

ANALYSIS OF THE COOPERATION NETWORK WITHIN AN INNOVATION ECOSYSTEM IN THE INTERIOR OF SÃO PAULO STATE

ESTUDO DA REDE DE COOPERAÇÃO DE UM ECOSISTEMA DE INOVAÇÃO DO INTERIOR DO ESTADO DE SÃO PAULO

ESTUDIO DE LA RED DE COOPERACIÓN DE UN ECOSISTEMA DE INNOVACIÓN EN EL INTERIOR DEL ESTADO DE SÃO PAULO



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ABSTRACT

This research addresses the importance of cooperation networks between public, private, and third-sector institutions, driven by technological advancements and the need for agile responses to social and economic challenges. These networks favor the exchange of knowledge, the articulation of resources, and the collective construction of innovative solutions, especially in the fields of education, research, and innovation. In this context, innovation ecosystems emerge as interconnected environments that promote synergies among skills, infrastructure, and human capital, generating value and transforming territories. The research presented focuses on the Alta Paulista region, in São Paulo, and seeks to understand how cooperation networks are structured in education and innovation ecosystems. The study uses Social Network Analysis (SNA), supported by Netdraw® and UCINET® software, to map interactions, identify subgroups, and measure structural indicators. The methodology combines qualitative and quantitative approaches, characterizing itself as exploratory and descriptive, and includes document analysis and bibliographic review in scientific databases. The results reveal low density in the global network (0.011), indicating few connections relative to the existing potential, but higher density in the innovation sub-network (0.033), suggesting more exchanges, although still insufficient. The centrality of FSNTEDUC (55.8%) and FSNTPESQINOV (30.4%) highlights the strategic role of the Shunji Nishimura Foundation of Technology (FSNT) as an articulator in education, research, and innovation. In specific sub-networks, FSNTPESQINOV achieves centrality of 87.3%, reinforcing its influence on network dynamics. It is concluded that FSNT plays a central role in the Alta Paulista ecosystem, acting on several fronts—education, research, innovation, entrepreneurship, culture, and services—and consolidating itself as a strategic agent in the dissemination of information, coordination of projects, and strengthening of governance. Improving the network, with greater connectivity and stronger ties, can expand collaboration among actors, enhancing social, economic, and technological impacts, especially in agribusiness.

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Keywords: Social Network Analysis. Innovation. Cooperation. Innovation Ecosystem.

RESUMO

A presente pesquisa aborda a importância das redes de cooperação entre instituições públicas, privadas e do terceiro setor, impulsionadas pelo avanço tecnológico e pela necessidade de respostas ágeis a desafios sociais e econômicos. Essas redes favorecem a troca de conhecimento, a articulação de recursos e a construção coletiva de soluções inovadoras, especialmente nos campos da educação e da inovação. Nesse contexto, surgem os ecossistemas de inovação, ambientes interconectados que promovem sinergias entre competências, infraestrutura e capital humano, gerando valor e transformando territórios. A pesquisa apresentada concentra-se na região da Alta Paulista, em São Paulo, e busca compreender como se estruturam as redes de cooperação em ecossistemas de educação, pesquisa e inovação. O estudo utiliza a Análise de Redes Sociais (ARS), apoiada pelos softwares Netdraw® e UCINET®, para mapear interações, identificar subgrupos e mensurar indicadores estruturais. A metodologia combina abordagens qualitativas e quantitativas, caracterizando-se como exploratória e descritiva, e inclui análise documental e revisão bibliográfica em bases científicas. Os resultados revelam baixa densidade na rede global (0,011), indicando poucas conexões em relação ao potencial existente, mas maior densidade na sub-rede de inovação (0,033), sugerindo mais trocas, embora ainda insuficientes. A centralidade das sub-redes FSNTEDUC (55,8%) e FSNTPESQINOV (30,4%) evidencia o papel estratégico da Fundação Shunji Nishimura de Tecnologia (FSNT) como articuladora em educação, pesquisa e inovação. Em sub-redes específicas, a FSNTPESQINOV alcança 87,3% de centralidade, reforçando sua influência na dinâmica da rede. Conclui-se que a FSNT exerce papel central no ecossistema de inovação da Alta Paulista, atuando em diversas frentes — educação, pesquisa, inovação, empreendedorismo, cultura e serviços — e consolidando-se como agente estratégico na difusão de informações, coordenação de projetos e fortalecimento da governança. O aprimoramento da rede, com maior conectividade e fidelização dos laços, pode ampliar a colaboração entre os atores, potencializando impactos sociais, econômicos e tecnológicos, especialmente no agronegócio.

Palavras-chave: Análise de Redes Sociais. Inovação. Cooperação. Ecossistema de Inovação.

RESUMEN

Esta investigación aborda la importancia de las redes de cooperación entre instituciones públicas, privadas y del tercer sector, impulsadas por los avances tecnológicos y la necesidad de respuestas ágiles a los desafíos sociales y económicos. Estas redes fomentan el intercambio de conocimientos, la asignación de recursos y la construcción colectiva de soluciones innovadoras, especialmente en los campos de la educación y la innovación. En este contexto, surgen los ecosistemas de innovación: entornos interconectados que promueven sinergias entre habilidades, infraestructura y capital humano, generando valor y transformando territorios. La investigación presentada se centra en la región Alta Paulista en São Paulo y busca comprender cómo se estructuran las redes de cooperación en los ecosistemas de educación, investigación e innovación. El estudio utiliza el Análisis de Redes Sociales (ARS), con el apoyo de los software Netdraw® y UCINET®, para mapear interacciones, identificar subgrupos y medir indicadores estructurales. La metodología combina enfoques cualitativos y cuantitativos, caracterizándose como exploratoria y descriptiva, e incluye análisis de documentos y revisión bibliográfica en bases de datos científicas. Los resultados revelan baja densidad en la red global (0,011), lo que indica pocas conexiones en relación con el potencial existente, pero mayor densidad en la subred de innovación (0,033), lo que sugiere más intercambios, aunque aún insuficientes. La centralidad de las subredes FSNTEDUC (55,8%) y FSNTPESQINOV (30,4%) destaca el

papel estratégico de la Shunji Nishimura Foundation for Technology (FSNT) como articulador en educación, investigación e innovación. En subredes específicas, FSNTPESQINOV alcanza una centralidad del 87,3%, lo que refuerza su influencia en la dinámica de la red. Se concluye que FSNT desempeña un papel central en el ecosistema de innovación de Alta Paulista, actuando en varios frentes —educación, investigación, innovación, emprendimiento, cultura y servicios— y consolidándose como un agente estratégico en la difusión de información, coordinación de proyectos y fortalecimiento de la gobernanza. Fortalecer la red, con mayor conectividad y relaciones más sólidas, puede ampliar la colaboración entre las partes interesadas, impulsando el impacto social, económico y tecnológico, especialmente en la agroindustria.

Palabras clave: Análisis de Redes Sociales. Innovación. Cooperación. Ecosistema de Innovación.

1 INTRODUCTION

In recent decades, the advancement of information technologies, the growing complexity of social and economic challenges, and the need for agile and collaborative responses have driven the formation of cooperation networks between public, private and third sector institutions. These networks are configured as dynamic arrangements that favor the exchange of knowledge, the articulation of resources and the collective construction of innovative solutions. In the field of education, research, and innovation, according to Lauxen (2024), these networks play a strategic role by integrating different actors — such as universities, research centers, companies, civil society organizations, and governments — around common objectives aimed at scientific, technological, and social development.

