, the financial resources devoted to research into animal health and productivity have mainly been concentrated in particular fields such as bacteriology, virology, production management, nutrition, and animal welfare and reproduction (69.19%). Indeed, the highest concentration of researchers was mainly in the generic areas of animal health (66.85%) and reproduction (8.12%). The main pig sicknesses studied by most researchers (65.23%) were porcine circovirus (32.18%), swine

Table 1. Principal institutions in the swine research system of Brazil.

Institutions	Frequency	%
Universidade de São Paulo (USP)	634	24.27
Universidade Federal de Minas Gerais	332	12.71
Universidade Estadual Paulista (UNESP)	292	11.18
Embrapa	181	6.93
Microvet	131	5.02
Universidade Estadual de Londrina	109	4.17

Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).

influenza virus (14.47%), porcine rotavirus (6.91%), Torque teno virus (TTV-2) (6.05%), and bovine viral diarrhea virus (5.62%).

Based on this, it is safe to assume that, underlying Brazilian pig farming research, there is a broad, complex interlinked social system with different organizational dynamics, protagonists, links, and reciprocities (Figure 1), in red, with peripheral social dispersion areas being observed, along with a central linkage component and a structural vortex around which most of the social prominence is clustered, displaying an egocentric dynamic. For their part, the reciprocities are limited to certain areas of the said structure, though their presence is an indicator of consolidated, albeit centralized, research groups.

This behavior indicates dispersed communicative capacities and linkages within the said social network. In this regard, the average degree of the general structure of the research network in porcine health in Brazil was 3.81, with an intermediation value of 23.75. In this respect, the average node-degree value was close to the standard deviation value, indicating a structure with limited intercommunication. On the contrary, the high variance value indicates dispersed communication skills, something that is replicated in the case of intermediation capacities, with the average and standard deviation being relatively close to the variance (Table 2).

4 RESULTS AND DISCUSSION

The above suggests that trust in scientific partnership in this sector is expressed via closed groups with a high degree of reciprocity that gives the said groups a certain degree of control over the information that circulates in their environments. However, this in turn suggests a structural limitation in the said group's processes of updating and rethinking their lines of research since they are based on the notion of "strong links" (Granovetter, 1973). In this respect, the groups have difficulty using the communication tools that are most efficient for networking and facilitating decision-making, along with limited access to research funding. Nevertheless, according to Viggiani et al. (2012), key factors for the strengthening of public policy are often identified in Brazilian academic and scientific networks, outstanding among which are improved interdisciplinary approaches, mainly in areas having to do with organizational and resource-management processes in the fields of government, public policy, civil society, economic sociology, migration, cultural studies, anthropology, and the information sciences, while the biological and health sciences were not outstanding before 2010 (Marques et al., 2014). In this context, according to Lages and Marcial (2021), the building of a system for training health professionals constitutes a big challenge both for the disciplines and sub-disciplines involved in the fostering of professional competencies and also for the infrastructure that must go hand-in-hand with the aforesaid process, as well as the historical processes pertaining to the social network per se. On the contrary, regarding structural trends in the period studied, one observes a process of accumulation of social capital in 2010, centralization of the said social capital in 2012, and broader structuring in 2014. While the said structure became fragmented in 2016, giving rise to separate centralized groups, a process of reunification and increased linkage was observed again in 2018 (Figure 2).

