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Relations Structure And Access To Knowledge: Influence Of Relational Properties On The Knowledge Transfer Process

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Abstract:
Background*: Access To Resources Within The Scope Of Inter-Organizational Networks Is An Attribute Of How The Actors Organize Themselves. These Positions Make Up Structures That Are Capable Of Promoting Access And Advantages Asymmetrically To Actors Embedded In Social Relationships.*
Materials And Methods *To This End, An Exploratory Quantitative Approach Was Adopted, Conducted In The Form Of A Case Study. Data Were Collected Using The Sociometric Assessment Questionnaire (QAS).*
Results*: The Study Made It Possible To Understand The Influence Of Relational Properties Throughout The Knowledge Transfer Process That Occurred Between The Associated Producers, Showing The Importance Of The Technical Support Provided By The Support Entity As A Central Actor In The Process Of Obtaining And Transferring Knowledge Between The Actors That Make Up The Network. It Also Demonstrated The Levels Of Density, Centrality And Network Connectivity During The Knowledge Transfer Process, Contributing To The Field From The Analysis Of The Evolution Of Relational Structures On The Same Phenomenon.*
Conclusion: *This Study Analyzed The Structural Characteristics Of Inter-Organizational Networks In The Knowledge Transfer Process. Relational Structures Changed Based On The Purpose Of Contact. The Density Of Relationships Reduced Throughout The Process, Leading To Centrality. Key Actors In Knowledge Acquisition Were The Support Technician, Board Members, And Former President. The Network Had An Average Connectivity Level Of 25%. Network Governance And Key Actors Influenced Knowledge Transfer. The Process Was Directed By Support Entities And The Current Board, With Opposition From The Former Board, Forming Three Clusters With Distinct Purposes.*
Key Word*: Social Networks. Sociometric Analysis. Knowledge.*

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I. Introduction

Inter-organizational networks promote a favorable condition for establishing access to solutions based on the services, products and infrastructure offered by them for the development of their members. Among these solutions, access to learning and innovation, generated by the socialization of ideas and experiences between actors, stands out; the reduction of costs and risks, linked to access to information and knowledge, which can generate savings and improvements in the production process and finally, the increase in the volume and intensity of social relationships as a source of knowledge transfer, characterized by the exchange of information and experiences (Balestrin & Verschoore, 2014).

Inter-organizational networks can be considered a locus of knowledge transfer among their actors, because, through a complex ordering of interactions, the network has the power to disseminate and organize the knowledge developed and improved within and outside the scope of its activities. This social structure has the power to make the information necessary for the dissemination of the practices arising from the experiences and learning flow. Thus, knowledge transfer in inter-organizational networks can be considered a process by which the experiences of one organization affect another organization and can occur explicitly or implicitly (Lima, 2016), so that the information, techniques, and improvements that occur in one organization and transmitted to the other, generate the necessary condition for the development of a process in which knowledge transfer will occur in the network so that the relationships promoted within the network establish social structures through which this knowledge will flow. Understanding the conditions necessary for this is one of the purposes of the network approach, as an analytical tool, since the social structures represented by the network properties can influence the processes and contents that transit in the social arrangement.

Social structures are a complex ordering of positions that will generate roles within the network (Wasserman & Faust, 1999); these positions are the means to understand the networks under the perspective of analysis, hence, from their structural properties and the positions occupied by the network actors, which will allow differentiated access to different network participants.

The central theme of this study falls on the process of knowledge transfer occurring from the establishment of inter-organizational relationships and their attributes, striving to understand how the relational structures established from the Association of Honey Producers from the interior of Paraná - Brazil contribute to the process of knowledge transfer amid its members.

The Association of Honey Producers will be the object of this study and it will be considered here as a network of formal structure and cooperative relationships amid its members. It is a private non-profit organization to promote, among the associated producers, access to techniques and knowledge for the improvement of production, commercialization of the products, market strategies, and most importantly, to discuss and plead with the public power issues of collective interest, such as technical support, credit lines to subsidize the development of the beekeeping activity in the city and to strengthen the segment in the region.

Theoretical Model of Knowledge Transfer in Interorganizational Networks

The theoretical model in this article was created by Silva (2011) and adapted to describe the knowledge transfer process in inter-organizational networks, representing the transmitter of knowledge to be transferred and the knowledge receiver as distinct organizations, in addition to the environmental factors determined by the relational structures as facilitating and inhibiting factors of knowledge transfer. The transmitter represents the organization that holds the knowledge and the receiver, the company that seeks knowledge, as represented in Figure 1.