This articulation gives rise to the so-called innovation ecosystems, interconnected environments that promote synergies between skills, infrastructure, human and institutional capital, creating favorable conditions for value generation and territorial transformation. Focusing on the generation of synergies, the union of assets (material, human, financial resources) of institutions in a network seeks to generate a value greater than the sum of the resources available separately, according to the logic of resource extension (Lavie, 2006).

Social networks, through the ordering of relationships, favor institutions access to business opportunities, strengthen institutional competitiveness by expanding the flow of information, resources, markets and technologies, enabling knowledge gains, economies of scale and scope, and risk sharing, according to the authors Mizruchi (2006); Kimura, Teixeira and Godoy (2004), Balestrin and Vargas (2004).

The analysis of these networks, through the Theory of Social Networks (SRT), allows us to understand how the actors relate to each other, what are the flows of information and influence, and how the thematic subgroups are structured within the ecosystem. SRT provides analytical tools to identify patterns of cooperation, levels of centrality and density of connections, revealing the strategic role of certain actors in sustaining and expanding the network.

In this context, understanding a cooperation network in the research and innovation ecosystem in the Alta Paulista region, in the interior of the State of São Paulo, contributed to reveal the mechanisms of articulation and offer subsidies for the strengthening of inter-institutional relations and for the proposition of more effective innovation policies. Improving the network of the Shunji Nishimura Foundation of Technology (FSNT), expanding it, increasing its maturity, bringing greater confidence to the actors of the network, are some of the benefits that can be generated for the areas of agribusiness, to which the FSNT has a direct or indirect connection.

The Netdraw® software was developed to enable the visualization of networks in the *Ucinet*® package, widely used in Social Network Analysis (SNA), released in 2002 by the company *Analytic Technologies*. Its main developers were Stephen P. Borgatti, Martin G. Everett and Linton C. Freeman, prominent researchers in the field of graph theory and social network analysis.

Since 1979, Borgatti, Everett and Freeman have been a reference in this area and have developed the theoretical concept and methodology of Centrality; they are founders of the journal *Social Network* (the main journal in the area) (Freeman, 1979).

Freeman is one of the most respected researchers in sociometry and was responsible for standardizing the ARS language. While Freeman established the fundamental metrics of centrality to measure power and influence, Borgatti and Everett advanced in the methodological and algorithmic application of these structures, allowing the analysis of roles, strategic positions, and the modeling of complex organizational ecosystems. Borgatti is the most influential contemporary author in the application of ARS in business and management, he has an interdisciplinary profile that unites heavy mathematics with organizational theory. Often a co-author of Borgatti, Everett brings mathematical and algorithmic rigor, is a professor of Social Network Analysis, and focuses on the deep structure of graphs.

For the analysis of social networks, graph theory provides the mathematical basis of the study, allowing to represent relationships between actors through graphs and adjacency matrices. Generally composed of binary values (1 or 0), they organize the connections between agents and usually have an empty diagonal, as the link between an actor and himself is not considered (Wasserman; Faust, 1994).

Graph Theory originated in the work of Leonhard Euler, when the Swiss mathematician solved the famous "Königsberg Bridges" problem, considered the founding milestone of the discipline (Szwarcfiter, 1984), later evolving as a branch of discrete mathematics, focused on the study of structures composed of vertices (or nodes) and edges (or connections), which model relationships between elements of a set (Harary, 1969).

When applied to the understanding of the structures of social interaction, graph theory gained great relevance in sociology, highlighted by Wasserman and Faust (1994) as enabling a formal reading of social relations, transforming abstract bonds into analyzable structures, which expands the ability to understand the organization and dynamics of groups.

While graph theory originated in mathematics, network theory had an interdisciplinary origin, including the area of Mathematics and Sociology, incorporating social, physical and computational theories. According to Ferreira and Filho (2010), Network Theory deals with a complex analysis of tangible (goods, materials) or intangible (ideas, values) interactions

between the actors involved in the network (people, organizations, environment), using concepts and metrics (centrality, density, modularity).

The central problem of this research is to understand how cooperation networks are structured in research and innovation ecosystems, evaluating the patterns of interaction between the different actors involved and the subgroups formed based on common interests. Through the analysis of social networks, we sought to identify the levels of influence and institutional articulation among the participants of the network, having as a case study an institution that acts strategically in this ecosystem, comparing it with other studies found in the literature.

To answer these questions, the study uses Social Network Analysis with the support of the software tools *Netdraw*® and *Ucinet*®, in order to visualize relationships and detect subgroups present in the cooperation network, allowing us to understand the role of the Foundation in the network and the links established with the other participants.

The present research is justified by the need to deepen the knowledge about how these networks are structured, what are the patterns of interaction between their actors and how certain institutions exert influence on the articulation of relationships. The application of Social Network Analysis (SNA), with the support of the *Netdraw*® software and the *Ucinet*® software, allowed a quantitative approach that contributed to evidence the relational dynamics of the network and the thematic subgroups formed by common interests of the actors.

The relational dynamics of the social network aims to generate value for institutions, people and communities, and the interdisciplinary approach observed in the formation of strategic partnerships was observed in the case study carried out that evaluates the role played by a central actor (Grupo Jacto, 2025). Based on the Theory of Social Network Analysis (SRA), this research searched the literature for consolidated studies on this topic and applied to the case study of the cooperation network where the FSNT is inserted, mapping the interconnections to demonstrate the influence of the institution in each sub-network, in order to identify and provide subsidies for the creation of actions aimed at strengthening this network and other networks to be studied.

This research may provide relevant information that can contribute to the fulfillment of at least five of the 17 sustainable development goals (SDGs) set out in the United Nations (UN) 2030 Agenda for Brazil (UN, 2023), SDG 4 "Quality Education"; SDG 8 – Decent Work and Economic Growth; SDG 9 – Industry, Innovation and Infrastructure; SDG 11 – Sustainable Cities and Communities and SDG 17 – Partnerships and Means of

Implementation. Although the main focus is education, research and innovation, there are also points of convergence with SDG 2.

The objective of this research is to identify relationships established between the actors of a cooperation network of an innovation ecosystem with the purpose of expanding the knowledge about the structure, intensity and dynamics of these interactions.

2 THEORETICAL FRAMEWORK

The study of networks identifies the actors and the relationship between them in order to characterize these forms of interaction, contributing to the knowledge about the social network and its development. Networks are systems composed of "nodes" and connections between them that, in the social sciences, are represented by social subjects (individuals, groups, organizations, etc.) connected by some kind of relationship. The social network can be studied basically in order to understand how the actors behave and how the connections of this network influence this behavior (Watts, 1999).

In addition to the identification of actors and their bonds, Ahuja, Zaheer and Soda (2012) highlight the relevance of examining the structural configurations or patterns that emerge from relationships. From this perspective, certain actors may present greater intensity of interaction, while others start to concentrate — or centralize — a significant volume of connections within a specific network.

Actors, in general, tend to establish relationships with those who share similar attributes, which evidences the presence of similarity (Olave; Amato Neto, 2001). This proximity generates benefits for those involved, understood as positive externalities (Verschoore Filho, 2006). Among the factors that favor this similarity, individual preferences, economic interests or converging goals stand out (BURT, 1992). As examples of positive externalities, we can mention the articulation of groups in unions and cooperatives for the defense of common interests, as well as the productive specialization of companies belonging to the same sector that are clustered in a given region.