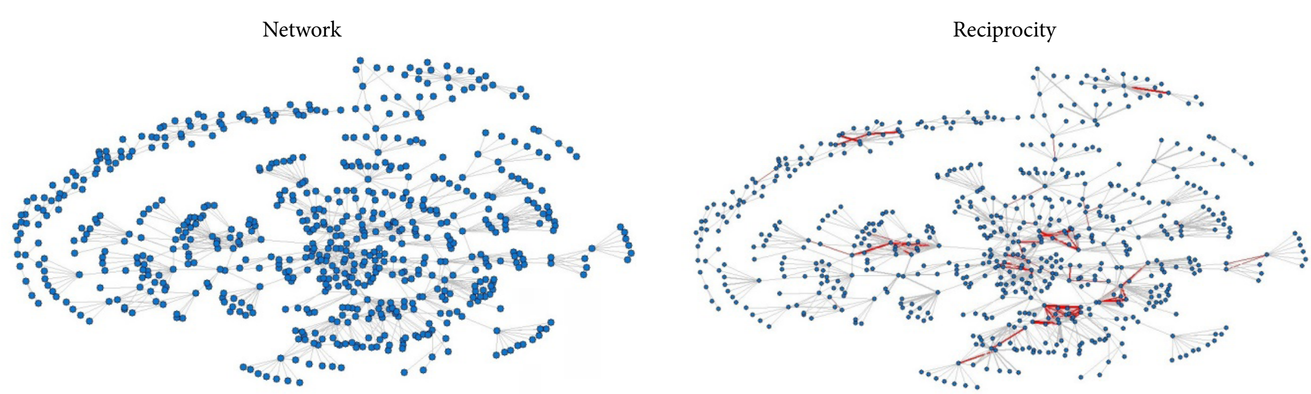
With regard to the above, while the behavior of the research network varied each time it was studied, taken together, these said behaviors formed part of an overall pattern of linkages between researchers of both sexes, enabling them to strengthen their collaboration, participate in their respective research groups, and, over time, maintain the aforesaid dynamics so as to ensure their continuance and consolidate them (Figure 3). Hence, one can observe ongoing linkage among the different scientific groups, although the prominent linkages are distributed, mainly in 2014, when the said network segment strengthened its structures.

In general, there were three particular patterns in the analyzed network: The slowing down of information exchange: a decreasing rate by 2.85% between 2010 and 2018; irregular inter-node linkage patterns, starting with a moderate downward trend in the first 2 years, followed by an increase in the third

Table 2. General trends in centrality measures in the studied structure.

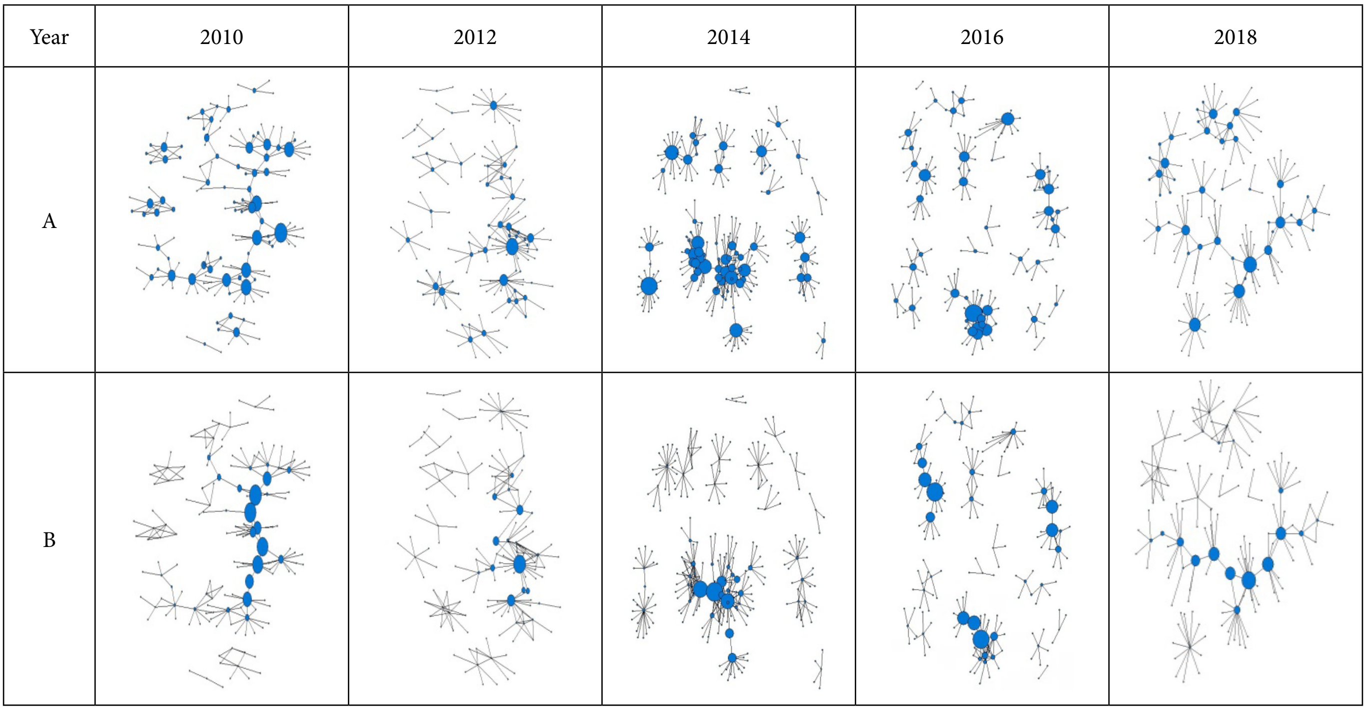
Measures	Degree	Betweenness
Mean	3.808	23.749
Std Dev	5.903	113.139
Sum	2456	15,318
Variance	34.844	12,800.426

Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).



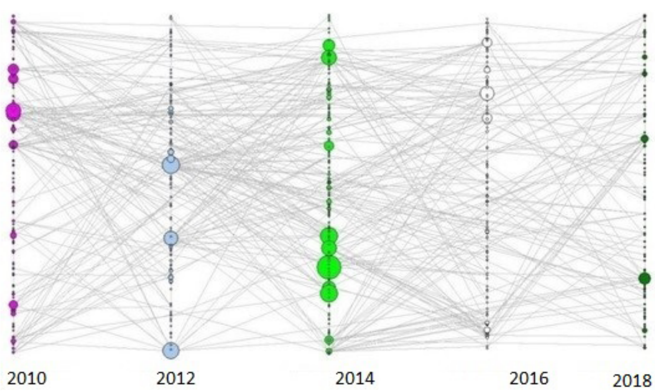
Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).

Figure 1. The pig farming research network in Brazil, 2010–2018



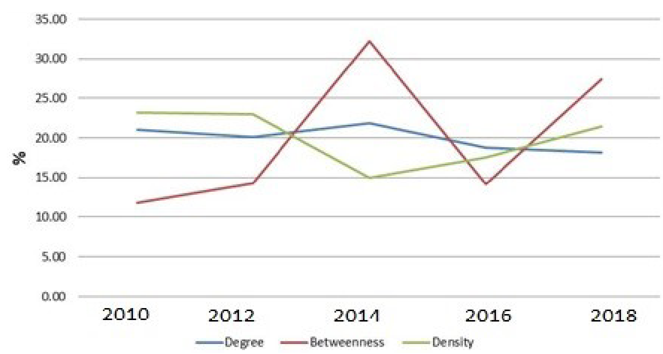
Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).

Figure 2. Evolution of the (A) degree and (B) intermediation in the pork production research network in Brazil, 2010–2018.



Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).

Figure 3. Interlinkage (betweenness) in the pig farming research network in Brazil between 2010 and 2018.



Source: IPVS (2010, 2012, 2014, 2016, 2018a, 2018b).

Figure 4. Structural trends in the pig farming research network in Brazil.

year, a collapse in the fourth year, and an increase in the final year; and a decrease in the capacity to transmit information among the nodes—i.e., its density (Figure 4).

5 CONCLUSIONS

The significant increase in pork production in Brazil is due to a central policy strategy oriented toward achieving self-sufficiency and positioning Brazil as an important pig farming country at the international level by exploiting its clear advantage in the use and transformation of its natural, financial, and intellectual resources and devoting the said resources to the provision of support in the areas of nutrition, management, and animal health. But while it was thus possible to identify groups with certain levels of reciprocity and control over the information circulating on the social network, communication problems that reduced the efficiency of the network were also identified. While the intellectual density of the network made it possible to overcome these inefficiencies to some extent, it was observed that there was a clear decrease in communicative and linkage capacities. These decreases suggest a centralizing—and a lessening—of innovative capacities, along with an increasingly centralized focus on certain technological narratives.

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