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# Building technologies to market: Can network structure and resources explain innovation in agribusiness?

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ABSTRACT

An innovation network can be understood as a heterogeneous interorganisational model, in which stakeholders interact through a series of collective actions based on innovation. From this perspective, and following a review of the literature, this paper aims to determine the factors related to international interorganisational knowledge networks that contribute to the achievement of innovation. To test our theoretical arguments, the empirical work has focused on organisations in the agribusiness sector in Brazil and Spain. In terms of the methodological aspects, the research is qualitative in nature and has used crisp-set qualitative comparative analysis (csQCA). The main conclusions we have drawn are the following: a) in the context of interorganisational knowledge networks, the 'strength of the ties' variable is decisive and sufficient to influence innovation; b) the 'density', 'size' and 'configuration' variables (agglomeration, power, contractual formalisation and directionality) of the networks are not sufficient on their own to explain innovative performance; and c) despite the vast body of literature pointing to territorial agglomeration (clustered networks) as a source of resources for networks, dispersed networks combined with other configurations with a different structure can generate innovations in knowledge networks.

## 1. Introduction

In recent times, we can find different theoretical perspectives that agree on the importance of contextual factors for the development of innovation (Ding, 2022) or success factors (Kraus et al., 2016). These perspectives focus on the environment of the organisations as a basis for innovation and on the need to possess capacities that allow different demands and knowledge to complement each other. Hence, innovation cooperation has been developed as an instrument that seeks to promote technological innovations (Scott et al., 2021) and has become the focus of the study, evaluation, and development of various forms of interaction among organisations for the exchange of resources.

Sharing resources within the framework of a set of collaborative relationships has a beneficial effect on a firm's competitiveness (Bulgacov et al., 2012), since it favours the generation of competitive advantages sustained by this interaction of resources (Sedita et al., 2021) and their complementarity in the interorganisational network (Lavie, 2006; Vieira et al., 2022). Therefore, the generation of innovation is facilitated by the existence of interorganisational relationships, as these allow firms to act in a way that enables them to

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complement each other (Chabbouh and Boujelbene, 2020) in their own dynamics and with specificities that maintain interdependent relationships within broader areas (Carvalho and Sugano, 2012).

In this regard, the theoretical review of the role played by networks and the complementarity of their resources in the innovation dimension makes it possible to visualise the importance of the strategy of interorganisational networks in technological environments, mainly because of their influence on the achievement of results of an innovative nature (Chabbouh and Boujelbene, 2020) and even to feed entrepreneurship (Fernandes and Ferreira, 2022). Thus, theoretical, and empirical studies on interorganisational networks pave the way for unprecedented research into their contributions to the achievement of performance (Lee and Raschke, 2016) within the innovation dimension (Kusa et al., 2021; Ding, 2022), linked to its strategy and thereby increasing value creation (Kyrgidou and Spyropoulou, 2013), and at the territorial level (Piazza et al., 2019).

In this theoretical framework, an innovation network can be understood as a heterogeneous interorganisational model (Huang and Bu, 2023), in which stakeholders interact by means of collective actions aimed at achieving innovation. For innovation networks, interorganisational relationships constitute the locus of innovation. In other words, firms and other stakeholders in innovation systems are induced to cooperate and to coordinate complementary activities in one or more sectors spanning the different dimensions of the innovation process (Pellegrin et al., 2007). Therefore, an innovation network can also be an interorganisational network, although it involves different types of stakeholders collaborating and sharing knowledge to promote innovation. An innovation network can also be linked to a particular territory (Piazza et al., 2019) or be geographically dispersed (Dias et al., 2019).

Networks can have very different structures in the agribusiness, as well as in each country and they can also depend on the institutional context. As an example, in a study in Bulgaria, Doitchinova et al. (2017) found that, in the period of a centralised economy (before 1990), cooperatives were the standard organisational arrangement. More recently, Ivanova (2023) found two new forms of organisation in the same country, as network arrangements: i) associations - non-governmental organisations, and ii) producer organisations. Another example, in an Argentine study, presented by Senesi et al. (2017), showed that different institutional contexts generated different network configurations, depending on the market uncertainty and the public intervention policies. In both studies we can see that context is influenced by government, and it affects the network structuring. This seems particular to agribusiness. Contrary to what we can find in the manufacturing sector (e.g., Hoffmann et al., 2014), agribusiness is a more controlled sector, directly (Senesi et al. (2017) or indirectly (Doitchinova et al., 2017), by government. However, this control can also be quite supportive, with the aim of promoting innovation and access to the international market (Serrano et al., 2023). That is why networks have different designs in agribusiness.

Studies on networks in agribusiness focus on the impact of the institutional context of the network arrangements (Doitchinova et al., 2017; Senesi et al., 2017); the benefits networks bring to a company (Serrano et al., 2023), the role of formal and informal networks on a firm's performance (Rout et al., 2020), and on a firm's ability to innovate (Rey et al., 2023). In the aforementioned articles regarding networks in agribusiness, there are two loci: the network and the firm. We are trying to contribute to the literature on networks within agribusiness.

In our study, we explore a specific kind of network: agribusiness innovation networks. These networks are created to develop a new cultivar, a new seed that will improve agricultural performance. In this sense, they are specific scope networks, and they exist as long as they produce meaningful results, so they are short- or medium-term networks. But the partners are more and less the same among different projects. From a relationship point of view, they belong to long term networks. Considering that relationships are complex and change with time (Scott et al., 2021), they can affect the performance of these networks. Studying this special kind of network is our first contribution.

From this perspective, our paper determines the factors related to international interorganisational knowledge networks that contribute to the achieving of innovation in agribusiness. To confirm our theoretical arguments, the objects of study chosen for this empirical work were the interorganisational networks derived from collaborative research, development and innovation (R&D) projects developed with the support of two reference public institutions in the agricultural sector: the Brazilian Agricultural Research Corporation (Embrapa) and the Spanish National Institute for Agricultural and Food Research and Technology (INIA). This is another contribution because for firms to generate innovation by knowledge exchange processes, it is more complex when a network is created that combines private-sector companies, universities and government (Feser, 2023).

## 2. Theoretical framework

### 2.1. Innovation

The literature recognises the multidimensional nature of business performance, which can be measured in a variety of ways (Bentes et al., 2012), such as innovation, itself (Wang and Li-Ying, 2015; Lin et al., 2023) and the agri-food sector increasingly rely on innovation to foster collaboration across the food supply chain and improve business performance (Annosi et al., 2021). In turn, innovation can be presented in many ways, at various intensities and supported by different organisational elements (Dávila et al., 2018). Without being exhaustive, innovation has been defined as a process, as a result, or as both; but above all, the different authors agree in understanding it as the adoption of a new idea or behaviour (Jimenez-Jimenez and Sanz-Valle, 2011). We understand that a widely accepted definition is the one offered by the Oslo Manual 2018: "A business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and has been introduced on the market or brought into use by the firm" (OECD/Eurostat, 2018). According to Dushnitsky and Lenox, 2005, the most popular measures of innovative performance are: (i) existence of publications or announcements of new products; (ii) patents (Griliches et al., 1991); (iii) patent citations; and (iv) R&D investment data statistics, with the patent being the most found outcome indicator of the innovative process in the innovation literature.

Several authors emphasise that evaluating innovation involves analysing the performance of the R&D process, which is part of innovation management (Kerssens-van Drongelen and Cook, 1997). Innovation performance is important for achieving objectives in research institutions and for the competitive advantage of companies (Keil et al., 2008; Sarvan et al., 2011; Dias et al., 2021). The R&D activities provide a basis for evaluating whether the organisation is progressing towards its objectives (Kerssens-van Drongelen and Bilderbeek, 1999). Therefore, that performance measurement for R&D activities helps to achieve the company's objectives, in addition to supporting decision making, improving R&D performance and motivating employees to achieve the desired results (Chiesa and Frattini, 2007; Chiesa et al., 2009). Achieving the necessary balance between research, and development is an increasingly difficult task. Organisations can fall into the renewal trap by investing in R&D without a clear development direction (Groen et al., 2002). The process of measuring technological innovation involves semi-quantitative techniques. These techniques seek to convert people's impressions of the performance of R&D activities into a metric unit. There are some framework references such as the Kerssens-van Drongelen and Cook measurement system (1997) that can be applied to analyse the return on R&D.

The literature shows that a lot of innovation is no longer considered a firm-level phenomenon, but a process involving a set of business stakeholders (Corsaro and Cantù, 2015; Scott et al., 2021). Organisations therefore seek internal and external alternatives to improve their innovative performance through interaction processes that generate cooperation and competitive advantages, so that innovation finds its place in interorganisational networks (Obstfeld, 2005; Pellegrin et al., 2007; Piazza et al., 2019; Powell et al., 1996). An innovation network can be understood as a heterogeneous interorganisational model (Piazza et al., 2019) whose stakeholders interact through a series of actions of a collective nature centred on innovation (Pellegrin et al., 2007). Collaboration allows different stakeholders (such as public institutions, research centres, enterprises, etc.) to pool, exchange and develop ideas, knowledge and other resources (Arranz et al., 2020) to reduce technological, market, financial and operational risks, among others (Cantner and Rake, 2014). Therefore, the interorganisational projects involve two or more organisational stakeholders working together to create a tangible/intangible product in a limited period (Haniff and Galloway, 2022; Jones and Lichtenstein, 2008). In this line we find important studies on the concept of Open Innovation that help to understand these collaborative processes as Bianchi et al. (2016), Moretti and Biancardi (2020) or Patrucco et al. (2022), among others.

