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Technology-based business incubators

An exploratory analysis of intra-organizational social networks

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Abstract

Purpose – Technology-based incubators depend on high-level knowledge to constantly meet the demands of the market. Incubators offer a variety of specialized services to help startups increase the chances of crossing the valley of death. These services include infrastructure, access to a professional network of mentors and an intensive support of a consultant team to help with managerial and legal challenges. Therefore, it is critical to incubators to develop both highly skilled teams of consultants and social environment that facilitates communication. The purpose of this paper is to understand how innovation-oriented social networks created within technology-based incubators are shaped.

Design/methodology/approach – Data were collected in five incubators participating connected to federal universities from the state of Minas Gerais. The network attributes collected in the survey were placed in a matrix form. The mapping and measurement of the relationships between individuals were developed using the Ucinet software. Ucinet enables the analysis of attributes (attitudes, behaviors and characteristics) characterized as relational (contacts, ties and relationships). The software also includes the Netdraw network visualization tool, which enables the creation of matrices and graphical network maps. The measurements of centrality, closeness and intermediation were analyzed to assess the intra-organizational social network.

Findings – The results indicate that although the flow of communication does not follow the formal hierarchy, the interaction between team members to spontaneously exchange ideas, information and experiences is rare. The workers are so concerned about their timely tasks, that they have few opportunities to exchange information and knowledge. The coordination is carried out by university professors, who also perform other tasks (e.g. teaching, research and administration activities) besides those related to the incubators. The results also suggest that in the technology-based incubators studied, besides dealing in an innovative environment, the distribution of tasks and responsibilities are still rigid and traditional.

Originality/value – By analyzing the degree of the relationship between team members, the proximity and the level of intermediation of co-workers, it is possible to see how the incubators workers interact, thereby identifying the flow of information. This study offers implications for theory and practice. To the theory, this study adds to the discussion of intra-organizational social network of technology-based companies in the Brazilian context. To practitioners, this research sheds light on the importance of the social network built within the organization to promote effective communication and knowledge sharing.

Keywords Innovation, Social network, Business incubation, Technology-based incubator

Paper type Research paper

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1. Introduction

Companies need to constantly search for new business strategies to help them survive and gain more representation in the face of an extremely competitive business environment (Anderson *et al.*, 2014). Innovation is one of the main factors related to the competitive advantage of technology-based organizations (Hage, 1999; Çakar and Ertürk, 2010; Fuck and Vilha, 2011). The concept of innovation comprehends the manufacturing of new products or services and, moreover, the significant improvement of products or services that already exist (Oslo, 2005).

Innovation is also pointed out as critical for the economic development of nations and for increasing their international competitiveness (Machado and Barzotto, 2012). A study by the Brazilian National Association of Entities Promoting Innovative Enterprises (ANPROTEC) confirmed that 98 per cent of incubated companies innovate: 28 per cent focus on a regional scale, 55 per cent on the national scale and 15 per cent on a worldwide scale. The ANPROTEC study also reveals the importance of building social relationships between team members to preserve the innovative and competitive environment (ANPROTEC, 2011). Therefore, creating dynamic and innovative environments, as those environments created in business incubators, is important to encourage innovation. As innovation is strongly associated with the intensive use of knowledge (Fuck and Vilha, 2011), relationships between incubator's team members establish patterns of behavior that favors the creation of opportunities and increases the chances of taking risks (Kaasa and Vadi, 2010).

The dynamic of innovation is associated with the organizational learning process (Correia *et al.*, 2010). In fact, there is a need for a higher degree of knowledge, capable of fulfilling the demands of the market that emerges in incubators of technology-based companies. Startups are known for their competitive capacity, rapid learning processes, fast decision-making and intense exchange of tacit knowledge. In other words, it is a culture oriented to performance in a short period of time, which is centered on the company's intellectual capital (Steele and Murray, 2004) that incubators need to develop.