According to Abramovay (2000), the network is an analytical instrument for understanding certain forms of collective organization, going beyond the field of social sciences to incorporate, for example, the ecology of the population.

Networks can be categorized according to the degree of legal formalization they present, considering the form of coexistence and organization among their members. In this sense, Fusco (2005) proposes a typology that classifies networks into social, bureaucratic or proprietary networks, varying into symmetrical or asymmetrical networks.

Symmetrical social networks are characterized as social groupings not governed by

formal legal instruments, where participants have the autonomy to join or withdraw from the network at any time and equality in decision-making power is ensured among all members (Fusco, 2005). In the asymmetric social network, the author points out that the relationships between individuals are organized through contracts aimed mainly at the exchange of goods and services.

Structured based on formal contracts that define the relationships between the members, according to Fusco (2005), symmetrical bureaucratic networks maintain the rights, duties, forms of exchange, agreements and the protection of the individual rights of all participants expressly guaranteed in contracts. In asymmetric bureaucratic networks, the legal instruments are directed to the strategic alignment of the members with the objectives of the managing agent, and in these arrangements, rights, knowledge transfer mechanisms and standards for services and information flows among the members of the network are defined.

In the model of symmetrical proprietary networks, Fusco (2005) reinforces that the participating companies form a new organization with the objective of balancing knowledge and capital contributions and formal contracts with specific clauses defining property rights and agreements between the members. In addition to these characteristics, asymmetric proprietary networks have explicitly incorporated the risk element, with the presence of an investor who establishes a partnership with the company, jointly assuming the risks of the enterprise.

It is observed that social networks have no or low degree of legal formalization, which makes it essential to consider the aspects related to human behavior that influence the permanence or dissolution of network relationships. This perspective is widely discussed in the works of Granovetter (1973) updated in 2007, Burt (1992) and Lazzarini (2008). In a convergent way, Grandori and Soda (1995) point out that social networks are characterized by having little or no contractual formalization.

In addition to the structural typology, it is relevant to analyze the forms of joint action existing in the networks, with emphasis on the modes of cooperation and the roles played by the different actors involved. As pointed out by Carvalho, Serra and Laurindo (2003), two main modalities stand out, horizontal cooperation and vertical cooperation.

While horizontal cooperation occurs between individuals or organizations that act as competitors, but who establish cooperative relationships with the objective of achieving common benefits, vertical cooperation is seen in arrangements in which the participants are interdependent to carry out their activities, and the articulation between the members of the chain is fundamental for individual growth and for the development of the other actors

involved (Carvalho, Serra and Laurindo, 2003).

At the end of the 1970s, the discussion about the relationship between networks and companies began in organizational studies to understand the behavior of organizations, emerging the Theory of Organizations, according to researchers Martes et al. (2006). While Granovetter (1985) points out that the absence of relationships between actors can compromise the formation of relevant social bonds, negatively affecting information flows and opportunities for cooperation within networks, Martes et al. (2006) identified, in organizational analysis, that social relations between two actors (individuals or organizations), because they have strength and content, include background, advice or friendship, shared or pertinent interests, and some level of trust.

According to the authors Mizruchi (2006); Kimura, Teixeira and Godoy (2004), Balestrin and Vargas (2004), social networks have been evidenced for enabling the entrepreneur to maintain contacts, expand the possibilities of finding business opportunities and a way for companies to achieve competitiveness in the markets through the ordering of relationships.

Kimura, Teixeira and Godoy (2004) also highlight that these social interactions improve or restrict access to resources, because, by incorporating social capital, they generate externalities such as knowledge about the behavior of other agents; knowledge about the market such as prices and technologies; and on the benefit of class action.

Some quantitative parameters are especially important to identify the structure of a social network. Density describes the overall level of interactions presented by the members of a network, being associated with the average number of connections per member of the group. Centralization reflects the concentration of connections in a small number of individuals, as opposed to a more egalitarian distribution, and is associated with variance in the number of connections per individual (Sparrowe, Liden, and Kraimer, 2001).

The central purpose of cooperation networks in the organizational field is to bring together attributes that allow adaptation to the competitive environment in a dynamic structure, supported by uniform but decentralized actions, which enables gains in the scale of the union, but which prevents the companies involved from losing the flexibility of lean size (Thompson, 2003).

According to Bourdieu (1985), social capital is the "sum of resources" made available by the network, related to the connections that the actors have, but not necessarily resources that are contained in them, because the benefits are acquired or received by the actors.

As a resource, social capital is subject to accumulation and transformation into other forms of capital, such as economic (Bourdieu, 1983) and human (Coleman, 1988), and in a

narrower view, according to Marteleto (2005), it can be defined as a set of norms and social networks that affect the well-being of the community in which they are inscribed.

The theory of resource dependence, according to the research of Dias (2011), is another approach used in studies on cooperation networks, where alliances, partnerships and relationships between organizations have been constituted as new business opportunities that are made possible based on new inter-company arrangements or the so-called inter-organizational networks of cooperation. The same author highlights that the existence of polycentric networks or structures that encompass several actors, organizations or modules linked to each other through the establishment and maintenance of common objectives and a compatible and adequate managerial dynamic is increasingly present.

According to Etzkowitz and Leydesdorff (1995), innovation ecosystems represent spaces in which the knowledge economy is strengthened by collaboration between universities, companies and government, enabling the emergence of mixed institutions that promote the continuous circulation of knowledge and technologies. The education and research ecosystem, on the other hand, can be understood as a collaborative and interdependent environment that brings together multiple agents, such as schools, universities, families, civil society, the productive sector, and digital technologies. In this arrangement, learning is seen as the result of complex interactions that are articulated at different levels (UNESCO, 2021),

The trust that the actor brings to the network of relationships in which he or she is inserted creates favorable conditions for cooperation, which in turn reinforces the trust between the various actors in the network (SMOLKA, 2006).

According to Tigre (2006), the authors Nelson, Freeman and Lundvall, in different works, developed the concept of the National Innovation System, to characterize the scientific and institutional environment capable of promoting innovations for competitiveness. Such studies show how the educational and scientific infrastructure, the mechanisms to support innovation and technological cooperation and business strategies contribute to creating positive externalities to the export effort in different countries (Tigre, 2006).

The challenges linked to Agribusiness, with activities related to land use, energy factors and labor in the field, demand systems with greater productivity aimed at meeting food demand, production and consumption of greater value of land and food. In this environment, sustainable practices, networks, and partnerships innovate the mode of production, consumption, and relationship, where actors - private and public - start to act engaged towards a society of greater development, even though in Brazil there is physical space and

climatic conditions more conducive to agricultural and livestock production (Zuin and Queiroz, 2019).

Sustainable agri-food innovation is a great development opportunity for Brazil, because, according to Zuin and Queiroz (2019), in addition to having good universities and research centers that enable technological advances, there is cultural richness and diversity, a demanding domestic and foreign consumer market, scarce and valuable natural resources, and competitive production.

Brazil is a strategic actor in global agribusiness, an essential sector of the Brazilian economy and an opportunity and catalyst for the country's development and as part of the sector's development strategy with technological products and businesses with higher added value, it is crucial to strengthen the pillars of innovation and reorganize the roles of key actors (university, company and government); prioritize teaching and research focused on strategic opportunities; increase skills for the transformation of traditional companies into innovative ones; stimulate the creation of research, development, and innovation centers (Zuin and Queiroz, 2019).