Despite efforts to develop alternative measures (see Henderson and Cockburn, 1994), patents are among the most widely adopted measures of innovative performance (Bedford et al., 2022; Griliches et al., 1991; Trajtenberg, 1990). Hence, a measure for innovation (Dushnitsky and Lenox, 2005) in interorganisational networks of R&D projects is the number of products that reach the market. This measure is inspired by the relation between R&D investments, innovation and patents (Bedford et al., 2022).

### 2.2. Network attributes

To understand a network, it is important to know its structure and content (Scott et al., 2021). In contrast to industrial manufacturing organisations that changed themselves into more knowledge-based business models (Lin et al., 2023), based on digitalisation of processes (Boucken et al., 2021), networks we studied were supported as knowledge-based organisations (Polidoro and Paula, 2024). This is why it is important to understand the composition of these networks.

The networks we studied have a specific scope, so their content is the same, and we think it is not necessary to discuss it. The agribusiness networks that were the subject of our study exhibited some main elements that appeared to be important in understanding their structure. These included: the size as an indicative of the diversity of actors involved and may include companies, research centres, public institutions, and others; the strength of the network ties can be useful in agribusiness for a wide range of outputs can be achieved, including innovation as a first target and product promotion as a second target; the links in the agribusiness networks can be social and economic simultaneously. In the economic scope, the networḱs own scope is housed, but it is the social links that preserve the network over time. This section will discuss these elements in further detail.

It is important to note that the networks we have studied are models of networks in agribusiness, not the models of other industries. For example, in the case of the wine industry, we can find some networks in agribusiness created to promote the Protected Designation of Origin - PDO (Serrano et al., 2023). This is a typical clustered network in agribusiness. Their scope is not innovation, when considering the product - wine - does not require innovation per se, but rather the promotion of the product beyond the cluster's boundaries. However, these networks can be long term purposes in both a social and an economic context, and in these cases, their structure is adapted to different knowledge exchanges in the value chain, as we can see in agribusiness, such as in the wine industry (Sedita et al., 2021; Serrano et al., 2023). Additionally, a network can also be project-driven (Haniff and Galloway, 2022), with different structural designs for each project. In the first case, the network is embedded in the social context to such an extent that it is impossible to distinguish what is the network and what is the social context or if the social context is part of the network (Nahapiet and Ghoshal, 1998) or if the network is a component of the social context (Sedita et al., 2021). As it is project driven, the structure is connected much more to a common objective, sharing resources (Scott et al., 2021) as well as to a governance model that allows the network to attain and cover its scope (Haniff and Galloway, 2022). As we said before, our network design has components from both models, with social and economic long-term relationships being driven by a specific scope, which is why network structure is important to our study.

The size of the network is therefore set by the number of participants (Thompson, 2003). Authors such as Shankar and Bayus (2003) and Thorgren et al. (2009) have highlighted several advantages for larger networks linked to the generation of scale. Moreover, Bulgacov et al. (2012) provided evidence of the relationship between performance and the number of firms in the network due to the existence of shared resources. Other studies in agribusiness have shown that networks can have different sizes, in relation to the exchanges of resources they carry out (Sedita et al., 2021). Hence, we see a link between size and the stock of resources. So, a greater number of participants increase network diversity, resulting in increased complementarity of resources (Dias et al., 2019; Piazza et al., 2019). However, size in agribusiness is also important in reaching the scope of the network of firms created. Studying PDO in the wine industry in Spain Serrano et al. (2023) shows that the process must involve all the firms of the protected territory, and, so, the local network is as big as the quantity of firms present in the local. It was necessary to involve all the firms and institutions because they have a scope to promote the PDO outside the region, but also to control local production.

Within the context of the agricultural sector, these networks can have different forms and can involve a wide range of organisations like government and or government agencies, universities, research centres, trade associations etc. (Li et al., 2022; Sedita et al., 2021; Serrano et al., 2023). This is what Fieldsend et al. (2020) called 'co-innovation', which means in the agribusiness, innovation rests on cooperation among partners in R&D projects (Fieldsend et al., 2020). In contrast to the digitalisation process demanded in industrial networks (Boucken et al., 2021) to generate innovation, in the networks we researched a diversity of partners is linked to the innovation process. Size is not the traditional source of the advantage of scale (Shankar and Bayus, 2003; Thorgren et al., 2009) in the networks we studied, but rather the diversity of resources (Scott et al., 2021) and the sharing of risks in the R&D process (Dias et al., 2019). Thus, our first research proposal is the following:

**P1**. : The size of the network influences the innovativeness of the interorganisational knowledge network in the agribusiness sector.

Networks also foster complex and reciprocal relationships of interdependence, in which there are diverse connections among the participants. Empirical studies have shown that the strength of the ties in networks promotes improvements in the competitiveness of organisations, especially in territorial clusters (Molina-Morales and Martínez-Fernández, 2003). Understanding the strength of the ties requires the combination of several factors, such as the amount of time, intimacy, emotional intensity, mutual trust and mutual services that characterise the ties (Granovetter, 1973). However, there are also studies that address the detrimental effects that can come from strong ties (Lazzarini, 2008; Uzzi, 1996).

In line with this relational dimension, Molina-Morales et al. (2008) analysed the strength of ties from the perspective of four indicators: (i) frequency, which identifies the number of times a person (unit) had contact with another person (unit); (ii) intimacy, which addresses the degree to which relationships are affective (e.g., friendship) and/or based on common goals and purposes; (iii) social interactions; and, lastly, (iv) the extent to which professionals worked in other firms in the same region (network clustered firms). Talking about clusters and networks, Kraus et al. (2021) wrote that the links between different kinds of local actors can create an appropriate environment for firms to develop innovations. These local actors can share their knowledge with one another, creating a source of competitive advantage for them when facing outsiders (Sedita et al., 2021).

Proximity, intensity of contact and innovation are closely connected constructs. Almost thirty years ago, Dyer (1996) wrote that the supply chain of the automotive industry, in which firms were territorially proximal, exhibited greater innovation., since suppliers and automotive firms have more opportunities to contact one another and then transfer knowledge inside their network. But what happens in a knowledge-based network? In contrast to Dyer (1996), in agribusiness more intangible networks exist, and they can share resources even if they are not clustered (Dias et al., 2019). Innovation from these networks come from intense communication and collaboration (Fieldsend et al., 2020). Studies by Dias et al. (2019) and Fieldsend et al., (2020) suggest that innovation depends on the strength of ties between the actors. In agribusiness, some studies support this argument. Rey et al. (2023) studied a network called Consortium of Pasta di Gragnano, a PDO of pasta in Italy. Their results show that firms that take part in that network increase the level of innovation of local firms because the Consortium acts as a source of knowledge and is a critical determinant of social capital - related to the interaction of local firms. In a further study conducted in Poland, Wiśniewska-Paluszak and Paluszak (2019) investigated some Polish fruit and vegetable firm networks. Their findings indicated that the strength of ties among agribusiness firms may influence their profitability. In such networks, this output is more important than to develop innovation. This may be attributed to the fact that pricing conditions and terms of payment constitute one of the foundations upon which the network is established (Wiśniewska-Paluszak and Paluszak, 2019). Therefore, the second proposition of this paper is as follows:

**P2**. : The strength of the network ties influences the innovativeness of the interorganisational knowledge network in the agribusiness sector.

A third dimension to be studied refers to the density of interorganisational networks. A network can be characterised by its structure (i.e., how the links among stakeholders are established) and by its position (i.e., how certain stakeholders can extract more benefits than others because of the way they are positioned in the network). One of the main indicators used for these two aspects is density (Lazzarini, 2008). Network density is based on the connectivity of the various stakeholders to each other (Lazzarini, 2008)—that is, the density of a network is a function of the number of existing ties relative to the maximum number possible, which is one of the most basic attributes of network analysis (Borgatti and Everett, 1997).

Organisations that belong to networks and have a greater number of connections among their members (i.e., are denser) have, among other benefits, a smooth flow of information and other resources, functioning as closed 'systems' of trust and shared norms where standard behavioural structures develop more simply, as well as with greater ease in assigning punitive sanctions (Houston et al., 2004). This accessibility to resources allows for both the potential generation of a competitive advantage through the interrelation of resources (Barney, 1991) and their complementarity in the interorganisational network (Lavie, 2006). Molina-Morales et al. (2008) analysed the structural dimension of the network of relationships and, in order to assess network density, proposed measurement indicators based on three aspects: (i) degree of redundancy (i.e., the extent to which exchanges overlap or are similar in content; (ii) the degree of network interconnectedness, which is the extent to which network stakeholders know each other; and (iii) the degree to which the firm depends on the dense network to obtain the resources that are important in being able to carry out its activities.

Density depends on many aspects. Fieldsend et al. (2020), who examine agribusiness networks, show that budget limitations can be a restrictive factor that limits a network's size and creates a risk of excluding some relevant actors. In this case, relevance based on complementary resources could be a criterion to foster density.

In agribusiness, firms can establish both formal and informal links. According to Sedita et al. (2021), who studied Valdobbiadene sparkling wine in Italy, the density of the network varies depending on the value chain link. For instance, the local network is highly dense, during the winemaking phases, but sparse during the commercialization phase. In this final phase, local firms require knowledge about internationalisation, but the local network cannot support it due to its low density. Rout et al. (2020) demonstrate that the Māori formal and informal collectives, known as Whakapapa, provide the necessary collaboration for Māori agribusiness organisations in New Zealand to reach a high performance level. In the wine case study conducted by Sedita et al. (2021) and in Māori agribusiness (Rout et al., 2020), the density of networks has an impact on firms. It can be argued that some of these organisations have a significant role to play in promoting network density. In a network analysis conducted by Canevari-Luzardo (2019), it was demonstrated that business associations have the capacity to connect network actors, thereby influencing the flow of information. Furthermore, information is linked to a network's capacity for innovation (Huggins, 2010).