However, Petrin *et al.* (2014) explain that cultural differences between companies and the individual's capability to absorb new knowledge affect the quality of the relationships established between team members of the incubators. Companies have to stimulate the collaboration between team members, improve the process of knowledge acquisition, and appreciate innovation to improve knowledge dissemination through social network (Campos, 2014). Social interactions established within the organization are fundamental for exchanging resources, such as information, social ties, and friendships. These interactions lead to informal learning processes, through storytelling, conversations, and meetings. Organizations have to identify and understand their interdependent and complex systems to lead with informal interactions. Having informal learning processes helps innovation because it facilitates the development of dynamic answers to specific organizational problems (Wenger *et al.*, 2002; Evans *et al.*, 2015).

In this context, this study aims to understand how innovation-oriented social networks set within technology-based incubators are shaped. This study is an effort to understand the dynamics of the socialization that takes place inside incubators, which can facilitate the knowledge sharing in innovation processes. The social network characteristics analyzed in this research were the level of relationships between team members, their closeness, and the level of intermediation among them. This research was conducted in technology-based incubators companies linked to Brazilian universities in the southeast region, more specifically in the state of Minas Gerais. Incubators linked to universities show a hybrid environment, in which scientific, technological, and business dimensions are found in the university-business interaction (Aranha *et al.*, 2002). The incubators are in an environment

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favorable to the acquisition and appropriation of new knowledge and competencies (Baêta, 1999). In addition, as a result, the incubators tend to develop inside their boundaries an environment of intensive creation and knowledge sharing.

The findings of this study can offer an understanding of the social network dynamics established inside technology-based companies, associating these dynamics with innovation-oriented knowledge sharing. This paper also intends to offer a perspective of the social network distribution in terms of centrality and frequency of interactions to better understand the incubator. This study also intends to help consultants, incubated businesses, and professionals involved in incubation projects in general. Moreover, we expect that the results of this study help the development of strategies that promote tacit knowledge sharing. In a broader context, this discussion can contribute to the society by enabling technology-based incubators to enhance the creation and consolidation of emerging companies, strengthening the relationship between university, society and business.

Finally, this research intends to contribute to the literature because it relates social networks developed within the incubators with the organizational context. Previous studies highlight the exploratory nature of social network research inside organizations. Although there is a substantial body of research, it still lacks of understanding especially in the Brazilian incubation context (Lagemann and Loiola, 2013). Incubators present a distinct profile regarding organizational processes because they are inserted in an environment with uncertainties, focused on short-term performance, limited resources and that is highly technological (Bach *et al.*, 2016; Chandra and Chao, 2016; Schmidt *et al.*, 2016). Therefore, this research adds to the discussion about Brazilians' technology-based incubators from the social network perspective.

2. Literature review

2.1 Innovation and incubation environment

Changes in the market and in the society push organizations to constantly search for innovation in processes, management, and strategies (Anderson *et al.*, 2014). The dynamics of innovation transform new ideas into opportunities and put them into practice, being able to incorporate new concepts into something that already exists or apply concepts that already exist in a new context (Tidd *et al.*, 2005; Machado and Barzotto, 2012). Innovation is a process that has great complexity and dynamism, requiring a set of organizational behaviors that promote the capacity to organize and manage innovation processes.

Business incubators, especially the technology-based ones, contribute significantly to the increase of the competitiveness in the national economy, as they are important components of the innovation process (Baêta, 1999; Martins *et al.*, 2014; Iacono, 2014). It is an environment favorable to the exchange of new knowledge, based on technological qualification stemming from continuous learning (Baêta, 1999; Petrin *et al.*, 2014). The success of incubation ventures is attributed to the skills and initiatives of both incubated businesses and incubators (Iacono, 2014). During the innovation process, an incubated business has the potential to absorb knowledge transmitted to them and develop technical and behavioral skills required in the innovation process. Furthermore, incubators have in their team highly qualified consultants to ensure that incubated startups are successful in their actions during the incubation process (Iacono, 2014). The association between the incubated business and the incubator shows great potential to generate good outcomes because of the intensity and quality of interactions among them.