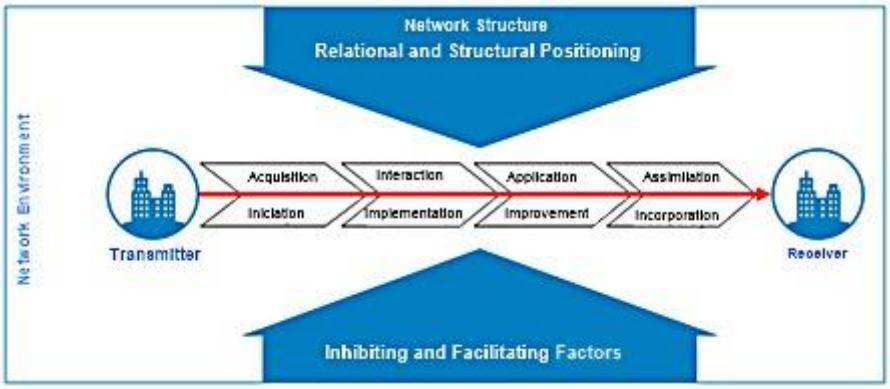


Figure 1 - Knowledge transfer in inter-organizational networks
Source: Prepared by the Author from Gilbert and Cordey-Hayes (1996, Silva (2011), Szulanski (1996) and Tichy, Tushman and Fombrun (1979).

(Silva, 2011) used as a source for the development of the theoretical framework, the ideas of Gilbert and Cordey-Hayes (1996) and Szulanski (1996), composing the phases in pairs for better representing the complementarity provided by the two theories. In the theoretical model presented in Figure 5, the phases of the decision-making process in inter-organizational networks are structured and organized as a path between the transmitter and the receiver.

Along this path, the knowledge transfer process suffers environmental pressures, represented by the network's structural factors portrayed by the structural and relational positions, described by Tichy et al., (1979), according to Table 1. The structural characteristics represent the positions established in the network environment, forming a complex ordering of roles. To understand these elements, the network properties presented by Tichy et al. (1979) present structural characteristics through which information and knowledge flow along paths formed by connections. As these structures establish the paths for obtaining knowledge, they can also inhibit access to the knowledge available in the social arrangement.

Given these arguments, the model proposed by (Silva, 2011) needed to be adapted by including environmental factors that influence the knowledge transfer process in order to meet the objective of this study. The detailing of the phases of the knowledge transfer process will be carried out in the topic presentation and discussion of results.

II. Material And Methods

This study is characterized as descriptive of exploratory nature with quantitative approaches conducted in the form of a case study, having as the object of this study an Association of Honey Producers in the interior of Paraná, a state in southern Brazil. Data collection occurred in two phases, the first phase being quantitative, by means of sociometric evaluation questionnaires, applied during meetings and gatherings promoted by the association, to characterize and map the relational structures presented in Table 1.

Table 1 - Quantitative phase analysis categories

Property	Term Definition	Data Source
Size	Number of actors participating in the network.	Analysis of the matrix generated from the sociometric evaluation questionnaires responses and Analysis of the sociogram generated by the UCINET© software.
Density	Number of actual links in the network as a ratio of the number of possible links.	
Cluster	Areas of the network where actors are more closely linked to each other than they are to the rest of the network	
Degree	Degree of connections that the actor has in the network.	
Closeness	refers to the distance between the actors, considering the geodesic distance.	
Betweenness	Intermediation centrality, considering the actor as means to establish communication with other actors.	
Reciprocity	Degree to which the actors report to each other.	
Access	Average number of links between two actors in the network.	

Source: Adapted by the author from Tichy et al., (1979).

The data collected through the sociometric evaluation questionnaires were analyzed using UNICET© software for social data analysis, using the properties described by Tichy et al., (1979), according to Table 1.

In a second sociometric evaluation questionnaire, two questions were structured. In question 1, referring to phase 1 of the knowledge transfer process in networks, the interviewees were asked about the sources for obtaining knowledge (which actors are sought when there is a need or opportunity to obtain new knowledge). In question 2, referring to phase 2 of the process, the respondents were asked about obtaining this knowledge (which of the actors provide knowledge when asked).