Even in a traditional agribusiness industry, taking part in a network where the firm can access new knowledge allows the firm to innovate. Density in this case is due to the diverse roles that actors can play inside the network, with some actors bringing tradition and others innovation to the agribusiness network (Rey et al., 2023). Hence, the evidence highlighted in relation to network density leads to the third proposition of this research:

**P3.** : Network density influences the innovation of the interorganisational knowledge network in the agribusiness sector.

The stakeholders that make up a networked organisational structure are interrelated through different interorganisational configurations. In this sense, the networks studied can be characterised as dynamic networks (Miles and Snow, 1992) and interorganisational projects (Jones and Lichtenstein, 2008). For this study, the typology of Hoffmann et al. (2007) was adopted for the analysis of these networks, since it was developed with interorganisational networks in the same countries considered in this paper as the objects of study.

Based on previous studies, Hoffmann et al. (2007) pointed to the existence of a typology of networks through the existence of four indicators: (i) directionality, which describes the direction of relationships between parties and emphasises two types of networks: horizontal networks (established between firms that compete in terms of products and/or markets) and vertical networks (those in which each process is carried out by specialised, non-competing firms, and which do not operate in the same market); (ii) location, which refers to the fact that networks can be agglomerated (i.e., territorially concentrated in a certain geographical area) or dispersed (in the sense of the territory); (iii) formalisation, which addresses the fact that networks can be formalised structures on a contractual basis, or they can be informal ones on a non-contractual basis; and (iv) power, which is the capacity for decision-making in relation to the directions that the network are going to take. This classification can be applied to the agricultural sector. Fieldsend et al. (2020), for example, identified the networks formed for knowledge exchange in this sector as being formal or informal, local or international. A study from Geldes et al. (2017) pointed out that business cooperation is a determinant to agribusiness company-level innovation. They also showed that cognitive-organisational proximity increases business cooperation among agribusiness companies in Chile. So, it is not necessarily the territory but the cognitive proximity that fosters innovation. Kühne et al. (2015), who analysed agribusiness networks, found that vertical networks, with peers and third parties, increase innovation in agribusiness firms.

Digital technologies play a crucial role in driving innovation in the agri-food sector because the advancement of IT systems has reached a stage characterised by the integration of complex systems and the formation of business ecosystems that engage numerous stakeholders in diverse roles (Wolfert et al., 2023). The studies of Kühne et al. (2015) and Geldes et al. (2017) reveal criticism regarding the internationalisation process in agribusiness. However, this cooperation can be developed with national and international partners to overcome the limits of resource scarcity (Polidoro and Paula, 2024). And especially in knowledge-based networks, the digitalisation of internal processes and communication can keep partners close even when they are in different countries. The innovation network is a key concept in the organisational framework of digital innovation ecosystems in agri-food (Wolfert et al., 2023). In particular, the aspect of internationalisation seems to be of special interest, since, within the context of Brexit, Arranz et al. (2020) recommended that public policies be made to foster informal or formal relationships between researchers in the UK and those in Europe to stimulate innovation in agribusiness. In agribusiness, the configuration of the network can vary greatly, even within the same production category. Serrano et al. (2023) present another point, demonstrating that agribusiness firms in the same territory, can have both formal and informal relationships with other actors. When the government, research institutions, and or commercial institutions are the resources provider (Li et al., 2022), relationships tend to be more formal, but when these relationships are with a local firm it can be on a more informal shape (Rout et al., 2020). The research of Gaitán-Cremaschi et al. (2022) showed that different network configurations, involving various actors, are essential for the processes of knowledge and innovation co-creation, as well as for the outscaling and upscaling of food systems from family farming. It is, however, incumbent upon these networks to develop innovations. And this innovation in agribusiness should provide solutions to farmers' problems (Silva et al., 2023). In our study, the aforementioned solutions are innovations in the form of new products that facilitate an increase in productivity and or efficiency. To develop these new products requires the formation of a network based on cooperation (Dias et al., 2019). The configurations of the network may be influenced by factors such as proximity. Geldés et al. (2017) highlighted the interconnection between cognitive-organisational proximity, cooperation and innovation. According to Geldés et al. (2017) it is more straightforward for managers to collaborate with organisations that are analogous in terms of cognitive and organisational levels with regard to innovation. And this proximity may have impacts on network configuration. Considering these arguments, the fourth proposition of this paper is the following:

**P4.** : Network configuration influences the innovation of interorganisational knowledge networks in the agribusiness sector.

### *2.3. Resources available in the network*

Resources are those assets that a firm can use to formulate and implement its own strategies. Thus, Resource-Based View (RBV) (Barney, 1991), as well as other seminal contributions to the conception of resources (Penrose, 1959; Peteraf, 1993; Wernerfelt, 1984), emphasises the structure of the firm's assets and its competitive advantage based on processes of resource accumulation and usage. Firms are therefore considered heterogeneous in relation to the endowment of imperfectly imitable resources among them (Barney, 1991) and the complementarity of these resources in the interorganisational network (Lavie, 2006). It should be added that networks in the agribusiness sector are also driven by the complementarity of resources (Fieldsend et al., 2020) and that these resources can even be provided by governmental stakeholders (Scheiterle et al., 2018).

Pike et al. (2005) distinguished four groups of resources: i) human (research and development-R&D), management capacity, business alignment, partnership capacity and learning); ii) Organisational (intellectual property, organisational structure, processes, image and brand, organisational culture and organisational strategy); iii) physical (facilities, equipment, products and materials and service infrastructure); and iv) financial (a firm's on-hand cash or other equivalent financial assets that can be converted into cash). In turn, for the group of organisational resources, Gonçalves et al. (2011) added the variable of 'detailed information on the operating market' because although the RBV has an internal emphasis on firms, they considered it essential to adopt competitive intelligence practices and interpret information from their environment, and that of competitors, to use them strategically.

Moreover, strategically relevant resources may be located not only at the firm level but also outside the firm (i.e., in inter-organisational networks) (Gulati, 1999), or even at the level of innovation systems (Carvalho and Sugano, 2012; Musiolik and Markard, 2011; Musiolik et al., 2012; Piazza et al., 2019). For Huggins (2010), resource networks in the form of knowledge alliances are likely to be positively related to innovation.

We can find similar results in agribusiness networks, which exhibit complementarity of resources. Polidoro and Paula (2024) also studied Embrapa. They employed comparable resources set to that we utilised in this study, comprising human, physical, financial and organisational resources. They suggest that complementarity among partners aids innovation in terms of patents. Their study found that the best results were achieved by partners who utilised their own resources and capabilities to access network resources. In addition, Ali et al. (2021) also used variables connected to human, financial and organisational resources set in their research. They state that innovation in agribusiness firms is influenced by internal, collaborative, and external factors. Particularly, collaboration with support institutions has been shown to improve product innovation (Ali et al., 2021). In the Embrapa case, institutions were involved in the network as actors (Polidoro and Paula, 2024), while in the case of Consortium di Pasta di Gragnano, they acted as a broker, connecting partners and resources (Rey et al., 2023). Another illustrative example can be found in Brazil, where Dall'Agnol et al. (2021) highlight that members of networks perceive participation in such networks as a gateway to diverse resources that would otherwise be challenging to access independently. So, our last proposition is:

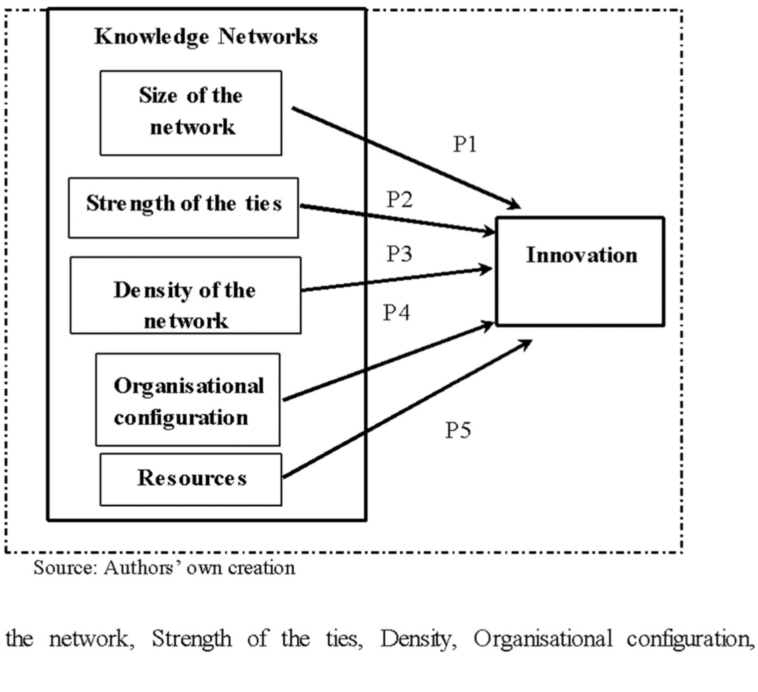


**Fig. 1.** Conceptual model of variables within the network in the context of innovation.

**P5**. : Network resources influence innovation in the interorganisational knowledge network in the agribusiness sector.