The interaction between team members of the incubator and incubated initiatives catalyzes creative dynamics into the innovation process (Van de Ven and Poole, 1990; Baêta, 1999; Serra *et al.*, 2011; Iacono, 2014; Petrin *et al.*, 2014). Socialization among those involved

in the process is one of the main mechanisms used to share knowledge (Evans *et al.*, 2015) to promote innovation. The exchange of tacit knowledge occurs through joint activities, such as working in the same environment, maintaining interactive conversations and sharing apprenticeships and experiences (Chang *et al.*, 2012). The dynamics of relationships are established by the way socialization happens because social ties developed within the organizations have different intensities, those ties being purely professional or friendly relationships among colleagues.

Organizations are constituted of people who have knowledge and skills that are shared through the act of socializing. In this context, one technique used to understand the relationships and the format of interactions is the study of networks. In this method, people are represented by their networking dots, and their links with co-workers are represented by ties (Tomaél *et al.*, 2005). The network analysis makes it possible to understand how people connect with each other within organizations in terms of exchange of information and knowledge.

2.2 Social networks and technology-based incubators

A social network is defined as a group of people or organizations connected by a set of social relationships, motivated by friendship, work relations, exchange of information and resources (Garton *et al.*, 1997). Social network refers to a group of people or institutions and its diverse set of relationships and functions (Marteleto, 2001). Thus, the network approach consists of an alternative for the analysis of social morphology, to the extent that the dynamics of networks comprise social experiences.

The analysis of social networks is used in the field of organizational studies as a methodological resource that makes it possible to understand the role of each actor in the group and the dynamics of collective processes (Bastos and Viana Santos, 2007). In the scope of organizational studies, the analysis of social networks allows researchers and practitioners to understand the flow of communication, the level of exchange of experiences, and the frequency of contacts. The performance of a business, in the knowledge-based economy, depends on informal networks (Hellms, 2007). Impersonal sources of information (e.g. database, documents) are only sought when there is no success in obtaining relevant knowledge from close co-workers or friends in the network (Cross *et al.*, 2002). From the same point of view, Silva (2008) states that the mapping and analysis of social networks that are not represented in the organization charts allow us to locate and visualize critical actors and paths.

Other studies highlight the effective contribution of social networks to strengthening the culture of innovation and designing strategies that strengthen competitive business intelligence (Alcará *et al.*, 2006). According to Pereira *et al.* (2013), the analysis of social networks identifies the social effects underlying the processes of innovation. Still, Lagemann and Loiola (2013) found that cohesive networks show better performances, suggesting that training practices based on network skills help to improve the incubated business.

The involvement of individuals in social relationships makes them more visible to others as they are recognized in the network for their connections (Wasserman and Faust, 1994), which can determine the access to the other actors in the network. To highlight the interactions and unravel informal relations, centrality is one of the main measurements. Centrality represents a locally central point; that is, a large number of connections to the other nodes in their immediate environment (Scott, 2017).

According to Wasko and Faraj (2005), individuals who are centrally placed in a network have a higher frequency of contacting other team members, which can contribute to the development of cooperative habits and influence people's willingness to transmit knowledge

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to others. In addition, these individuals are more likely than others to understand and follow the norms and expectations of the group.

To indicate the level of the centrality of the individual in the network, measurements of proximity, degree of contact, and intermediation can be used. Proximity represents the ability of a person to monitor the flow of resources and to understand what is happening in the network (Fellman and Wright, 2008). As the proximity between the individuals in the network becomes larger, the possibility of sharing resources, information, knowledge, and promoting innovative processes increases. The degree of contact represents the bonds established by one network actor with the others (Johnson, 2011). Finally, the contact intermediation among network team members refers to how the individual connects to other individuals within the network. Therefore, social networks within incubators may be characterized with stronger contact intermediation and high levels of proximity and degree of contacts. It happens because of the intensive knowledge activities that are developed in this context, as stated in the first proposition:

P1. Social networks within incubators tend to present high degree of centrality.