In Brazil, the national system of technology and innovation was consolidated through several actions such as the creation of the National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES), in the 1950s, the structuring of policies for the training of researchers and generation of knowledge and in the 1970s, creation of public policies such as the II National Development Plan (II PND) and the foundation of the Brazilian Agricultural Research Corporation (EMBRAPA, 1973).

Making the Brazilian economy more competitive was necessary with Brazil's economic opening and globalization in the 1980s and 1990s, and stimulating initiatives to bring scientific production closer to the productive sector and technological innovation proved to be a factor in the country's economic and social development (Zuin and Queiroz, 2019).

The Innovation Law (Law No. 10,973/2004) allowed the promotion of research, development and innovation (RD&I) through the sharing of public laboratories with companies, the transfer of technology and the encouragement of public-private partnerships.

The Lei do Bem (Law No. 11,196/2005) granted tax incentives to companies that make investments in technological innovation, and the Legal Framework for Science, Technology and Innovation (Complementary Law No. 167/2016, which updates the Innovation Law) modernized the rules to facilitate the execution of innovative projects.

The approval of the Legal Framework for *Startups* (Complementary Law No. 182/2021) reinforced support for innovative entrepreneurship through mechanisms for

contracting innovative solutions by the public sector and incentives for new technology-based businesses.

Public institutions in Brazil play an essential role in fostering innovation, such as FINEP - Financier of Studies and Projects, with financing and economic subsidies; the National Bank for Economic and Social Development (BNDES), with specific credit lines; the Brazilian Company for Industrial Research and Innovation (EMBRAPPI), which co-finances projects between companies and research institutes; in addition to scholarships and notices offered by CNPq and CAPES.

All these actions are important advances in fostering innovation in Brazil and overcoming challenges such as low private investment in the sector and the lack of a culture of innovation that is part of the organizational culture of companies and institutions.

3 METHODOLOGY

The research strategy is based on the single case study protocol, meeting the reliability criterion, and adopts a qualitative, exploratory and descriptive approach. The research is supported by Social Network Analysis (SNA), with the use of Netdraw® software for the graphical mapping of networks and UCINET® for the quantitative measurement of structural indicators. From the interactions between the actors — represented by nodes, links and flows — metrics such as density and centrality (*Degree, Betweenness and Closeness*) are calculated, allowing the analysis of the configuration and positioning of the actors in the network.

The methodology articulates a qualitative and quantitative approach, with the ARS as a central technique for the investigation of the interactions between the actors. The combined use of Netdraw® and UCINET® software enables the visualization of connections, the generation of network maps and the calculation of structural metrics, essential for understanding relational dynamics, identifying thematic subgroups and evaluating the role played by the different actors in the analyzed ecosystem.

The research is characterized as exploratory, as it allows inferring the ties established between the actors of the social network, and as descriptive, due to the application of mathematical tools in the analysis of the variables that make up the relational matrices (Gil, 2021). In addition, documentary analysis was adopted as a procedure for data constitution and analysis, in line with the qualitative approach of the research (Minayo, 2009).

To bring to the research the historical context of the environment where the FSNT is inserted and its development, documentary research was carried out using books and annual reports available in the institution's private collection, as well as a search on the website.

For the theoretical basis of the scientific knowledge used in the research, research was carried out in books and scientific articles, dissertations and theses of works pertinent to the themes addressed in this research, searched in the *Scielo*, *Capes*, *Unesp* library, *Science Direct* databases.

The research was developed in two phases. In the first, for qualitative analysis, the first network was built with the identification of all actors to have an overview of the collaboration network. To achieve this first objective, a table was built in Excel file format of the overview of the network for the organization of the actors and their attributes and their relational ties; a VNA file of the general network was built and inserted into the *Netdraw*® software, generating the graph of the first network (GENERAL). Initially, these relationships were inserted with a weight of 1 to 1 in order to establish balanced (Binary) relationships.

As *insights* obtained from the first graph (GENERAL), subnets were identified, based on the main attributes of the actors, where there are collaborations of common interest, which led to the construction of new VNA files for each of the identified subgroups. The new VNA files were inserted into the *Netdraw*® software, generating the graphs of the subnets.

From this set of sub-networks, the network identified as research and innovation was highlighted for the study, where the actors that interact in this sub-network were isolated with the help of the *Netdraw*® software.

In the second phase of the studies, the *UCINET*® software was applied to insert the new weights to the relational ties of the networks, the GENERAL and the research and innovation sub-network, in order to evaluate the relational matrices and determine the densities and centralities, in a quantitative way.

In this phase, the names of the actors were replaced by acronyms to preserve their identification in their interactions in the General and sub-networks of research and innovation.

4 RESULTS AND DISCUSSIONS

4.1 CASE STUDY: HISTORY OF THE FORMATION OF THE INNOVATION ECOSYSTEM OF ALTA PAULISTA

4.1.1 The Foundation and Its Evolution

The Shunji Nishimura Technology Foundation was created by Japanese immigrant Shunji Nishimura in 1979 as part of the "Thank you, Brazil!" project, with an initial focus on education. With a professional life dedicated to the advancement of agriculture in Brazil, Nishimura, at the age of 70, created the FSNT with the objective of supporting Brazilian agriculture through education, training young people prepared for life in the countryside and with solid values adopted by him (Morais, 2019).

Since then, with the support of Grupo Jacto, the Foundation has played a key role in the training of young people and technological development, fostering innovation and entrepreneurship actions in the areas of agribusiness, health, biotechnology and the food industry, integrating actors in the quadruple helix of innovation in the context of bioconvergence (Grupo Jacto, 2025).

The first initiative of the FSNT was the creation of the Agricultural Technical College. During his business life, Shunji Nishimura approached universities, especially the agronomy faculties of USP - University of São Paulo, in Piracicaba, and Unesp - São Paulo State University, in Jaboticabal and Botucatu. From the partnership with professors from the Faculty of Agronomic Sciences of Unesp in Botucatu, the Soil Analysis Laboratory also emerged, which is still active today and one of the best in Brazil (Cesar, 2018).

In 1988, the Shunji Nishimura School was created, maintained by the FSNT, which in 2019 gained a new building on its campus, specially designed to enhance an innovative educational approach, *Profound Learning*, a Canadian methodology based on the formation of autonomous, innovative and future-ready people (Morais, 2019).

The first major partnership in the field of education: a Senai (National Service for Industrial Learning) school within the FSNT, the result of the agreement with Senai-SP, which began operating in 2009. Senai Pompeia Shunji Nishimura was the first institution to adopt the *Profound Learning methodology*, starting in 2015, and maintains the only high school among Senai schools in the state of São Paulo (Morais, 2019).

In 2010, another major educational project began: the Pompeia Faculty of Technology, a public-private partnership with the Paula Souza Technological Education Center (CPS), an institution of the government of the State of São Paulo responsible for technological professional education, offering technological undergraduate courses, in the context of agribusiness, to young people in Pompeia and region (Morais, 2019).

To promote Culture, FSNT maintains a Museum, open to visitors, intended to preserve the history of the founder of Grupo Jacto and FSNT, Shunji Nishimura, and which maintains his memories and philosophy of life (Morais, 2019). Also as part of actions to encourage culture and volunteering, FSNT maintains the "Volunteering Project", composed of floriculture, horticulture and ceramics workshop activities (Morais, 2019).

4.2 CHARACTERIZATION OF THE INNOVATION ECOSYSTEM

The education and innovation ecosystem where FSNT is inserted has the three main components that the specialized literature identifies as essential (talents, technology and investment), in addition to being located in a region that favors economic development based

on biodigital convergence, through integrated solutions in the areas of Agribusiness, Food Industry and Health, driven by genomics, information and communication technologies (Marchiori, 2024).