To sum up, Fig. 1 presents the different relationships shown in the propositions between the elements that make up the model of innovative performance in the field of interorganisational networks.

## 3. Method

The object of this investigation comprises multiple cases, and we aim to carry out a comparative study. In this sense, the method used to investigate the selected phenomenon was qualitative comparative analysis (QCA) (Ragin, 1987), which offers comparative research as a systematic and more precise method based on maths (Boolean algebra) and formal logic.

Ariza and Gandini (2012) emphasise that the methodological perspectives of the QCA method are as follows: i) the validity of the analysis is not based on statistical variability but on the qualitative assessment of the set, conditions and causal situations linked to the result; ii) the cases observed are not important because of their quantitative weight but because of their singularity, where one has the same weight or relevance as many; iii) the cases examined are treated holistically (i.e., each one is seen as a unit integrated with a complex combination of properties); iv) the causal combinations obtained are contextual and become intelligible through a careful process of interpretation by the researcher Through meticulous engagement with the literature dealing with theory, and these combinations are not self-evident, nor a product per se of the technical resources employed (Boolean algebra, computer packages); and v) the emphasis of the analytical effort is on the depth of knowledge of the cases.

In Ragin's (1987) view, the number of cases is not a limitation but a deliberate choice on the part of the researcher, since a central aim of comparative research is to achieve close familiarisation with each case. Knowledge of the cases is an end that cannot be achieved when they are too numerous. (Ragin, 2007).

### 3.1. Unit of analysis and selection of cases

This paper studies multiple cases and conducts a comparative study across countries (Huang et al., 2022). The sector targeted by this research is the agricultural sector. Moreover, the unit of analysis was the interorganisational knowledge network derived from R&D projects. Cases that received support from two institutions were selected as the focus of study because of their reputation as innovative public institutions (Damian and Manea, 2019) and their representative action to promote the sector: the Brazilian Agricultural Research Corporation (Embrapa) in Brazil, and the National Institute for Agricultural and Food Research and Technology (INIA) in Spain. Brazil is one of the world's largest food producers, and Spain is one of the few countries in Europe working on plant breeding of genetically modified organisms (GMOs); it is the European country with the largest area planted with GMOs. Following Ariza and Gandini (2012), both successful and unsuccessful knowledge networks were selected in Brazil. The successful networks had the best innovations, and the unsuccessful ones resulted in a technology with low innovation performance (i.e., they did not reach the market or society or only did so in low quantities). This selection allows them to be compared in terms of results.

The selection of the cases (interorganisational networks) was made by consulting secondary data from both Embrapa and INIA (publicly available, as well as internal materials, not available to the public, such as reports and digital files). These institutions provided us with a list of interorganisational networks with the most important researchers in each of the countries for this sector. They were in two kinds of networks: those with research that concluded with successful outcomes, and others that were unsuccessful.

This paper focuses on innovation in interorganisational projects, where two or more organisational actors collaborate to create a tangible product or service within a limited timeframe (Jones and Lichtenstein, 2008). The concept of innovation, as defined by the Oslo Manual, and adopted in this paper, requires that new products be useful to the market or society (OECD/Eurostat, 2018; Khraisha and Mantegna, 2020). Thus, this research derives the measure for innovative performance in interorganisational networks of R&D projects from the creation of a tangible product that has reached the market. The measure is based on the royalties collected for the technology analysed, as suggested by Dushnitsky and Lenox (2005) and Dias et al. (2019). So, with the definition of innovative and non-innovative technologies derived from interorganisational knowledge networks or, in other words, the outcomes of success and failure, the procedure adopted was to define the proxy for innovation performance, the creation of a tangible product the market for which has been reached (OECD/Eurostat, 2018), which can be measured by direct monitoring with obtaining information on the commercialization values of seeds/seedlings or royalties, payment of a percentage of the total sales of the technology, concerning the intellectual property of the inventing company. Therefore, a selection of successful and unsuccessful cases was made, based on royalty collection data (over the last 5 years).

In Brazil, for the selection of successful and unsuccessful cases, the study prepared by the Strategic Management Office (AGE) of the Brazilian Ministry of Agriculture, Livestock and Food Supplies (MAPA) was used, which shows agricultural income expressed in gross value of production (GVP), to define the main species/crops. Then, successful and unsuccessful technologies were selected according to the collection of royalties in recent years (2010–2014), and the date of protection of the technology, represented by its patent, was consulted on the MAPA website to identify the main researchers and especially the leader of the knowledge network.

The selection of successful cases in Spain, in the plant breeding segment of the agricultural research sector, was defined with the collaboration of the Department of International Scientific Relations of the Subdirectorate of the Multilateral Relations Area of INIA, which systematised a table with information (crops, main researchers, institutions and contacts) of the most successful Spanish cases in the sector under study. The cases of failure in Spain were not studied because no information was available. Moreover, the aim of the research was, after the comparative analysis between successful and unsuccessful cases in Brazil, to add the successful Spanish cases in order not to restrict the study to factors that influence innovation in only one country—that is, possible endogenous characteristics of

Brazil—and to broaden the limited empirical diversity with the successful cases in Spain.

The success cases (successful interorganisational networks) were made up of those networks that owned technologies that had obtained high royalties because of their sales. In other words, these technologies (seeds) were bought by producers because they meant an increase in productivity, greater precocity, or resistance to pests, and were therefore considered to be innovations. On the contrary, there were other networks with technologies that were not accepted by the market, being considered as 'non-innovations' according to the OECD/Eurostat definition (cases of failure in our research).

The choice of the method of analysis used for this study, QCA, guided the definition of the number of cases in the study. The use of QCA is generally defined for an intermediate N, whose most frequent applications are in the range of 10–50 cases (Rihoux and Ragin, 2008). The empirical research (Table 1) was therefore carried out in 25 interorganisational networks derived from R&D projects, composed of a total of 450 organisations, supported by Embrapa in Brazil (eight successful and nine unsuccessful) and INIA in Spain (eight successful)—that is, an international comparative research study using the QCA method (Huang et al., 2022).

Table 2 shows the typology of organisations that participated in the interorganisational networks in Brazil and worked together to create a technology. We can point out that in all these networks, there is an Embrapa research unit, since Embrapa is the promoter of these innovation networks. Secondly, there is an Embrapa Service Unit that supports the production of seeds and the articulation with partners for the development or commercialisation of technologies. Regarding organisations external to Embrapa, the main partners are state or federal research organisations (53 %) and universities (47 %).

As far as Spain is concerned, the various organisations participating in the interorganisational networks were classified according to Table 3. In Spain, in all networks, there is a governmental research organisation, these being the main institutions in the innovation networks. In second place, they are followed by private, non-research institutions (national or international), comprising 50 % of the total. Finally, within 25 %, we find private, national or regional research institutions and foreign research institutions.

### 3.2. Data collection

The research used a combination of primary and secondary data sources. For the documentary analysis, both public and internal information, not accessible to the public, from Embrapa and INIA were used, such as reports and digital archives from the two institutions. In the second step, the cases were classified into networks with innovations (success stories) in Brazil, networks that failed in innovation (failure stories) in Brazil, and innovative networks (success stories) in Spain.

To refine both the theoretical and methodological aspects and the research propositions and to broaden the understanding of the research field, pilot case studies were carried out. The pilot case study, according to Yin (2017), should not be understood as a pre-test (used to refine and validate data collection instruments), as its function is to support the researcher in refining the research design, allowing the questions and propositions formulated to be aligned and some theoretical aspects of the research to be clarified. The pilot case studies took place at Embrapa (Brazil) and INIA (Spain) through interviews, as detailed in Table 4 (data collection), managers in both organisations who worked in the context of the final cases investigated in this research were interviewed.

Data collection, which included document analysis, interviews and the use of questionnaires, sought answers from the leaders of the RD&I projects (i.e., the network manager). The deliberate choice of this actor to represent the organisation to answer about the network was because the networks studied here are temporary and dynamic, so it takes several projects (with a beginning, middle and end) to develop the technology. The organisations contained in the network of the first project may not continue until the end, and new institutions may join in the final project.

Therefore, only the leader organisation, represented by the leader researcher of the research projects, can have a holistic view of the variables to be measured. Many of the institutions that took part did not know the others (the network as a whole), so they could not answer the questions. The data collection stages can therefore be visualised in Table 4.

The primary data were obtained through an online questionnaire using the LimeSurvey program. In this phase, case studies were investigated (i.e., research networks and the development of technologies, or varieties, which are made available through seeds or seedlings, the result of a plant breeding programme). The categories present in the questionnaire were developed based on the literature. The measurement instrument met the criteria of validity and reliability (Villavicencio, 2011). The questionnaire was submitted to the evaluation of judges, as specialists in scientific content and in the method adopted or in the development of data collection instruments (Villavicencio, 2011). Lynn (1986) recommended a minimum of five and a maximum of ten participants in this process. This research involved the participation of 10 judges from Brazil and Spain, chosen according to these criteria, five for the validity stage and another five for the reliability stage, involving both qualitative (opinions for improvement) and quantitative (Cronbach's alpha) procedures. Finally, the pre-test was carried out in both Spain and Brazil as an additional measure to guarantee the

**Table 1**
Number of respondents (selected cases).

| Country | Cases | Quantitative | Crops/species |
|---|---|---|---|
| Brazil | Unsuccessful | 09 | Wheat, potatoes, dry rice, tropical rice, black beans, carioca beans, table tomatoes, GM soybeans and conventional soybeans. |
| | Success | 08 | Wheat, potatoes, dry rice, tropical rice, black beans, carioca beans, table tomatoes and GM soya. |
| Spain | Success | 08 | Wheat, strawberry, brassica, pepper, barley, maize and custard apple. |
| **Total of Networks** | | **25** | Grouped into grains, winter cereals, vegetables and fruits. |

Source: Own elaboration.