The level of analysis was the inter-organizational level and the unit of analysis was relationships, considering each actor as a distinct and interdependent organization, immersed in a particular social context composed by the association of honey producers.

III. Result

To map the relational structures that make up the knowledge transfer process among the associated producers, the sociometric evaluation questionnaire was used. The interviewed producers indicated in the questionnaires their relationships considering only active members related to the transfer of knowledge that occurred within the association.

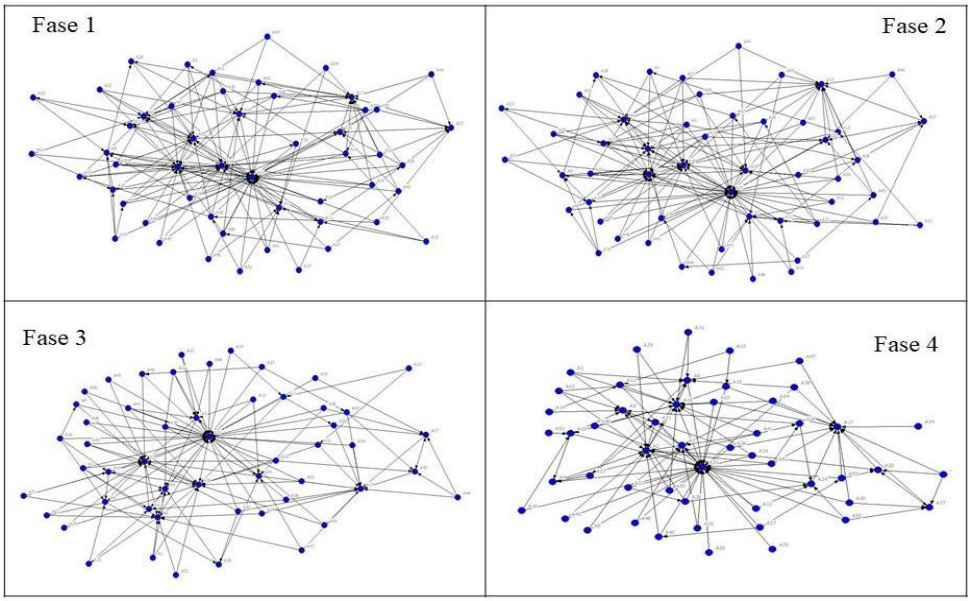
The theoretical model presented in section 3 describes the process of knowledge transfer in inter-organizational networks and is composed of 4 distinct and interrelated phases, as described. The process begins with the acquisition or initiation phase process of obtaining new knowledge, and then enters the phase of interaction and implementation of knowledge, composed of exchange relationships among the network actors. In the third phase, the application and improvement of the knowledge obtained is performed, and in the fourth phase, the assimilation and incorporation of the knowledge obtained in the network take place (Silva, 2011).

For each phase of the knowledge transfer process described in Table 3, questions were designed to understand how the network structure is organized throughout the process, since the relationships structured in the network environment are direct sources for obtaining knowledge and, thus, they become strategic and organized according to their interests and results (Sacomano Neto et al., 2015).

Answers were organized into four square matrices of 54 rows and 54 columns that were later analyzed using the UCINET© data analysis software, which then generated 4 sociograms, one for each phase of the process, presented in Figure 2. Data generated through the sociometric evaluation questionnaire made it possible to verify the categories presented in Table a, in section 3, for each phase of the knowledge transfer process.

In a second sociometric evaluation questionnaire, two questions were structured. In question 1, referring to phase 1 of the knowledge transfer process in networks, the interviewees were asked about the sources for obtaining knowledge, listing in field A the name of the actors who are sought when there is a need or an opportunity to obtain new knowledge. In question 2, referring to phase 2 of the process, the interviewees were asked about obtaining this knowledge, that is, which of the actors mentioned in question 1 provide knowledge when requested. The names were listed in field A, following the same criteria as the previous questions.

Figure 2 - Network sociogram during the 4 phases of the knowledge transfer process.



Source: Primary research data.

In a third sociometric evaluation questionnaire, two questions were designed. The first question dealt with phase 3 of the knowledge transfer process in networks, and queries about the application/enhancement of the knowledge obtained in the previous question, asking which of the indicated players provide knowledge that is effectively useful to the work, applied, and adjusted to their activity. In the second question, referring to phase 4, the objective was to identify which actors provide the interviewee with the knowledge that is effectively applied and that becomes part of the organization's routines, being a valuable relationship capable of generating changes in the functional structure and in its work routines.