The education and innovation ecosystem in which FSNT is inserted seeks to develop a culture of innovation based on cooperation, creating an environment open to opportunities and favorable to the most diverse interactions between entrepreneurs, companies, universities, research organizations, investors and government agencies in order to maximize the economic impact and potential of research and technological innovations (Marchiori, 2024).

At the regional level, the actors in the education and innovation ecosystem are concentrated in Alta Paulista, a region in the state of São Paulo where the city of Pompeia is located. It is an important university and agro-industrial hub, located in the center-west of the state of São Paulo, with a population of 886,735 people, in 2023, distributed in 51 municipalities. It has adequate road infrastructure for cargo transport, in addition to regional airports in Marília, Tupã, Assis and Ourinhos (Grupo Jacto, 2025).

In the state of São Paulo, the Alta Paulista region is responsible for 7% of Brazilian agricultural production and stands out in the food, beverage, machinery and agricultural equipment industries and has important educational, science and technology institutions, such as: Marília Medical School – FAMEMA, São Paulo State University – Assis Campus, Marília Campus, Tupã Campus, Shunji Nishimura Technology Foundation (FSNT), which covers: Fatec Pompeia Shunji Nishimura, Senai Pompeia (SENAI School "Shunji Nishimura") and Agribusiness Innovation Center (CIAg) (Grupo Jacto, 2025).

In more than four decades of existence, FSNT has consolidated itself as a serious institution, with an excellent reputation and with ties of relationships with important actors in national education and research and Brazilian agribusiness (Morais, 2019). The trust that the NSF brings to the network of relationships in which it is inserted creates favorable conditions for cooperation and that, in turn, reinforces the trust between the various actors in the network (Smolka, 2006).

As a result of this trust among the actors in the network, FSNT created, in the area of innovation, through partnerships: the Center for Innovation in Agribusiness (CIAg), a private non-profit research and development center focused on the development of solutions framed in technological programs; Plant Monitoring and Protection Laboratory – LMPP, the first research laboratory created after the Paula Souza Center (CPS) received recognition as a Scientific, Technological and Innovation Institution (ICT) by the Council of Research Institutions of the State of São Paulo (Consip); Alta Paulista Innovation Center (Citap), a

formal innovation environment in the Alta Paulista region, recognized by the government of São Paulo (Grupo Jacto, 2025).

Established in 2014, through a partnership established between FSNT and *Imaginal Education* (Canadian educational institution), the *Imaginal Transformation Center* - ITC Brasil aims to disseminate, in Brazil, the Imaginal Philosophy - a teaching methodology based on principles of student autonomy in the learning process, through consultancy provided in public and private education networks, schools, municipal secretariats, and through *workshops* promoted to train educational managers and teachers (Grupo Jacto, 2025).

The FSNT Agronomic Analysis Laboratory, created in 1985 with the objective of providing soil fertility analysis and chemical analysis of plants to rural producers, cooperatives, consultants, companies and teaching and research institutions throughout the Brazilian territory, contributes to the undergraduate courses of Fatec Pompeia Shunji Nishimura, through support for research projects by professors and students, practical classes and the offer of supervised internships (Grupo Jacto, 2025).

Based on strategic partnerships with institutions such as the Government of the State of São Paulo, the Paula Souza Center, SENAI, the São Paulo Agency for Agribusiness Technology - APTA, the ITAL Institute of Food Technology, the Araucária Foundation, the Institute for Cancer Research of Guarapuava - IPEC, *Cilla Tech Park* and the Government of the State of Paraná, - FSNT operates in education and innovation ecosystems in the areas of Agribusiness, Genomics, Artificial Intelligence, Biotechnology, and the Food Industry (Marchiori, 2024).

4.3 CONSTRUCTION OF THE GENERAL NETWORK

The application of the social network analysis method in this research sought to achieve the proposed objectives through the mapping of the network where the FSNT is inserted and its study to identify possible opportunities for action in strengthening the ties between the actors of this cooperation network.

To process the networks in *the Netdraw® software*, it was necessary to build a set of data structures in a set of plain text files, using Windows® Notepad. In these files, the actors, their attributes and the ties between them were listed according to the subgroups of common interests, indicated in the data collection. After processing, the data was visually represented in the *Netdraw® software*. Figure 1 shows a typical VNA file used in the research. The remaining datasets identifying other subnets followed the same file structure. This procedure was repeated for the general network, as well as for all identified subnets.

Figure 1

Example of VNA file, from the Research and Innovation subnet

```

Arquivo  Editar  Exibir  H1  ...  Windows (C)  UTF-8

*NODE DATA
NOME CLASSIF_ORGANIZACIONAL COR_CLASSIF_ORGANIZ 5_SUB_REDE
FSNT FSNT VERDE FSNT
AMAZON EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
API_GEN_PR OSC ROXO FSNT_PESQ_INOV
BUNGE EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
CARGILL EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
CIAG ICT AMARELO FSNT_PESQ_INOV
CILLA_TECH_P OSC ROXO FSNT_PESQ_INOV
COOPADAP EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
COPLANA EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
DORI EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
E_ENG_USP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
EMBRAER EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
EMBRAPA ICT AMARELO FSNT_PESQ_INOV
EMBRAPA_INST ICT AMARELO FSNT_PESQ_INOV
ESALO_USP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
FADCT_PR ORGAO_GOVERNAMENTAL MARROM FSNT_PESQ_INOV
FADCT_SP ORGAO_GOVERNAMENTAL MARROM FSNT_PESQ_INOV
FAPESP ORGAO_GOVERNAMENTAL MARROM FSNT_PESQ_INOV
FCA_UNESP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
FCAV_UNESP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
FCE_UNESP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
FRAUNHOFER ICT AMARELO FSNT_PESQ_INOV
GRUPO_VITTIA EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
IAC ICT AMARELO FSNT_PESQ_INOV
IARA OSC ROXO FSNT_PESQ_INOV
IBM ICT AMARELO FSNT_PESQ_INOV
IEA ICT AMARELO FSNT_PESQ_INOV
IFSP ICT AMARELO FSNT_PESQ_INOV
INGREDION EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
INST_FIS_USP ICT AMARELO FSNT_PESQ_INOV
INTEL EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
IPEC_PR ICT AMARELO FSNT_PESQ_INOV
ITAL ICT AMARELO FSNT_PESQ_INOV
MARILAN EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
NODUSOJA EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
PLUG_PLAY EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
R_S_BLUMOS EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
RIZOMA_AG EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
SEARA EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
SECR_AG_SP ORGAO_GOVERNAMENTAL MARROM FSNT_PESQ_INOV
SEMANTIX EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
SETI_PR ORGAO_GOVERNAMENTAL MARROM FSNT_PESQ_INOV
SL ALIM EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
SOLO_RICO EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
SPLICE_G EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
STELLANTIS EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
U_SAO_FCO EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
UBYFOL EMPRESA_PRIVADA VERMELHO FSNT_PESQ_INOV
UFMA INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
UFPA INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
UFRJ INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
UFSP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
UNESP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
UNIV_ECO_PR INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
USP INSTITUICAO_EDUCACIONAL AZUL FSNT_PESQ_INOV
CONS_CUR_FSNT OSC ROXO MANTENEDORA
G_JACTO EMPRESA_PRIVADA VERMELHO MANTENEDORA
JACTO EMPRESA_PRIVADA VERMELHO MANTENEDORA
RODOJACTO EMPRESA_PRIVADA VERMELHO MANTENEDORA
SINTEGRA EMPRESA_PRIVADA VERMELHO MANTENEDORA
G_BRUDDEN EMPRESA_PRIVADA VERMELHO MANTENEDORA

*TIE DATA
FROM TO PESO
AMAZON FSNT_PESQ_INOV 1
API_GEN_PR FSNT_PESQ_INOV 1