**Table 2**
Typology of organisations participating in interorganisational networks in Brazil.

| Category | No. of networks | % |
|---|---|---|
| Embrapa research unit | 17 | 100.00 % |
| Embrapa service unit | 11 | 64.71 % |
| Embrapa central unit | 0 | 0.00 % |
| Federal or state university | 8 | 47.06 % |
| Federal Institute of Education, Science and Technology | 3 | 17.65 % |
| Governmental research institution (federal or state) | 9 | 52.94 % |
| Private research institution (national or foreign) | 2 | 11.76 % |
| National or international private institutions (industries, seed companies, multinationals, etc.) | 9 | 52.94 % |
| Third sector (organised civil society) | 0 | 0.00 % |
| Consulting company | 1 | 5.88 % |
| Rural extension agency | 6 | 35.29 % |
| Others | 2 | 11.76 % |

Source: Own elaboration.

**Table 3**
Typology of organisations participating in interorganisational networks in Spain.

| Category | Number | % |
|---|---|---|
| Governmental research institution (national or regional) | 8 | 100 % |
| Private research institution (national or regional) | 2 | 25 % |
| Foreign research institution | 2 | 25 % |
| Other private national or international non-research institutions (industries, seed companies, multinationals, etc.) | 4 | 50 % |
| Consulting company | 0 | 0 % |
| Others | 0 | 0 % |

Source: Own elaboration.

**Table 4**
Data collection phases.

| Phase | Activity |
|---|---|
| **Documentary Analysis in Brazil** | List of cultivars (with information on the name of the cultivars, the species, the date of registration and protection, the name of the licensee, the duration of the partnership, etc.).<br>Proposal cultivar adjustments (data on some crops, containing various pieces of information, including the average yield of groups of cultivars of these species).<br>Spreadsheet 'financial-cubo' (robust spreadsheet with a large amount of confidential data on the various species and cultivars with Embrapa technology, with emphasis on net collection data and the year of the note generated).<br>RD&I projects (confidential research projects approved—completed and in progress—under the plant breeding macro-programme).<br>Final report of contracted market research (market data for some of the main agricultural crops on the participation of Embrapa technologies and those of other companies in the sector). |
| **Documentary Analysis Spain** | INIA Memory.<br>National PD&I Plan.<br>INIA's Strategic Plan.<br>Spreadsheet systematising cases (renowned researchers and research institutions). |
| **Pilot- applied Interview questionnaire** | Interview with the coordinator of one of the macro-programmes, located in the Research and Development Department, Embrapa Headquarters – Brazil.<br>Simultaneous interview with two people: the department head, and an analyst of the Multilateral Relations Department of the 'General Sub Directorate for Prospecting and Programme Coordination at INIA – Spain. |
| **Questionnaire test** | Questionnaire based on the literature, using the questionnaire from the Industrial Survey of Technological Innovation (PINTEC, 2011).<br>A pre-test of the questionnaire was carried out, asking people to make their own judgements about the questionnaire, in Brazil and Spain, and six contributions were received.<br>Finalisation of the questionnaires (with contributions provided by judges and pre-test respondents) that were applied in the survey in Brazil and Spain. |
| **Questionnaire application** | The online questionnaire was constructed and applied using the LimeSurvey programme, with versions in Portuguese and Spanish.<br>Messages sent to the target audience by e-mail, detailing the instructional aspects of this research.<br>Storage of responses from the target audience (Brazil and Spain) in the LimeSurvey programme database. |

Source: Own elaboration.

suitability of the questionnaire. The variables that influence innovation can be seen in Table 5.

### 3.3. Data processing

Considering the phenomenon under investigation, QCA was used, which offers comparative research with a systematic and precise method based on mathematics (Boolean algebra) and formal logic (Ragin, 1987). Furthermore, according to Wagemann (2012), the QCA method is a technique that allows the analysis of an intermediate number of cases (it would prevent issues concerning the number to perform a case study where the N must be small, or statistical analysis where a high number of cases is required). It is also a method

**Table 5**
Table showing the explanatory variables of the model.

| | | |
|---|---|---|
| **NETWORK ATTRIBUTES** | **V1 Size of the network** (Thorgren et al., 2009) | 1.1. Identification of the organisations that participate in the network.<br>1.2. Number of organisations in the formal and in the informal networks.<br>1.3. Perception on the number of organisations in the network (small, medium and large). |
| | **V2 Strength of the ties** (Granovetter, 1973; Molina-Morales et al., 2008) | 2.1. Frequency of contacts.<br>2.2. Amount of time on the network projects.<br>2.3. Mobility of staff members (researchers and technicians) among network organisations.<br>2.4. Common goals shared within the network.<br>2.5. Social relationships with people from other organisations in the network. |
| | **V3 Density of the network** (Lazzarini, 2008; Molina-Morales et al., 2008) | 3.1. Intensity of the relationships among all the organisations in the network.<br>3.2. Intensity of the relationships between the leader organisation and the rest.<br>3.3. Closed nature of the relationships among organisations outside the formal network. |
| | **V4 Organisational configuration** (Hoffmann et al., 2007) | 4.1. Directionality (vertical or horizontal).<br>4.2. Location (geographically dispersed or agglomerated).<br>4.3. Formalisation (formal contractual status or informal—with no contract).<br>4.4. Power (orbital or non-orbital). |
| **RESOURCES AVAILABLE IN THE NETWORK** | **V5 Resources (tangible and intangible)** (Barney, 1991; Pike et al., 2005; Barney and Clark, 2007; Gonçalves et al., 2011) | *Physical Resources (for Innovation)*<br>5.1. Facilities.<br>5.2. Equipment.<br>5.3. Products and materials.<br>5.4. Service infrastructure.<br>*Human Resources (for innovation)*<br>5.5. Research and Development (R&D) capacity.<br>5.6. Management capacity.<br>5.7. Commercial alignment.<br>5.8. Cooperative associations capacity.<br>5.9. Learning.<br>*Financial Resources (for Innovation)*<br>5.10. Funding through calls for proposals, within the limit set in the call for projects.<br>5.11. Funding through calls for proposals, higher than the maximum set in the call for proposals.<br>5.12. Funding exclusively from other external organisations.<br>5.13. Funding with both public money (projects) and from other non-public organisations.<br>*Organisational Resources (for Innovation)*<br>5.14. Intellectual property.<br>5.15. Organisational structure.<br>5.16. Processes.<br>5.17. Image and brand.<br>5.18. Organisational culture.<br>5.19. Detailed information on the market segment.<br>5.20. Organisational strategy.<br>*Complementarity of resources*<br>5.21. Role of the organisation in the complementarity of resources (financial, human, physical and organisational). |
| **INNOVATION** | **V6 Innovation** (OECD/Eurostat, 2018; Dushnitsky and Lenox, 2005; Dias et al., 2019) | 6.1. It derives from the creation of a tangible product (variety) that has reached the market or society.<br>6.2. Average profitability figure (royalties and/or seed sales) over the last 5 years. |

Source: Own elaboration.

that allows the number of variables to be larger than the number of cases (Roig-Tierno et al., 2017).

Crisp-set qualitative comparative analysis (csQCA) was also used, which is a method of analysis using binary datasets (Ragin, 1987), where 1 (one) symbolises the presence of the indicator in question and 0 (zero) its absence. The Boolean algebra analysis was implemented with the help of the Tosmana software (Tool for Small-N Analysis).

Table 6 shows the indicators of the variables identified in the research model, the process of dichotomisation of the causal conditions (i.e., the operationalisation of the Boolean technique, presence and absence) and the codes.

## 4. Results

We analysed all the variables of this study in terms of the ways to articulate causal complexity to obtain the dependent variable (i.e.,