In all questions, there were no limits of indications, following the criteria described in the previous subsection, including in relation to the research audience and the questionnaire application procedures. Through the data collected from these questions, it was possible to evidence the network structure during and the phases of the knowledge transfer process between the actors that make up the network established among the associated producers.

From the data collected in the second and third sociometric evaluation questionnaire and processed through UCINET©, it was possible to understand the evolution of the network in structural aspects and map the evolution of the network throughout the knowledge transfer process from changes suffered in its social structures. First in aspects of relational density: as already presented in the previous subsection, density is the network property that represents the ratio between existing and possible relationships (Lemieux & Oumiet, 2012), determining the degree of connection existing throughout the process of knowledge transfer in the association.

When analyzing the data, one notices a drop of 31.84% in the number of existing ties between the first and the fourth phase of the knowledge transfer process that occurred in the association, according to Table 2.

Table 2 - Network indications per phase

Property	Fase 1	Fase 2	Fase 3	Fase 4
Density	6,3%	5,8%	4,9%	4,3%
Network size	179	166	139	122
Reciprocity	7,8%	7,2%	7,2%	6,6%
Number of actors indicated	29	25	22	20

Source: Primary research data.

The reduction in the number of ties shows the cutback in network density. In other words, of the 2,862 possible connections between network members, 179 were made in the first phase, representing 6.3% density, and in the last phase of the process, the network created 122 ties, 4.3% density. This allows understanding that the actors during the knowledge process reduce their ties, revealing a tendency to centralize in the search for relationships that offer them knowledge.

Table 1 also presents the data referring to reciprocity, representing the reciprocal indications that occurred during the knowledge transfer process in the association. The results point out that the network had 7.8% of reciprocal dyads (connections) in the first phase of the process, that is, 14 reciprocal indications, and 6.6% of reciprocity in the last phase of the process, being 12 reciprocal connections.

Regarding the important actors in the network, table 3 shows the 6 most cited actors in the 4 phases of the knowledge transfer process. It can be seen that actor A33, the technician responsible for conducting training and consulting, is the most cited actor in the 4 phases, followed by A18, A2, and A5, members of the current board of directors, and also by actor A17, former president of the association.

Table 3 - Network indications per phase

Actor	Number of Nominations			
	Fase 1	Fase 2	Fase 3	Fase 4
Supporting Entity - A33	37	37	37	33
Association President - a18	20	18	14	14
Association Secretary - a2	19	18	15	11
Association member - a17	15	15	14	14
Association Treasurer - a5	14	13	7	7
Association member - a17	12	12	10	7

Source: Primary research data.

These relationships established in the network environment form a complex ordering of roles among its actors that, in turn, reveal positions that can translate the degrees of importance and interdependence of the connected actors (Wasserman & Faust, 1999). To understand the centrality aspects, Freeman's (1978) three types of centrality were used, being the degree centrality, closeness, and betweenness, presented in the previous subsection. As of the data collected and processed utilizing the UCINET© software, table 3 presents the 5 main players per centrality level for each phase of the knowledge transfer process.

Centrality degree represents the direct number of links that the actor has, considering the input and output links. According to this measure, the higher the degree of centrality, the greater the importance of the actor in the network structure (Gnyawali & Madhavan, 2001).

Table 4 – Centrality Degree - Fase 1 to 4

Actor	Fase 1			Fase 2			Fase 3			Fase 4		
	Outdeg	Indeg	nDegree	Outdeg	Indeg	nDegree	Outdeg	Indeg	nDegree	Outdeg	Indeg	nDegree
A33	4,00	37,00	**0,774**	4,00	37,00	**0,774**	2,00	37,00	**0,736**	2,00	33,00	**0,660**
A18	6,00	20,00	**0,491**	4,00	18,00	**0,415**	3,00	14,00	**0,321**	3,00	14,00	**0,321**
A2	5,00	19,00	**0,453**	5,00	18,00	**0,434**	3,00	15,00	**0,340**	3,00	11,00	**0,264**
A5	4,00	14,00	**0,340**	4,00	13,00	**0,321**	3,00	7,00	**0,189**	2,00	7,00	**0,170**
A17	0,00	15,00	**0,283**	0,00	15,00	**0,283**	0,00	14,00	**0,264**	0,00	14,00	**0,264**

Source: Primary research data.