```

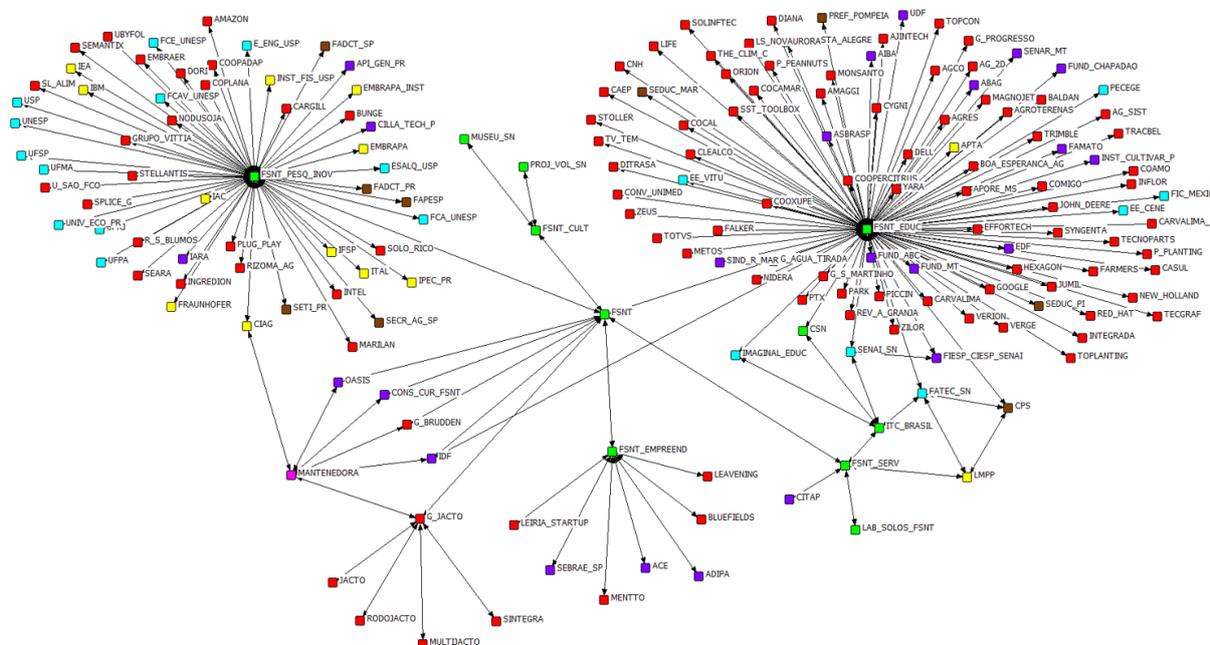
Source: The authors.

Through the Network Theory, with the support of the *Netdraw® Software tool*, an initial analysis of the interactions between the network actors was made and the image of the

general network was constructed (Figure 2), which encompasses subgroups of common interests identified as: i) education; ii) culture; iii) services; iv) research and innovation; v) entrepreneurship, allowing visualization of its reach and the relationships between all actors and the FSNT.

The social network in which FSNT is inserted has a number of connections created from cooperation actions between actors, whose purposes range from the development of the community, Industry and Agribusiness, through support for research and education, expanding this mission to all geographic regions that FSNT reaches through relationships with actors connected by the same purposes.

Figure 2
General Network



Source: The authors.

Figure 2 shows the graph representation of the general cooperation network, composed of institutional connections and partnerships established by the Foundation in its nuclei of action with various institutions, represented by us. The central nodes, highlighted in green, indicate the divisions according to the activities and areas of activity of the FSNT, classified in Chart 1.

Table 1

Classification of sub-networks

DIVISÃO	SIGLA
Cultura	FSNT_CULT
Educação	FSNT_EDUC
Empreendedorismo	FSNT_EMPREEND
Pesquisa e Inovação	FSNT_PESQ_INOV
Serviços	FSNT_SERV
Fundação Geral	FSNT

Source: The authors.

The FSNT_PESQ_INOV sub-network concentrates connections with educational institutions, research centers and technology companies, evidencing a focus on innovation and development in scientific research. The FSNT_CULT subnetwork connects cultural and educational initiatives. The FSNT_EMPREEND sub-network concentrates institutions classified as incubators, accelerators and entrepreneurship support organizations. The FSNT_SERV subnet, on the other hand, relates to service provider divisions of the FSNT itself. These institutions were classified by type of actor represented by groups classified by color, as indicated in Chart 2.

Table 2

Classification of actors by categories

Cor no Grafo	Tipo de Ator	Exemplos
Vermelho	Empresa privada	Jacto, IBM, John Deere, Trimble, Cargill, Bunge, Syngenta, Google, Amazon
Azul	Instituição educacional	USP, UNESP, ESALQ, FATEC, SENAI, UFPR, FIC_MÉXICO
Amarelo	Instituto de ciência e tecnologia	APTA, FAPESP, SECR_AG_SP, SENAR_MT, FUND_MT
Roxo	Organização do terceiro setor	Plug & Play, IDF, CITAP, Fraunhofer, OASIS
Marrom	Órgão governamental	ABAG, PREF_POMPEIA, COOPADAP, CONS_CUR_FSNT
Verde	Núcleos internos da FSNT (pontos centrais da rede)	FSNT, FSNT_EDUC, FSNT_PESQ_INOV, FSNT_CULT, FSNT_SERV, FSNT_EMPREEND
Rosa	Organização do terceiro setor – mantenedora	Mantenedora

Source: The authors.

The FSNT, positioned as the central link of the network, connects with all partners according to each sub-network divided by area of operation, thus indirectly connecting all the actors inserted in the FSNT Global network. The institutions of the network were classified through their attributes into: educational, private companies, science and technology institutes, government entities, civil society organizations, divisions of the FSNT itself and sponsor. The connections indicate relations of cooperation, project development, research, technological innovation, culture and entrepreneurship.

While the actors of the networks benefit from the solid reputation of the Foundation built over the years mainly by its founder, Shunji Nishimura, the latter benefits from the specificities brought to the network by each actor, within their areas of activity, in line with Martes et al., (2006), who identified that the social relations between two actors (individuals or organizations), Because they have strength and content, they include background, advice or friendship, shared or pertinent interests, and some level of trust. Aspects such as expertise in corporate governance are also benefits brought by the FSNT to the cooperation network.

The global network was classified, according to Fusco (2005), by its relations as symmetrical social networks where social groupings are not governed by formal legal instruments, the participants have the autonomy to join or withdraw from the network at any time and equality in decision-making power is ensured among all members.