**Table 6**
Model variables and their indicators, codes and values.

| VARIABLE | INDICATORS | CODES | VALUES |
|---|---|---|---|
| **V1 Size of the network** | 1.2. Number of organisations in the formal and in the informal networks | Large-size network | Large Network 1 = Presence; 0 = Absence |
| **V2 Strength of the ties** | 2.1. Frequency of contacts | F1_Freq_Contacts | 1 = High; 0 = Low |
| | 2.2. Amount of time on the projects of the network | F2_Time_Projects | 1 = High; 0 = Low |
| | 2.3. Mobility of staff members (researchers and technicians) among network organisations | F3_Mobility_team | 1 = Presence; 0 = Absence |
| | 2.4. Common goals shared within the network | F4_Common_goals | 1 = Presence; 0 = Absence |
| | 2.5. Social relationships with people from other organisations in the network | F5_Social_Relations | 1 = Presence; 0 = Absence |
| **V3 Density of the network** | 3.1. Intensity of the relationships among all the organisations in the network | D1_Intens_relat_Org | 1 = Presence; 0 = Absence |
| | 3.2. Intensity of the relationships between the leader organisation and the rest | D2_Int_conec_OrgLeader | 1 = Presence; 0 = Absence |
| | 3.3. Closed nature of the relationships among organisations outside the formal network | D3_Recur_Net_Form | 1 = Presence; 0 = Absence |
| **V4 Organisational configuration** | 4.1. Directionality (vertical or horizontal) | C1_Horizont_Direction | 1 = Horizontal; 0 = Vertical |
| | 4.2. Location (geographically dispersed or agglomerated) | C2_Agglomerated_Red | 1 = Agglomerated; 0 = Dispersed |
| | 4.3. Formalisation (formal contractual status, or informal—with no contract) | C3_Formalis_Contract | 1 = Formal; 0 = Informal |
| | 4.4. Power (orbital or non-orbital) | C4_Orbital_Power | 1 = Orbital Power; 0 = Non-orbital |
| **V5 Resources (tangible and intangible)** | ***Physical Resources (for Innovation)*** | | |
| | 5.1. Facilities | RPhys1_Facilities | 1 = Presence; 0 = Absence |
| | 5.2. Equipment | RPhys2_Equipm. | 1 = Presence; 0 = Absence |
| | 5.3. Products and materials | RPhys3_Prod_Mater | 1 = Presence; 0 = Absence |
| | 5.4. Service infrastructure | RPhys4_Servic Infra | 1 = Presence; 0 = Absence |
| | ***Human Resources (for Innovation)*** | | |
| | 5.5. Research and development (R&D) capacity | RHum1_Capac_R&D | 1 = Presence; 0 = Absence |
| | 5.6. Management capacity | RHum2_Manag_Capac | 1 = Presence; 0 = Absence |
| | 5.7. Commercial alignment | RHum3_Comer Align | 1 = Presence; 0 = Absence |
| | 5.8. Cooperative associations capacity | RHum4_Assoc_ Cap | 1 = Presence; 0 = Absence |
| | 5.9. Learning | RHum5_Learning | 1 = Presence; 0 = Absence |
| | ***Financial Resources (for innovation)*** | | |
| | 5.10. Funding through calls for proposals, within the limit set in the call for projects | RFin1_Inst_limit | 1 = Presence; 0 = Absence |
| | 5.11. Funding through calls for proposals, higher than the maximum set in the call for proposals | RFin2_Inst_Above | 1 = Presence; 0 = Absence |
| | 5.12. Funding exclusively from other external organisations | RFin3_External | 1 = Presence; 0 = Absence |
| | 5.13. Funding with both public money (projects) and from other non-public organisations | RFin4_Inter and Exter | 1 = Presence; 0 = Absence |
| | ***Organisational Resources (for innovation)*** | | |
| | 5.14. Intellectual property | ROrg1_Intellec_Prop | 1 = Presence; 0 = Absence |
| | 5.15. Organisational structure | ROrg2_Organis_Struct | 1 = Presence; 0 = Absence |
| | 5.16. Processes | ROrg3_Processes | 1 = Presence; 0 = Absence |
| | 5.17. Image and brand | ROrg4_Imag_Brand | 1 = Presence; 0 = Absence |
| | 5.18. Organisational culture | ROrg5_Organis Cult | 1 = Presence; 0 = Absence |
| | 5.19. Detailed information on the market segment | ROrg6_Info_Market | 1 = Presence; 0 = Absence |
| | 5.20. Organisational strategy | ROrg7_Org Strategy | 1 = Presence; 0 = Absence |
| **V6 Innovation (Dependent variable)** | ***Innovation*** | Innova_Perform | 1 = Success; 0 = Failure |
| | 6.1. It derives from the creation of a tangible product (variety) that has reached the market or society | | |
| | 6.2. Average profitability figure (royalties and/or seed sales) over the last 5 years | | |

Source: Own elaboration.

innovation), considering all the networks in Brazil and Spain. To this end, the 'best practice' procedures of Rihoux and De Meur (2009) were followed, and these variables were dichotomised using the median occurrence of the conditions in each case (i.e., with the median value for the variables of this study). The comparative qualitative analysis showed the set of variables influencing the successful outcome (Table 7), in a first step with just Brazilian networks.

The reduced equation obtained by the logic minimisation in Table 7 are Equation 1 and Equation 2, as follow:

Strength_Ties {1}+C4_Orbital_Power{1}*Resources{1} +

Density{1}*C4_ Orbital_Power {0}*Resources{0} → Innovation (1)

Strength_Ties {1}+C4_Orbital_Power{1}*Resources{1} +

C3_Formalis_Contract {1}*C4_ Orbital_Power {0}*Resources{0} → Innovation (2)

Equations 1 and 2 with Brazilian Networks show three combination sets. The first and second sets are the same in both minimized logic equations from Brazilian Networks (Table 7) and Brazilian and Spanish Networks (Table 8): *Strength_Ties{1} + C4_Orbital_Power{1}*Resources{1}*. The third combination set can explain just two Brazilian Networks successes (*BR_Success_1 + BR_Sucess_7*) (see Table 7).

The QCA showing the set of variables influencing successful outcomes (Table 8) is the main analysis of our study. Results that include data from Brazil and Spain simplify the logic equation with more accuracy and show a combination of conditions that influences innovation performance.

The reduced equation obtained by the logic minimisation in Table 8 shows specifically the result obtained with the logic equation with parsimony:

Strength_Ties{1} + C4_Orbital_Power{1}*Resources{1} + Size{0}*C4_ Orbital_Power {0}*Resources{0} + Size{1}*Density{1}*C2 Agglomerated_Red {0}*Resources{0} → Innovation

**Table 7**
Reduced equation of variables influencing success in Brazilian networks.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tosmana Report | | | | | | | | | |
| Algorithm: Graph-based Agent | | | | | | | | | |
| Settings: | | | | | | | | | |
| | Minimizing: | 1 | | | | | | | |
| | including | C R | | | | | | | |
| Truth Table: | | | | | | | | | |
| v1: | Size | v2: Strength of the ties | | | | | | | |
| v3: | Density | v4: Resources | | | | | | | |
| v5: | C1_Horizont Direction | v6: C2_Agglomerated_Red | | | | | | | |
| v7: | C3_Formal_Contract | v8: C4_Power_Orbital | | | | | | | |
| O: | Innova_Perform | id: | Cases | | | | | | |
| **v1** | **v2** | **v3** | **v4** | **v5** | **v6** | **v7** | **v8** | **O** | **id** |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | BR_Ins_2 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | C | BR_Ins_4(0), BR_Suc_4 (1) |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | BR_Ins_6 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | BR_Ins_5 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | BR_Suc_6 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | BR_Suc_7 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | BR_Suc_3 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | BR_Suc_5 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | BR_Ins_1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | BR_Ins_7 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | BR_Suc_8 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | BR_Ins_3 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | BR_Suc_1 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | BR_Ins_8 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | BR_Ins_9 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | BR_Suc_2 |
| Result(s): | | | | | | | | | |
| | Strength_Ties {1}+C4_Orbital_Power{1}*Resources{1} +Density{1}*C4_ Orbital_Power {0}*Resources{0} | | | | | | | | |
| | (BR_Suc_2 +BR_Suc_3 +BR_Suc_5)(BR_Suc_5 +BR_Suc_6 +BR_Suc_8)(BR_Suc_1 +BR_Suc_7) | | | | | | | | |
| | Strength_Ties {1}+C4_Orbital_Power{1}*Resources{1} + C3_Formal_Contract {1}*C4_ Orbital_Power {0}*Resources{0} | | | | | | | | |
| | (BR_Suc_2 +BR_Suc_3 +BR_Suc_5)(BR_Suc_5 +BR_Suc_6 +BR_Suc_8)(BR_Suc_1 +BR_Suc_7) | | | | | | | | |
| Created with Tosmana Version 1.61 | | | | | | | | | |

Source: research data

**Table 8**
Reduced equation of variables influencing success.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tosmana Report | | | | | | | | | |
| Algorithm: Graph-based Agent | | | | | | | | | |
| Settings: | | | | | | | | | |
| | Minimizing: | 1 | | | | | | | |
| | including | | C R | | | | | | |
| Truth Table: | | | | | | | | | |
| | v1: | Size | v2: Strength of the ties | | | | | | |
| | v3: | Density | v4: Resources | | | | | | |
| | v5: | C1_Horizont Direction | v6: C2_Agglomerated_Red | | | | | | |
| | v7: | C3_Formalis_Contract | v8: C4_Power_Orbital | | | | | | |
| O: | Innova_Perform | id: | Cases | | | | | | |
| **v1** | **v2** | **v3** | **v4** | **v5** | **v6** | **v7** | **v8** | **O** | **id** |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ES_Success_7 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | BR_Failure_2 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | C | BR_ Failure _4(0), BR_Success_4(1) |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | ES_Success_8 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | BR_Failure_6 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | BR_Failure_5 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | BR_Success_6 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | ES_Success_3 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | BR_Success_7 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | BR_Success_3 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | ES_Success_6 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | BR_Success_5 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | BR_Failure_1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | BR_Failure_7 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | BR_Success_8 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | BR_Failure_3 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | BR_Success_1 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | BR_Failure_8 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | BR_Failure_9 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | ES_Success_5 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | ES_Success_4 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | BR_Success_2 |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | ES_Success_2 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | ES_Success_1 |
| Result(s): | | | | | | | | | |
| | Strength_Ties {1} + C4_Orbital_Power {1}* Resources {1} + Size {0}* C4_Orbital_Power {0}* Resources {0}+Size {1}* Density {1} * C2_Agglomerated_Red {0}* Resources {0} | | | | | | | | |
| | (BR_Success_2 +BR_Success_3 +BR_Success_5 +ES_Success_1 +ES_Success_2 +ES_Success_6) | | | | | | | | |
| | (BR_Success_5 +BR_Success_6 +BR_Success_8) | | | | | | | | |
| | (BR_Success_7 +ES_Success_3 +ES_Success_7 +ES_Success_8) | | | | | | | | |
| | (BR_Success_1 +ES_Success_1 +ES_Success_2 +ES_Success_4 +ES_Success_5) | | | | | | | | |
| Created with Tosmana Version 1.61 | | | | | | | | | |

Source: research data

To analyse the result of the minimised equation, the ways of articulating causal complexity to obtain the result are shown: asymmetric causality, equifinality, and conjunctural causality (Wagemann, 2012).