According to Table 4, actor A33, technical representative of the support entity, presents the highest degree of centrality during the entire process of knowledge transfer in the network. According to the data collected, on average, this actor is directly connected to 74% of the network ties during the four phases of the process, demonstrating its importance and power level within the social structure. Also present among the most central in the network are the current board members, actors A18, A2, and A5. Actor A17, a member of the previous board of directors, also appears with an average degree centrality index of 27% during the process.

In relation to closeness, a measure that represents the shortest path connecting two actors, table 4 presents the level of output and input closeness relations of each actor in the phases of the knowledge transfer process. The actor A33 appears as central of proximity to the other nodes in the network, however, this condition is a reflection

of the high level of centrality degree obtained by him. Furthermore, other actors appear in this context, they are A6, A37, A24, A17, and A20, which present themselves as central due to their position from the relationships established with the other actors that, through their contacts, establish a condition of greater reach through the geodesic paths.

Table 5 – Closeness - Fase 1 to 4

Actor	Fase 1		Fase 2		Fase 3		Fase 4	
	Out Close	In Close	Out Close	In Close	Out Close	In Close	Out Close	In Close
A33	0,213	0,570	0,205	0,570	0,165	0,535	0,165	0,469
A18	0,217	0,473	0,202	0,465	0,165	0,424	0,165	0,393
A2	0,215	0,473	0,205	0,469	0,165	0,384	0,165	0,331
A4	0,212	0,398	0,205	0,396	0,167	0,379	0,167	0,346
A24	0,209	0,321	0,203	0,270	0,166	0,251	0,163	0,237
A5	0,208	0,431	0,203	0,424	0,166	0,312	0,164	0,290
A6	0,204	0,408	0,199	0,405	0,164	0,376	0,164	0,331
A17	0,167	0,434	0,167	0,431	0,143	0,294	0,143	0,275
A20	0,172	0,453	0,172	0,449	0,148	0,167	0,148	0,160
A37	0,172	0,340	0,172	0,338	0,148	0,169	0,148	0,159

Source: Primary research data.

Regarding intermediation or control: from the data collected it was possible to measure the intermediary position occupied by the network actors as shown in Table 5. This position gives the actor differentiated access to the traffic of information and knowledge that flows from the established social arrangement (Gnyawali & Madhavan, 2001; Lemieux & Oumiet, 2012).

Table 4 shows the 10 central actors in the aspect of intermediation of information and knowledge that transit through the network. Some actors differ from the other indicators of centrality, it occurs due to the levels of centrality and closeness degree. Then, actors who assume the role of intermediaries between the groups in the network appear.