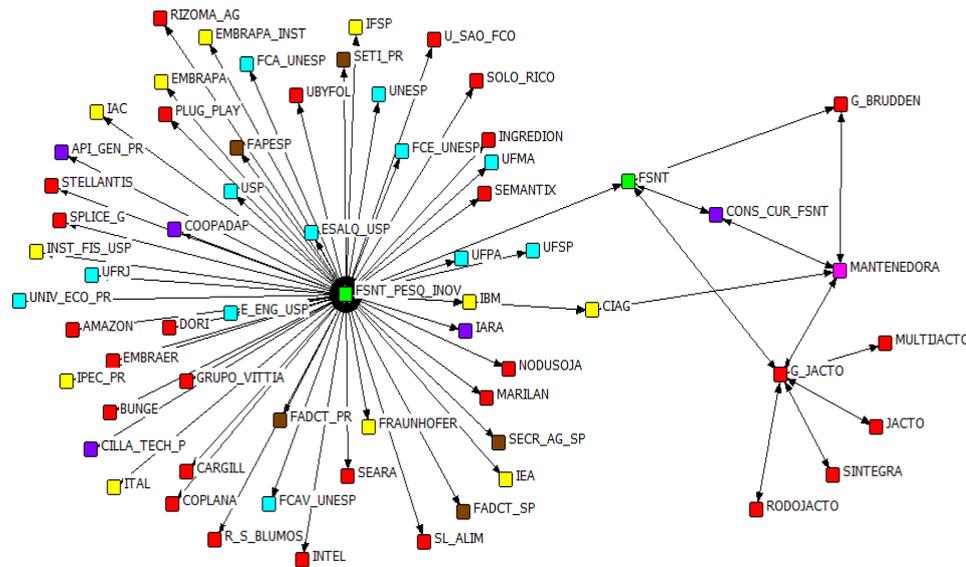
The results of the qualitative analysis of the generated graphs point to a network that encompasses subgroups of common interests identified as education, culture, services, innovation and research and entrepreneurship. The sub-networks were reconstructed separately from the larger network for a better visualization and understanding of their reach and the relationships between the actors and the FSNT.

4.4 CONSTRUCTION OF THE RESEARCH AND INNOVATION NETWORK

The sub-network entitled FSNT_PESQ_INOV, detached from the general network and represented by Figure 3, is composed of several types of institutions such as private companies, teaching and research institutions, science and technology institutes, third sector organizations, development agencies, all with common attributes linked to research and innovation and connected by the FSNT actor, which is positioned with centrality and demonstrates a high degree of importance for the connection between all actors. This sub-network was classified as an asymmetric bureaucratic network, where the relations between individuals are organized through contracts aimed mainly at the exchange of goods and services, according to the indications of Fusco (2005).

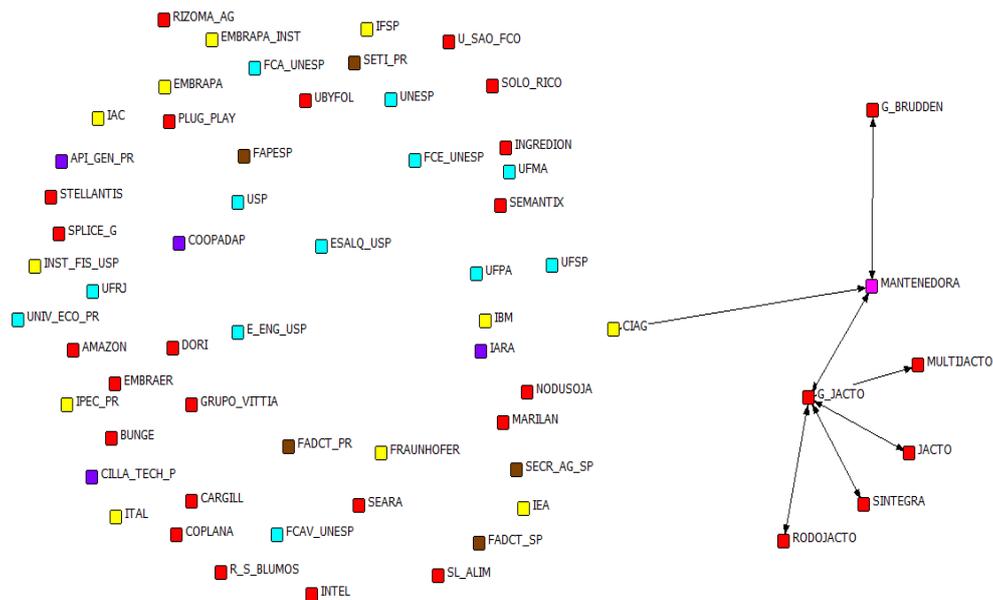
Among the actions present in this sub-network, there are research projects, coordinated by the FSNT, in which resources are shared among all actors in the network, and thus, optimized to achieve common goals. The simulation of the FSNT actor's output from this network indicates the disconnection that can occur with the other actors (Figure 4).

Figure 3
Research and innovation subnetwork



Source: The authors.

Figure 4
Research and innovation subnet without FSNT



Source: The authors.

The quantitative analysis of the network indicators was carried out, with the application of the *UTINET® software*, in its version 6.817, obtained from *Analytic Technologies*, according to the guidelines of Borgatti, Everett and Freeman (2002), and the quantitative data and the lists of data outputs from the *URINET® software* were obtained. The following is a summary of the main indicators calculated for the networks (TABLE 3).

Table 3

Summary of the quantitative indicators of the networks studied

NETWORK	Summary of General Network Measures			
	We	Ties	Centralities	Density
GLOBAL	182	378	0,55	0,011
INNOVATION	64	132	0,854	0,033

Source: The authors.

The indication of nodes presents the number of actors participating in the network and sub-network studied. Bonds, on the other hand, correspond to the bonds or between the actors, which represent the interactions between them.

As the relational matrices constructed considered the weights of the relationships (ties) between the actors with unit weight, it is observed that the results of the centralities, also in the interval between 0 and 1, are identical for both the output centralities and the input centralities.

Centrality is a set of metrics used in social network analysis to assess which nodes (or actors) are most important to the network. In this case, Table 1 demonstrates the centrality of the Innovation subnetwork with the measure 0.854.

The densities obtained from the networks showed that in the global network there is a low density, equal to 0.011, which could be increased through a greater number of interactions, increasing the weight of the links (ties) between the actors and possibly creating more connections between these actors. This indicates the possibility of improving the network, building loyalty and strengthening relationships, leading to greater connectivity and greater exchange of information of common interest, in order to ensure that almost all users are connected to each other, thus achieving greater collaboration between the actors of the networks.

With the result of the analysis obtained from the global network as previously indicated, it can be stated that there are still few connections in relation to the total possible connections for this network.

In the case of the Innovation network, the graph obtained showed a density with a result of 0.033, three times higher than the density of the global network, demonstrating that this sub-network has a higher volume of exchanges, but there are still opportunities to increase collaboration within the network.

Table 4 presents a summary of the major centralities found in the network studied, so that it is possible to ascertain the power of the participation of the actors in the respective social networks raised in the case study.

In the global network, it is possible to verify the centrality of the FSNTEDUC actor, which reached 55.8% of centrality, that is, it is the actor with the greatest influence in the network that considers unitary ties, followed by the FSNTPESQINOV actor, with 30.4% of influence over the network participants. Even so, the participation of the FSNT is observed with a centrality of 10% in the global network.

The other actors have centralities lower than 8 points and, in this way, it was perceived how important Education and Research and Innovation are for this network, as well as the monitoring of the FSNT.

Still observing Table 4, we can highlight the importance and power of influence of the actor FSNTPESQINOV, with a value of 87.3% of prominence over the other participants of the network. It is, without a doubt, a major player that contributes to the functioning of the network. The other actors can have their centralities increased in order to expand exchanges and their individual responsibilities.