Wagemann (2012) clarified that asymmetric causality is about the search for the causes of a successful outcome, as is the analysis through quantitative methods, but it also aims to determine the causes of an opposing outcome. In this sense, analyses were carried out for the unsuccessful outcome for each individual variable.

Equifinality is expressed in the fact that there can be more than one sufficient (but not necessary) condition to achieve a result. The result of the variables of the first two combinations (e.g., *'Strength_Ties{1}+C4_Orbital_Power{1}*Resources{1} + …'*) shows that these are sufficient but not necessary conditions: if there were no strong ties in the networks, innovation could also be achieved by the combined presence of networks with 'orbital power' (C4) and networks with the presence of many different types of 'resources', both combinations can be present at the same time in successful networks.

Thus, in equifinality, causal conditions count as an 'ingredient' with which a complex causal relationship can be modelled, since in the social sciences, one does not arrive at certain results univocally (i.e., with only one possibility) by introducing several factors summed-up in the logic equation. On the contrary, social reality forces us to discover several paths to the result based on the analyses.

Lastly, conjunctural causality consists in the fact that sometimes one condition alone is not sufficient, as it must exist to be combined in the context of more than one variable. In this regard, for example, the 'density' variable in this study stands out; its analysis in isolation showed no influence on performance. Yet the large size of the network combined with the high density, geographically dispersed type of network (c2) and the low variability of resource types in the combination *(Size{1}*Density{1} *C2_Agglomerated_Red {0} *Resources{0})* are sufficient to achieve innovative performance—that is, the variable 'network size' must be combined with more than one variable in the form of conjunctural causality.

The configuration of the relationship between all the study variables with 'innovation' (the dependent variable) is summarised in Table 9.

The summary table shows that the variable 'strength of the ties' alone is a sufficient, but not necessary condition, because there are other combinations that also achieve the result, according to the equifinality of QCA. This result showed that only successful networks include in their configurations the presence of high strength ties contained in several networks, as can be seen in the isolated analysis of the 'strength of the ties' variable.

The variables size; density; configuration: (C2) location (i.e., dispersed networks) and (C4) power (i.e., capacity for orbital or non-orbital decisions); and resources are neither necessary nor sufficient conditions on their own. They need to be combined with others to achieve innovation, according to conjunctural causality as one of the ways of considering the causal complexity of the phenomenon under study.

In this sense, analysing each set of combinations, in addition to the sufficient condition, (i.e., high strength of the ties) happens in the first of these combinations; in the second, we obtain the presence of networks with orbital power (C4), combined with the presence of many different types of resources in the networks, as can be seen in this part of the equation: *'C4_Orbital_Power {1}* Resources {1}'*. In this set of variables, for networks with many types of resources, the centralisation of decision-making power in the leader organisation is also a necessary condition to achieve innovation.

The third combination for obtaining the result is the association of small networks and the decision-making capacity (power) on matters affecting the project, which is distributed in each organisation in the network; and also, networks with low diversity of resources, as we can see in the third combination of the equation *'Size {0} * c4_Orbital_Power {0} * Resources {0}'*. Here, we observe cases of networks with a low number of organisations, and since they were key organisations, there was no centralisation of decision-making power; they were all relevant to the network and presented high quality in the resources of each organisation, although these resources were not diversified. In this sense, the individual analysis of the variable 'resources' shows us which resources are a priority for the agricultural research networks; among them, physical resources, such as facilities and equipment, were present in all the networks in Brazil, thus showing the need for this type of resource.

Lastly, the fourth combination obtained shows the existence of large, dense and geographically dispersed networks. The combination of the last variable is the only one that changes in the two equations, and its equation is added to the *'Size {1} * Density {1} * e2_Agglomerated_Red {0} * Resources {0}'*. The fourth combination of variables in the equation shows that to achieve innovation, large networks need high connectivity between organisations (high density), and they also need to be geographically dispersed and have a low presence of resource diversity.

Not only does this combination show that the individual analysis of the variables 'size', 'density' and 'configuration (network types)' has a clear influence on innovation performance but also that combining them leads to good results. Networks with a larger number of organisations (larger networks) should achieve an interrelationship between organisations with higher density so that resource sharing is allowed, and some are not isolated without resource complementarity; they also need to be geographically dispersed. This characteristic is important to test/validate technology in different regions with different climatic and agronomic conditions. However, empirical evidence shows that a wide range of physical, human, financial and organisational resources is not necessary, as it is the quality of the resources, rather than their diversity, that contributes to the outcome of the innovation.

**Table 9**
Summary of the analysis of the relation among the variables.

| ***Response Variable (Outcome)*** | **Variables** | | | | | |
|---|---|---|---|---|---|---|
| | **Minimised equation** | **Necessary condition** | **Sufficient condition** | **Neither necessary nor sufficient condition** | **Superfluous condition / absent in the equations** | **Cases** |
| **Innovation** | Strength_Ties{1} +C4_Orbital_Power{1} *Resources{1}+ Size{0}*C4_Orbital_Power {0}*Resources{0}+ Size{1}*Density {1} *C2_Agglomerated_Red{0}*Resources{0} | No condition is required in the equation | Strength of ties | Size;<br>Density;<br>Location: dispersed networks;<br>Power: capacity for orbital decision or not;<br>Resources | Horizontal directionality;<br>and<br>Contracts entered into | BR_Success_1<br>BR_Success_2<br>BR_Success_3<br>BR_Success_5<br>BR_Success_6<br>BR_Success_8<br>SP_Success_1<br>SP_Success_2<br>SP_Success_3<br>SP_Success_4<br>SP_Success_5<br>SP_Success_6<br>SP_Success_7<br>SP_Success_8 |

Source: research data

It should be noted that these four combinations, according to Wagemann (2012), can be present simultaneously in the success stories (i.e., a single combination), with more than one combination or all of them at the same time.

## 5. Discussion

As posited by Corsaro and Cantù (2015) and Scott et al. (2021), innovation is a process involving a set of business stakeholders. Furthermore, limited knowledge exists regarding the collaborative practices employed by actors in the agrifood supply chain to address problems (Annosi et al., 2021). Our findings indicate that innovation development in agribusiness using a network approach is not a firm level phenomenon. Rather, it is a set of long-term relationships that aim to generate competitive advantage for network members, due to new products (Dias et al., 2021). So, the definition of an innovation network as a heterogeneous interorganisational model, as presented by Piazza et al. (2019), is an appropriate fit for the agribusiness networks that were the subject of our investigation.

The result of the QCA with all the explanatory variables shows that when associated with the variables 'size', 'territorially dispersed network type' and 'resources', dense networks (most cases) become an essential and necessary attribute in combination with others to influence innovation outcomes. These results are in line with the findings of the research by Gaitán-Cremaschi et al. (2022), in the context of family farming, which, although there is no 'ideal' network structure for innovation, trade-offs will always need to be managed in terms of network structure, density, diversity and composition. Moreover, they reinforce the fact that in knowledge-based networks, a significant presence of territorially clustered stakeholders is not common in either the manufacturing sector (Belussi and Porcellato, 2012) or in agribusiness (Canevari-Luzardo (2019). Although, when considering Maori local networks in New Zealand, where social capital drives the knowledge exchange (Rout et al., 2020), our results may appear contradictory. In agribusiness, various network arrangements can be found (Canevari-Luzardo, 2019), which can be either informal and formal (Rey et al., 2023, Sedita et al., 2021), or exclusively formal (Polidoro and Paula, 2024), or even exclusively informal (Rout et al., 2020). In agribusiness, formal agreements can be particularly useful in networks where innovation in products are protected by patents (Polidoro and Paula, 2024), as they can help to minimise some eventual risk of opportunistic behaviour. The literature we consulted about production on manufacturing (Hoffmann et al., 2014; Molina-Morales et al., 2008) and agribusiness (Sedita et al., 2021; Serrano et al., 2023) suggests that territorial proximity facilitates knowledge exchange and innovation. However, the knowledge network we studied in agribusiness, communication technologies can overcome the limitations of territorial context.

In this aspect, it is worth highlighting the fact that in Brazil, international firms and research centres are present in 9 of the 16 networks studied, while in Spain they are present in four out of eight. Thus, we observe that the percentage of internationalisation is practically the same in both countries. Unlike other networks analysed (i.e., clustered networks), where innovation is driven by resources (Hoffmann et al., 2014) or local stakeholders (Piazza et al., 2019), having international stakeholders seems to be more common, at least in half of the networks we have examined. They are multinational enterprises that are present in Brazil and in Spain. So, we can say that they are not just national or just international firms, although the reason for this kind of limit is not so clear when we are dealing with knowledge networks. The work regarding the Spanish wine industry (Serrano et al., 2023) sheds light on this point. Their results show that taking part in a network facilitates internationalisation by giving firms access to specific knowledge about this process. In the Italian wine industry studied by Sedita et al. (2021), the scarcity of members with international experience creates a low-density network at the commercialization stage. In our case, our results emphasise that if the scope of the network is to generate innovation, having members with international experience may not be relevant for success, but it is a best practice.