The process of innovation is influenced by the environment, making it reliant on social interaction, which can be determinant for the growth and solidification of the project (Tomaél, 2007). In this sense, Tomaél (2007) found that networks that motivate information and knowledge sharing are more likely to engage their members in innovation processes. Therefore, the analysis of the social network formed among the members of the incubator offers a perspective of exchange of knowledge relationships and information, which is fundamental for the dynamics of innovation. In a technology-based incubation environment, team members with a high degree of contact with one another are expected to be more likely to understand and share ideas, experiences and information. Thus, the proximity between these actors expands the view of the process, allowing the resources available in the network to be used effectively. Finally, it is expected that team members of technology-based incubators assume strategic roles of intermediation in the network, as they tend to act as mediators of internal processes and agents of information exchange and dissemination of knowledge. Even in the incubator environment, which tends to work with reduced team members, some heterogeneity is expected in terms of proximity and degree of contacts because of the nature of their work. In other words, team members who develop similar activities will contact each other more often in comparison to those who work on support activities, such as office jobs. Therefore, the second proposition is posed:

P2. Incubators members who work in activities directly related to incubated initiatives tend to present high degree of contacts and proximity.

3. Method

This study aims to understand how innovation-oriented social networks created within technology-based incubators are shaped. An exploratory survey research was employed in a quantitative approach (Creswell and Clark, 2007). It is a multiple case study composed of five technology-based incubators linked to different universities in Minas Gerais, Brazil.

3.1 Population and sample

The research population included team members of technology-based incubators of the state of Minas Gerais, especially those linked to universities. The team of the incubators included staff, professors in the role of mentors and coordinators, graduate students, innovation

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institutions and, mostly, undergraduate students that seek for opportunities to apply and increase their knowledge acquired in the classroom. The unit of analysis is the technology-based incubator.

The five incubators participating in this study were connected to federal universities from the state of Minas Gerais. We named them Gamma, Omega, Sigma, Beta and Zeta:

(1) Incubator Gamma belongs to the Nucleus of Technological Innovation and Entrepreneurship, which is part of the Deanship of Scientific Research and Graduate Studies. It was founded in 2006 in a partnership between the university, a local business, and the city hall. It has six team members. One member is the coordinator of the incubator who is hired as a technical employee of the university. The Gama incubator also has three managers –operational, marketing and administrative – one analyst and one assistant. All the managers work at the incubator for more the two years, whereas the analyst and assistant are interns with less than six months of membership.

(2) Incubator Omega is one of the units of the Regional Technological Center. It was founded by the university in 1966. The management team is directly subordinated to the Executive Board of the Regional Technological Center, and it has ten team members. The Omega Incubator has six undergraduate interns, one coordinator, one project manager, one manager of new businesses and one manager of managerial support. The last two managers work in a room apart from the rest of the team.

(3) Incubator Sigma was established in 2000. It is already installed as part of the Science and Technology Park in the city. Only in 2005 this incubator was consolidated with an innovative administration, with the provision of resources and strategic partnerships including public authorities, associations and class entities. It has five team members, distributed in the following positions: one coordinator, three advisors (quality, legal and communication) and one administrative assistant.

(4) The incubator Beta, created in 2004, is hierarchically linked to the Office of Outreach and Community Development and is decentralized. The central unit is located in the metropolitan area of Belo Horizonte and, also, in the cities of Divinópolis, Nepomuceno, Araxá, Curvelo and Leopoldina. Each unit has a local coordinator, who has the autonomy to manage the unit. The team of this incubator has five members, two of which are situated in the central unit, while the others are distributed in each one of other cities. In the central office, the incubator Beta has the general coordinator and one undergraduate intern.