The results obtained in the analysis of social networks applied to the study of the social network in which the FSNT is inserted, so far, show the relevance of the FSNT as a central articulating actor on different fronts of action: education, research, innovation, entrepreneurship, culture and services. The centrality of the FSNT actor within the sub-networks indicates its strategic role in the education and innovation ecosystem, within the Alta Paulista region.

This arrangement of the actors of the social network and the centrality of the FSNT in the ecosystem points to its ability to disseminate information and act in roles of support for governance and project coordination, consolidating the FSNT as a strategic actor in the education and innovation ecosystem.

Table 4

Greater Centralities of the Evaluated Networks

NETWORK	ACTOR	Summary of the Major Network Centralities	
		Centrality	Central. Norm. (%)
GLOBAL	FSNT	10	5,5
	FSNTCULT	3	1,7
	FSNTEDUC	101	55,8
	FSNTEMPREEND	8	4,4
	GJACTO	6	3,3
	FSNTSERV	5	2,8
	FSNTPESQI NOV	55	30,4
INNOVATION	FSNTPESQI NOV	55	87,3
	FSNT	4	6,3
	G_JACTO	6	9,5
	MAINTAINE R	4	6,3

*The sum of the values in the column of the normalized centralities may exceed 100% due to the contribution of the degrees of centrality of entry and exit of the actors.

Source: The authors.

The analysis of social networks, in this research, as instruments of inter-institutional cooperation revealed their strategic importance for the strengthening of competitiveness and innovation, as highlighted in the review, by the authors Mizruchi (2006), Kimura, Teixeira and Godoy (2004), as well as Balestrin and Vargas (2004), pointing out that the ordering of relationships favors access to business opportunities, it expands information flows and resources, and enables knowledge gains and risk sharing.

As described by Ahuja, Zaheer and Soda (2012), during the development of the research, it was necessary, in addition to identifying the actors and their links, to examine the structural configurations that emerge from the relationships, looking for patterns by individual preferences, economic interests or convergent goals, thus resulting in positive externalities such as unions, cooperatives or productive specialization in specific regions as indicated by

Burt (1992). Fusco (2005) contributed to the definition of the typology that classifies the networks studied.

In the field of cooperation, as indicated by Carvalho, Serra and Laurindo (2003), we observe vertical cooperation, in an interdependent chain. This perspective dialogues with organizational studies initiated in the 1970s, when Martes et al. (2006) identified that social relations between actors involve trust, shared interests and bonds of friendship, while Granovetter (1985) warned that the absence of relationships compromises information flows and opportunities for cooperation.

From a quantitative point of view, according to Sparrowe, Liden and Kraimer (2001), the parameters of density and centralization were calculated to understand the structure of the networks. As indicated by Bourdieu (1985), with the mapping of networks, it was possible to conceptualize social capital as the sum of resources accessible through the identified connections.

In the context of innovation ecosystems, as Etzkowitz and Leydesdorff (1995) pointed out, the triple helix between universities, companies, and government strengthens, in this network under study (research and innovation), the knowledge economy, a perspective expanded by UNESCO (2021) by including multiple agents in collaborative education and research environments.

Finally, we can highlight that, in Brazil, as evidenced by the authors Zuin and Queiroz (2019), agribusiness, combined with sustainable practices and cooperation networks, represents an opportunity for agri-food innovation, supported by universities, research centers, and cultural diversity. This scenario reinforces that the performance of institutions such as FSNT, by articulating Science, Culture, Innovation and Entrepreneurship in cooperation networks, contributes both to organizational efficiency and to generate positive social and economic impacts in line with the UN Sustainable Development Goals.

5 CONCLUSION

The analysis of social networks and the use of *Netdraw*® software to create the graphs allowed to obtain an integrated view of the general network and the sub-networks studied, indicating that the FSNT plays a central role as an agent of intersectoral integration, articulating Science, Culture, Innovation and Entrepreneurship in the same collaborative ecosystem, located in the Alta Paulista region.

FSNT's performance in a research and innovation ecosystem in a cooperation network structure strengthens internal organizational efficiency and contributes to expanding the positive social and economic impact of its actions, consolidating FSNT as a central actor in

the social network, in the institutional articulation for the technological, social and educational development of the community and Agribusiness.

This case study highlights the relevance of cooperation networks in education and innovation ecosystems, highlighting how the articulation between universities, companies, research centers, civil society and governments favors the exchange of knowledge, the collective construction of solutions and territorial transformation. The analysis of social networks, supported by the Netdraw® and UCINET® software, revealed low density in the global network and greater intensity of exchanges in the innovation sub-network, although insufficient to achieve full collaboration. The centrality of the FSNTEDUC and FSNTPESQINOV sub-networks confirms the strategic role of FSNT as an articulating actor in education, research and innovation, consolidating it as a central agent in the dissemination of information, coordination of projects and strengthening of governance.

These results dialogue directly with the UN Sustainable Development Goals. The work contributes to SDG 4 (Quality Education) by strengthening educational institutions and expanding access to knowledge; to SDG 8 (Decent Work and Economic Growth) by fostering innovation and entrepreneurship actions, especially in Agribusiness; and SDG 9 (Industry, Innovation and Infrastructure) by promoting interconnected environments that drive technology and knowledge infrastructure. In addition, territorial transformation and community strengthening are related to SDG 11 (Sustainable Cities and Communities), while the essence of the research — inter-institutional cooperation — is aligned with SDG 17 (Partnerships and Means of Implementation), reinforcing the importance of networks as instruments of sustainable development. Although the main focus of this research has been education, research and innovation, there are points of convergence with SDG 2, that is, it is related to SDG 2 to the extent that it highlights agribusiness as a field of impact, since the strengthening of networks can generate social, economic and technological effects, especially in this sector, connecting directly to the goal of promoting sustainable agriculture and increasing the productivity of smallholders. In addition, innovation ecosystems favor the development of technologies and practices applied to food production, capable of improving agricultural efficiency, reducing waste, and expanding access to nutritious food. The articulation between teaching and research institutions also plays a fundamental role, as it contributes to the training of professionals and the dissemination of knowledge that strengthens both food security and agricultural sustainability. Finally, the centrality of the Shunji Nishimura Technology Foundation demonstrates how an institution can coordinate collective efforts, aligning resources and actors in favor of innovative solutions, which

reinforces the importance of governance and cooperation to implement policies and practices that directly support the goals of SDG 2.

Thus, the investigation shows that improving the FSNT network, expanding its maturity and connectivity, strengthens internal organizational efficiency and enhances positive social, economic and technological impacts, consolidating FSNT as a strategic actor in the promotion of the SDGs in the Alta Paulista region.

The investigation fully fulfilled the objective of identifying the relationships established between the actors of a cooperation network in an innovation ecosystem, expanding the knowledge about its structure, intensity and dynamics. The analysis of social networks, supported by *the Netdraw® and UCINET® software*, allowed the visualization of the general network and its sub-networks, revealing patterns of interaction, levels of centrality and the influence exerted by different actors in common purposes. By relating these purposes to the UN SDGs, the research demonstrates that understanding cooperation networks meets the scientific purpose of mapping interactions, and contributes to the promotion of quality education, economic growth, innovation, sustainable communities and strategic partnerships. Thus, the study confirms that strengthening the FSNT network is essential to expand the maturity and connectivity of the ecosystem, being able to enhance its capacity to generate value and promote sustainable development in the Alta Paulista region.

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