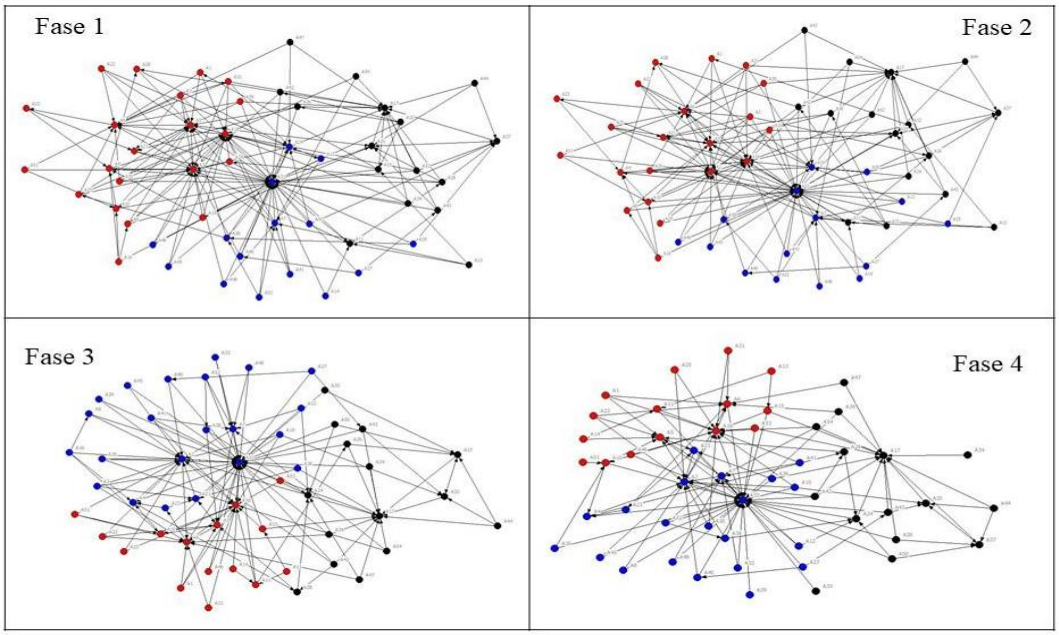
Table 6 – Betweenness - Fase 1 to 4

Fase 1	Fase 2	Fase 3	Fase 4
A33	A33	A33	A33
A18	A2	A4	A4
A2	A18	A18	A18
A11	A4	A28	A28
A5	A5	A6	A6
A12	A20	A2	A10
A4	A6	A10	A2
A20	A11	A24	A5
A6	A28	A5	A24
A26	A7	A23	A23

Source: Primary research data.

Still related to the changes undergone in the network structure during the knowledge transfer process among the associated producers, it remained to understand from the properties of density and centrality the cluster structures arranged in the network. As presented in the previous topic.

Figure 3 - Clusters 1st phase of the knowledge transfer process.



Source: Primary research data.

In figure 3, the clusters that compose the network during the four phases of the knowledge transfer process are presented. According to Gnyawali and Madhavan (2001), clusters are dense regions of the network or groupings generated from specific contingencies that unite these actors.

It is very noticeable the existence of the three groups that make up the association and its central actors. The clusters did not change in their composition during the phases of the knowledge transfer process, even maintaining the role of the central actors in each of the clusters.

Cluster 1 (blue) is composed of producers and some board members who are involved in issues related to increasing productivity, seeking solutions directly with the technical consultant (actor A33) who gives support to the association's producers. Cluster 2 (black) is the group composed of the association's former board of directors and opposition to the current board. Cluster 3 (red) is led by the current president of the association, actor A18, and is mostly composed of some members of support entities and the current board.

Based on the structural measures of the knowledge transfer process in the researched association, the network connectivity level was calculated for each of the stages of the process. The connectivity or accessibility measure is defined by Wasserman and Faust (1999) as the condition of the network structure that enables the flow of information and knowledge among the associated actors. Table 7 shows the statistical data generated from the UCINET© software regarding accessibility.

Table 7 – Network Accessibility

Property	Fase 1	Fase 2	Fase 3	Fase 4
Accessibility	33,0%	29,0%	23,0%	21,0%

Source: Primary research data.

The association's network of producers has 33% of connectivity in the first phase of knowledge transfer, which means that for a piece of knowledge or information to be transmitted to the entire network, it is necessary to randomly connect to 3 members. In the second phase, it is necessary to connect to 4 members to access the whole network; in the third and fourth phases, it is necessary to be connected to 5 producers randomly to connect to the whole network.

This section has demonstrated the structure of the network composed of the associated producers during the knowledge transfer process. The 54 people interviewed indicated 29 actors as a source of knowledge in the association representing 179 relationships. In each phase of the process, the changes in the relationship structure caused by both the reduction of the network density and the decrease of reciprocity levels are verified, directing the analysis to understand the levels of the centrality of the actors in the structure. The central actors are directly linked to the association's governance, however, actor A33 presents the highest level of centrality throughout the knowledge transfer process, with the average level of connectivity or accessibility of the network being 26.50% during the knowledge transfer process.

IV. Discussion

The knowledge transfer process plays a vital role in inter-organizational networks, enabling the exchange and implementation of knowledge among associated producers. This discussion presents the results of a study that aimed to map the relational structures within an association and analyze the dynamics of knowledge transfer among its members. By utilizing sociometric evaluation questionnaires and network analysis techniques, the study investigated the phases of knowledge transfer and identified key actors and their centrality within the network.

The study adopted a theoretical model comprising four interrelated phases of the knowledge transfer process: acquisition or initiation, interaction and implementation, application and improvement, and assimilation and incorporation. The sociometric evaluation questionnaires were designed to understand how the network structure evolved throughout each phase, with a focus on the relationships established among the actors involved in knowledge transfer.