(5) Incubator Zeta was created in 2009 and is connected to the Deanship of Scientific Research of the university. It is established, in legal terms, as a basic structure of the Nucleus of Technological Innovation (NIT). The team of this incubator has eight members. One member is the operational and administrative manager. The incubator has also an advisor for innovation and enterprise. The other members are undergraduate interns who receive scholarships from research funding agencies.

3.2 Data collection

Data were collected using standardized surveys. After each incubator accepted to participate in the study, we asked for the name, job position, and contact information of the

team members. Then, an invitation was sent to each participant via e-mail. The e-mail included the term of confidentiality, a presentation letter, and a link to the survey. The survey was created on the online platform SurveyMonkey®, in which we could monitor the answers. The surveys started with a consent form in which we explained the goals of the study and reaffirmed the confidentiality of data and anonymity.

In the first part of the survey, there were questions regarding the social network of each team member. The questions sought to know the informal contact network of each of the consultants. To do that, we asked questions such as:

Q1. In all work environments there are colleagues who communicate informally (chat). To whom, among your co-workers, do you talk about work and personal matters, that is, talk about your personal life, exchange ideas, information and experiences?

These questions are frequently used in the assessment of social networks and were derived of the work of Ibarra (1993), Wasserman and Faust (1994) and Borgatti *et al.* (2002). We intended to verify the strength of the contacts, which according to Granovetter (1973) can be recurrent with strong connections, or non-recurrent with weak connections. In that way, it is possible to identify all possible existing networks and their members, providing information for calculating the links and the centrality of the network. We used a five-point Likert scale. The points used in the scale were: (1) never; (2) rarely; (3) sometimes; (4) often and (5) every day.

The second part of the survey aimed to identify the major forms of communication used by the participant to connect with each other. They informed the frequency they used each of these forms of communication. The options available in the survey were in person, via phone calls, via email, via formal documents (e.g. formal letters, memorandums and others) and apps (Whatsapp, Trello, and others). To measure the frequency of the connections, we used a five-point Likert scale. The points used in the scale were: (1) several times a day; (2) a few times a week; (3) a few times a month; (4) up to once a month; (5) and never.

3.3 Method of analysis

Initially, the network attributes collected in the first section of the survey were tabulated in the software Excel. Then, the social networks of the incubators were analyzed. The mapping and measurement of the relationships among people were carried out with the help of the software UCINET 6.268 for Windows, developed by Borgatti *et al.* (2002). Ucinet enables the analysis of attributes (attitudes, behaviors, qualities and characteristics) characterized as relational (contacts, ties, and relationships among network actors). The software also includes the NETDRAW 2.091 network visualization tool, which enables the creation of matrices and graphical network maps.

The UCINET software shows the relationships among the actors in a square matrix. All square matrices must be identical, that is, they must contain the same names of actors in the columns and rows. Relationships are converted into a set of binary numbers, in which "0" represents the absence of binding. To calculate the networks, we used a scale from 1 to 4 to represent the existence and the intensity of the connections among the actors. The main measurements used to characterize the network were cohesion and centrality. Group cohesion helps to understand the direct relationships in the sharing of knowledge, ideas and resources among team members of the incubator. Centrality allows us to understand the position of the actor in the network and how important it is to maintain the network. For a better understanding of the structure, all the names mentioned were considered in their asymmetrical form, whose non-reciprocal connections are considered. The analysis at the level of the actors and their connections emphasizes the connections among the individuals,

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that is, the analysis of the networks is centered in the egos. We tried to understand if the actor is a central connector, border expander or peripheral specialist. In a different stage, the networks were represented in graphs using NETDRAW, which is a software linked to the Ucinet that allows us to visualize the set of network connections from sociograms.