In their work, Haniff and Galloway (2022) noted that in project networks, it is necessary to have common objectives in addition to considering the complexity of the project clients themselves. Our results place us in networks closer to those of Haniff and Galloway (2022) and Wiśniewska-Paluszak and Paluszak (2019), as opposed to those studied in the work of Piazza et al. (2019). But being closer does not mean being the same. In the networks we analysed, there is an important component, which is the risk involved in any R&D activity. In the agribusiness networks we investigated, this risk is shared between the different stakeholders that make up the network, both national and international. Because of their size, international firms have larger budgets to devote to R&D investment, as evidenced by Ding (2022). Therefore, firms seek to position themselves, through their strategies, in networks with these characteristics. Thus, both Embrapa and INIA make it easier for their stakeholders to incorporate knowledge from outside the network, as these associations are present in different projects in several countries. This allows Embrapa and INIA to reduce the risks in their own strategies and increase their capacity to invest in R&D, a necessary condition to attain higher performance in innovation (Ding, 2022). In the networks we studied, each of the network organisations were largely similar in their monitoring of their constituents to prevent opportunistic behaviours among. The network is created based on a general contract that encompasses many different investigations simultaneously, but an informal network also operates, focusing the network performance as observed in other informal networks (Rout et al., 2020). The networks studied may take 8–12 years to produce a positive or negative result. This perspective highlights the importance of having a common objective, whether it be innovation, as evidenced by our study, or the pursuit of increased profitability, as highlighted by Wiśniewska-Paluszak and Paluszak (2019).

Regarding density, we can say that when it is higher, it can have some consequences in organisations, including the promotion of trust and cooperation (Coleman, 1988) and interdependence among its members. The first aspect of trust and cooperation can be considered positive, but according to the literature, interdependence is not necessarily so, since, as Molina-Morales et al. (2008) pointed out, there may be redundancy and with it a lower volume of knowledge exchange (Belussi and Porcellato, 2012). This research represents a step forwards, as it shows that network density can have a positive aspect when combined with other network characteristics in the agribusiness. A network that is denser from the point of view of the exchanged knowledge can therefore obtain good results when combined with other variables. The knowledge we deal with in these networks is different from that explored by

Hoffmann et al. (2014) and Sedita et al. (2021). In these two previous papers, it was technical knowledge, which can have a quadratic effect (an inverted 'U' shape) on innovation, as we have already seen with other variables (Jiang et al., 2022). In the Italian wine industry studied by Sedita et al. (2021), the network becomes less dense as the process approaches commercialization. This was due to actors being hesitant to share knowledge in relation to the international market, thus limiting opportunities for knowledge sharing. The study by Canevari-Luzardo (2019) demonstrated that in agribusiness business associations can facilitate the connections among the other actors influencing the information flow. Our study revealed that the issue at hand differs because the actors are largely the same, and they possess both formal and informal networks. However, density alone is insufficient as the target, since innovation requires additional network characteristics.

The result of the joint analysis of the variables, as far as interorganisational configurations are concerned, shows the need for orbital type networks combined with a high diversity of resources as explanatory factors for innovation. This is corroborated by Gaitán--Cremaschi et al. (2022), so the centralisation is the other trade-off that will always need to be managed for innovation in public food procurement from family farming. The result can also be achieved by non-orbital networks combined with small networks and low resource diversity or with dispersed networks in combination with other variables. Empirical studies on networks show that in other countries gains from networks derived from clusters were evidenced (Molina-Morales and Martínez-Fernández, 2003) and promote regional innovation capability (Huang et al., 2022), although territorially dispersed networks can also be found, mainly knowledge networks (Dyer and Singh, 1998), which can likewise provide their participants with gains (Belussi and Porcellato, 2012). Networks in agribusiness vary from one to another. For example, they can be intensive in social capital or intensive in production process (Sedita et al., 2021), with formal and or informal ties (Li et al., 2022; Rout et al., 2020). Nevertheless, the strength of ties is an important element in our, and in other, studies on agribusiness, as these ties are associated with cooperation and cooperation is linked to innovation (Geldés et al. (2017). The networks we studied cooperatively provide solutions to address real problems faced by farmers as previously highlighted by Silva et al. (2023).

The joint analysis of all the variables showed that resources are an integral and necessary part of combining various conditions to improve performance, as evidenced in the findings from Kusa et al. (2021). Resources, together with other network attributes, can influence innovative performance. This is also a contribution from our study because we are extending the use of the RBV. RBV was originally conceived by Barney (1991) for firms. Previously, RBV was applied to study clustered networks by Molina-Morales et al. (2011) in Spain and by Hoffmann et al. (2014) in Brazil, and now we have used RBV for geographically dispersed networks. One aspect that should not be forgotten is the absorptive capacity of firms to generate innovation (Jiang et al., 2022). In other words, it is not enough to possess or have access to resources; one must also know how to put them to good use (Hoffmann et al., 2014). And when these networks are created from the outset with different national and international stakeholders (Scheiterle et al., 2018) and the motivation to explore the complementarity of their resources (Fieldsend et al., 2020), reaching innovation seems less difficult. A study by Polidoro and Paula (2024) describes how the complementarity of resources between partners in an agribusiness network can generate innovation and patents. However, these authors found that each firm member should have its own resources to be able to access the resources of the network. Moreover, Polidoro and Paula (2024) deal with the same networks we do. Therefore, their study and our results point to the same aspect: a firm with its own resources can participate in a network to access these network resources. To many agribusiness firms, participation in a network such as this represents a more cost-effective solution and may be the only viable option for accessing these resources (Dall'Agnol et al., 2021). In agri-food digital innovation ecosystems, a minimal viable ecosystem emerges only after substantial resources, time, and ingenuity is invested, and it may also require external intervention, such as that from the government (Wolfert et al., 2023).

It is worth noting that we sought to know whether the outcome is also influenced by the diversity of resources. Hence, after the comparative qualitative analysis of the networks of both countries, the results showed that in the last combination of variables, 'resources' influence innovation through their quality and not through the diversity of their attributes. This is a contribution that seems important to us, since whenever we talk about networked innovation contexts, complementarity appears as a plausible justification (Chabbouh & Boujelbene, 2020; Piazza et al., 2019). In short, networks are based on objective principles, such as complementarity of roles (Vieira et al., 2022) and of resources (Piazza et al., 2019). In the networks we investigated, the complementarity of roles is clear; they invite international companies to take part in the network of firms because Embrapa and INIA do not have a logistics background to access the market when the output from the network can be sold.

For both countries, our results prove that the influence of the complementarity of resources and attributes of interorganisational networks result in successful performance, and which necessarily need to be combined for the outcome to be achieved. The result also shows which network attributes identified in the literature are relevant, when acting in parallel with other essential attributes.

## 6. Conclusions and recommendations

The main conclusions we have drawn are the following: i) in the context of interorganisational knowledge networks, the 'strength of the ties' variable is decisive and sufficient to influence innovation; ii) the 'density', 'size' and 'configuration' variables (agglomeration, power, contractual formalisation and directionality) of networks are not sufficient on their own to explain innovative performance; and iii) despite the vast body of literature pointing to territorial agglomeration (clustered networks) as a source of network resources, dispersed networks combined with other different configurations in their structure can generate innovations in knowledge networks.

As Kühne et al. (2015) argued, cognitive proximity fosters innovation. The partnership actors build is a long-term network, which they use as knowledge-based networks. We have here a typical project network with a limited scope and a typical social network with a wide scope. Actors share risks, which means the R&D projects are not always successful. If they are not, actors lose resources and time.

But if they are, actors can share revenues. If the social network can overcome these eventual negative outputs, it may be because actors have cognitive proximity to one another.

Regarding the limitations of our research, the data collection itself is a complicating factor, as the sociocultural context in Brazil and Spain must be considered. Furthermore, with QCA, it is not possible to establish whether the dependent variable increases or decreases in relation to how much the value of the independent variables under study varies. Yet QCA makes it possible to investigate in a combined way all the variables contained in the model of this research and to check if there is any arrangement or order of isolated variables that need to be combined to achieve innovative performance. We studied cases from different countries, that is why we have chosen Crisp-Set QCA. Even though it is a promising technique (Kraus et al., 2018, Kumar et al., 2022), the use of a fuzzy set QCA depends on the definition of the values. According to Ragin (1987), this definition is contextual. So, with different countries we could have problems defining the values. Thus, this is another limitation of our paper.

We studied Brazilian and Spanish innovative networks that are nationally relevant to agribusiness. We avoid dealing with potential national factors that could influence the conclusions regarding some of the dimensions we investigated. However, we must consider that the institutions supporting these knowledge-based networks can be so different from one country to another (Fieldsend et al., 2020). In that case, results can be different because institutional structures are different. This is a limitation of our paper. For future research, the number of variables under examination should be increased while also considering some institutional aspects, such as cooperation propensity.

In addition, the empirical research networks in the agricultural research sector in the context of plant breeding programmes, while not precluding the generalisability of the results, can be complemented by other research analyses in different contexts in the same sector and in different sectors. We believe that the pharmaceutical sector also has great potential for testing some of the propositions we have outlined in this paper.

## CRediT authorship contribution statement

**Valmir Emil Hoffmann:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Funding acquisition, Conceptualization. **Cleidson Nogueira Dias:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Teresa Martínez-Fernández:** Writing – review & editing, Visualization, Validation, Supervision, Funding acquisition, Conceptualization.

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