The data collected from the questionnaires were analyzed using the UCINET© software, which generated sociograms representing the network structure for each phase of the knowledge transfer process. The analysis revealed changes in network density, reciprocity, and the number of ties among the actors throughout the process. Specifically, there was a significant reduction in the number of ties and network density, indicating a tendency among actors to centralize their relationships with key knowledge sources.

The study identified the most cited actors in each phase of the knowledge transfer process. Actor A33, the technical representative of the support entity, emerged as the most influential actor, being consistently mentioned across all phases. The current board members (A18, A2, and A5) and a former association president (A17) were also among the key actors. Centrality analysis revealed that actor A33 had the highest degree of centrality throughout the process, indicating their importance and power within the network structure.

The study assessed the network's connectivity level, which represents the flow of information and knowledge among the associated actors. The results indicated a decrease in connectivity from 33% in the first phase to 21% in the fourth phase, implying that an increasing number of actors need to be connected to transmit knowledge across the entire network.

The analysis of cluster structures demonstrated the existence of three distinct groups within the association's network of producers. These clusters remained relatively stable throughout the knowledge transfer process, with central actors maintaining their roles within each cluster. The clusters represented producers seeking productivity solutions, former board members, and the current association president and their supporters.

The findings provide valuable insights into the network structure and knowledge transfer dynamics within the association. The decreasing density and reciprocity levels suggest a trend toward centralization and reliance on key actors for knowledge exchange. Understanding the centrality of actors and the formation of clusters can help identify influential individuals and promote effective knowledge transfer strategies within the network.

V. Conclusion

The study shed light on the relational structures and dynamics of the knowledge transfer process within an association. By analyzing network properties, centrality measures, and cluster structures, the study revealed important insights into the network's evolution and the roles played by key actors. These findings can guide future efforts to optimize knowledge transfer and enhance collaboration among associated producers, ultimately contributing to the association's growth and success.

The structural characteristics were built from the phases of the knowledge transfer process in inter-organizational networks composed of phases, according to the theoretical model adopted. Each phase of the knowledge transfer process was analyzed from the categories presented in table 1 and subsequently justified from the questions in table 2. In this aspect, there is the contribution of this study, since it observes the structural dimensions of the network during the knowledge transfer process, building the evolution of the structural properties according to the phase of the process, launching the view that the contingencies and accesses alter the network structures and, in this way, act as facilitating or inhibiting factors during the knowledge transfer process between actors immersed in social relationships.

From the analysis of the network properties in different scenarios, it is possible to state that the relational structures change concerning the purpose for which the contact is intended (Wasserman & Faust, 1999), a fact that was proven with the association researched.

The relational density of the network during the knowledge transfer process had a significant reduction of relationships in all phases of the process, an important aspect that says a lot about the social structure of the producers participating in the association. This means that the ties that generate access to knowledge are reduced throughout the process, thus generating conditions of centrality.

The five most-cited actors in relation to knowledge are the support technician, the board members, and the former president. From this data it is possible to affirm that the issues related to obtaining knowledge are directed to these actors, who assume a central role in the network, holding the power over what is passed on and how it is passed on. Especially actor A33, a technician from the support entity, who holds high levels of centrality,

is the actor with the greatest influence and control over the process of dissemination and attainment of knowledge in the social arrangement.

In terms of accessibility, the network presents an average level of 25% of connectivity, that is, for information or knowledge to be disseminated during the process of knowledge transfer it is necessary to randomly connect 4 associates to access the entire network. The connectivity is influenced by the measures of density and centrality and changes throughout the process but remains balanced in terms of access.

Regarding the structural properties referring to knowledge transfer, in important aspects, it is possible to observe the relevance of the network governance, represented by the current board of directors, and the presence of the former president in the network arrangement. Another actor considered important is the technician who provides services to beekeepers by the support entity. His importance is revealed by the structural positioning of actor A33, who presents himself as central at all measured levels. During all stages of the process, both in aspects of centrality, accessibility, and cluster, there is a great reach to the whole network structure by these mentioned actors.

Thus, from the sociometric data and the reports collected through the interviews, it is possible to understand that the process of knowledge transfer among associated producers occurs within the network, and is directed by the support entities and coordinated by the current board, with the opposition of the former board, thus composing three clusters with distinct purposes and contingencies exerting influence on the flow and obtaining of knowledge by members.

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