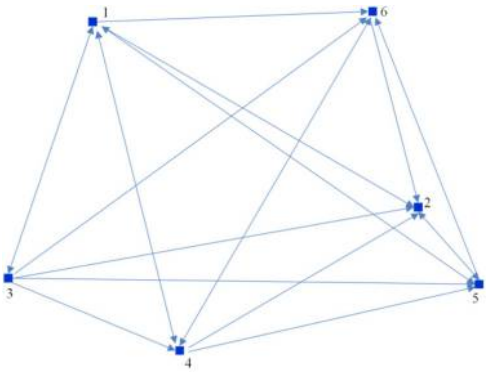
4. Results

The measurements of centrality indicate how a person is centrally located; that is if it has a large number of connections to the other individuals in its immediate environment. The degree of centrality of an actor allows the analysis of the position in which a person is in relation to the others. The measurements of the degree of centrality consider the number of bounds that are placed among the actors of the network. On the other hand, the proximity allows the understanding of how far the member of the network needs to go through to reach other individuals. Finally, the intermediation measurement analyzes how individuals act as mediators in the network since an actor can be an important mediator of the flow of information and conduct the knowledge within the network.

4.1 Incubator Gama

Incubator Gama is composed of six members. Five of which work daily in the building of the incubator, while the coordinator works in the building of the Nucleus of Technological Innovation and Entrepreneurship, which is located on the university campus. The results of Figure 1 show that there is, in fact, contact among team members in different levels. The network graph of the inner members of Gamma incubator has uniformity distribution in the degrees of centrality equal to 5. That is, the nodes have the same size. All of the connections are pointed out as reciprocal, which facilitates the sharing of knowledge and information.

The measurements of the centrality of incubator Gamma indicate that team members have a high degree of proximity, which reaffirms the cohesion, density and connectivity indicators. The degree of intermediation of the incubator is also indicated as 0, which is a reflection of the close proximity among team members and the strong cohesion found in the network. Regarding the degree of centrality, team member number 1 has less contact with others, as a consequence of the physical distance. Team member number 1 is the marketing manager and his/her activity requires less frequent contact with other team members. The high level of activities the coordinator has to handle including the ones outside the incubator



Source: Research data

Figure 1.
Graph of incubator Gama

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helps to decrease contact with other incubator members. The coordinator is represented as number 6.

The Gama graph is basically divided into two groups. On the left side, individuals number 1, 3, and 4 are managers who work for more than two years at the incubator. On the right side, individuals 2 and 5 are interns, showing greater contact with the coordinator (6). Intern number 5 is the analyst and presents a higher average of centrality than intern number 2 (who is the assistant), probably because he/she has flexible working hours and spends more time with other incubator workers (Table I).

Most of the team members of the Gama incubator work in the same physical environment, which facilitates the flow of information. It also eliminates the need for intermediation among them. The main form of communication used is personal contact. Being in the same environment promotes a high degree of knowledge and information sharing regarding the projects being carried out, reinforcing an environment of trust among them. Gama team members answered that besides personal contacts they share information through e-mail and WhatsApp. They added that they exchange a lot of experiences, information and knowledge among them. Finally, team members of the incubator Gama said that besides the physical distance between them and the coordinator, the coordinator is frequently in contact and is always available to discuss any issue related to the incubator.

4.2 Incubator Omega

At incubator Omega, the relationships among most of the members are highly reciprocal, represented in Figure 2, as well as the degree of centrality of the members. Only team members 8 and 2 present a degree below the others, which confirms the non-reciprocal relations found by the analysis.

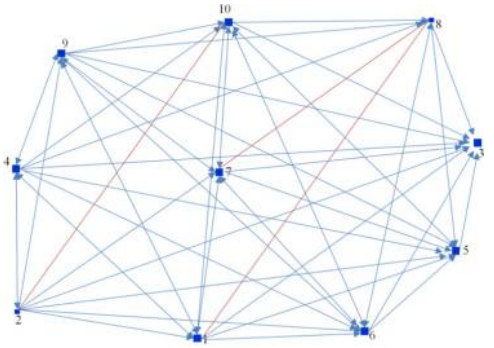
According to the measurements of the centrality of the incubator Omega, team member number 8 has a low degree of centrality compared to others. His/her task is to raise funds and, which makes him/her work most of the time outside the incubator. Team members numbers 2 and 8 present greater distance from the others, which can be an indicator of the difficult access to other partners, as well as an obstacle to receiving and sharing tacit knowledge with the other team members of the incubator. Their tasks are well delimited and they stay physically in a room far from the others. Team members 2 and 8 are the manager of managerial support and the new businesses manager. The coordinator presents the highest level of centrality (number 4), which means that the average of inputs and outputs is higher than the other team members (Table II).

With regard to the intermediation between team members numbers 2, 3, 6, 8 and 9, there is high potential that they support the mediation of knowledge in the network. That is because, as

Table I.
Measurements of centrality of the incubator Gama

Member	Centrality input*	Centrality output*	Average* centrality	Closeness input*	Closeness output*	Intermediation*
1	60	80	70	100	100	0
2	88	72	80	100	100	0
3	88	72	80	100	100	0
4	88	84	86	100	100	0
5	88	96	92	100	100	0
6	80	88	84	100	100	0

Note: *Normalized values
Source: Research data



Source: Research data

Figure 2.
Graph of incubator Omega

Member	Centrality input*	Centrality output*	Average* centrality	Closeness input*	Closeness output*	Closeness * closeness	Intermediation*
1	69	58	63.5	90	100	95.0	0.397
2	73	58	65.5	100	100	85.9	1
3	73	56	64.5	100	100	100	1
4	73	71	72.0	90	82	100	0
5	71	67	69.0	90	100	100	0.397
6	58	76	67.0	100	100	100	1
7	49	82	65.5	90	100	95.0	0.694
8	53	42	47.5	100	100	82.5	1
9	64	69	66.5	100	100	100	1
10	64	71	67.5	90	75	95.0	0

Note: *Normalized values
Source: Research data

Table II.
Measurements of centrality of the incubator Omega

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indicated by the cohesion indicators, the network has high connectivity and low average distance. These factors facilitate direct contact among the team members of the incubator.

Incubator Omega has a high number of incubated projects and a limited number of team members. This limitation provides a rigid division of tasks by reducing the degree of personal contact, even in the same physical environment. Thus, the contact occurs mainly through electronic interaction, like instant messaging software and e-mails. Some strategies, such as get-togethers, are used to stimulate the sharing of tacit knowledge. However, knowledge sharing takes place as a result of specific demands of team members. The flow of information is well structured because of the use of software resources and shared database access. Some of the team members are in advantageous positions in the network regarding access to information and knowledge inside the database, which is represented by the degree of intermediation among them.

4.3 Incubator Sigma

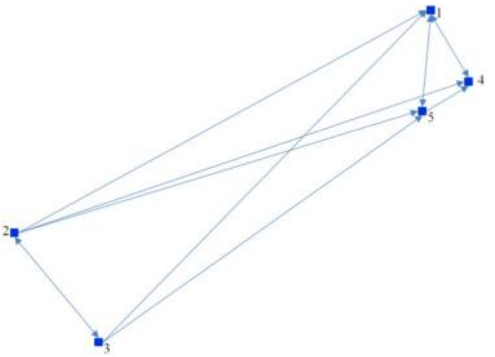
Incubator Sigma has a reduced the number of team members, five people in total. This justifies the high degree of reciprocity in the relationships, represented by Figure 5, as well

as the equality of degree of contact among team members, with equivalent sizes on the same figure (Figure 3).

The measurements of centrality in incubator Sigma indicate that team member number 1 has a high degree of centrality with other team members of the network. Team member number 1 works at the incubator for a long period of time and performs activities other than those formally required. On the other hand, team member number 5 has a low degree of centrality within the network. The contact among team members is highly related to their tasks. For example, person number 1 is the coordinator of quality, person 2 is communication advisor, and person 5 is a legal advisor. Their daily activities require them to keep constantly in touch with each other.

On the other side, members 2 and 3 are the coordinator and the administrative assistant of the incubator, respectively. However, the measurements of proximity indicate that all members are close. Thus, the centrality measurements clarify how a strong division of tasks interferes with the individuals' relationships in the network of the incubator Sigma (Table III).

Incubator Sigma also has a very limited work team with a high division of tasks and with peculiar journeys among team members. Thus, two team members have an 8-h workday and the rest of team has a 4-h workday. The schedules result in some team members having more personal contact with the ones they meet during the same work hours, which causes limitations in the sharing of information. Although they have proximity and ease of access



Source: Research data

Figure 3.
Graph of incubator Sigma

Member	Centrality input*	Centrality output*	Average* centrality	Closeness input*	Closeness output*	Intermediation*
1	90	100	95.0	100	100	0
2	85	85	85.0	100	100	0
3	80	85	82.5	100	100	0
4	80	70	75.0	100	100	0
5	65	60	62.5	100	100	0

Note: *Normalized values
Source: Research data

Table III.
Measurements of centrality of the incubator Sigma

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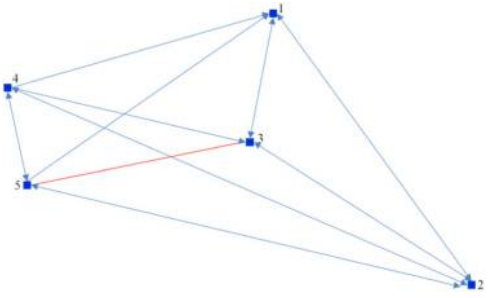
via telephone, via e-mail, and database, interaction and daily exchange of knowledge are restricted, causing a low trade of information.

4.4 Incubator Beta

Incubator Beta has a particular set-up with decentralized units. The unit is located in the metropolitan area of Belo Horizonte while the other units are located in other cities of the state. The internal network graph of the incubator indicates that all members have a degree of centrality equal to 4 and individuals are represented as having the same sizes. Team member 3 has a non-reciprocal relationship (in red) with person 5. Factors such as working time at the incubator, distance and little personal contact contribute to the non-reciprocity of relationships in this decentralized environment. Person 3 is the general coordinator of the incubator and person 5 is located in the farthest city with reduced contact with the central office.

The measurements of the centrality of incubator Beta indicate that the team member number 1 has the lowest degree of centrality with other team members of the network. Figure 4 shows that team members 1 and 2 have a greater distance from the rest of the network. Team member 1 performs his daily work activities in a building far from the incubator, which helps to explain the distance between him/her and other members. In addition, the distance of the relationship between team member number 2 with and rest of the network is justified by his reduced working hours at the incubator. Person 2 is the undergraduate intern, who was a newcomer in the period in which data was collected. Team members 4 and 5 are the general management and the management consultant, respectively. They physically work apart, which helps to explain their position on the graph (Table IV).

Regarding the distance among team members of the network, the results indicate that all of them have a high degree of proximity. However, team members 3 and 5 have a lower degree than the others. Since the network is decentralized, there is a need to be closer to other team members to maintain contact. In relation to mediation, team members 1, 2 and 3 stand out with a degree of intermediation equal to 3. This result indicates that the working time and the job functions exercised by the members allow them to have greater control of information upon others. The contact between members of incubator Beta is predominantly done via email, via instant messaging software, and over the telephone. This level of contact can enhance the level of information sharing, but can also constraint the effective sharing of tacit knowledge.



Source: Research data

Figure 4.
Graph of incubator Beta

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4.5 Incubator Zeta

Incubator Zeta shows two degrees of centrality, based on the Netdraw analysis. Team members 3 and 7 have lowest degrees of centrality in comparison to others. As result, the boxes that represent individuals 3 and 7 are smaller in size. Regarding the links, team members 6 and 8 have a non-reciprocal bond with member 3 (Figure 5).

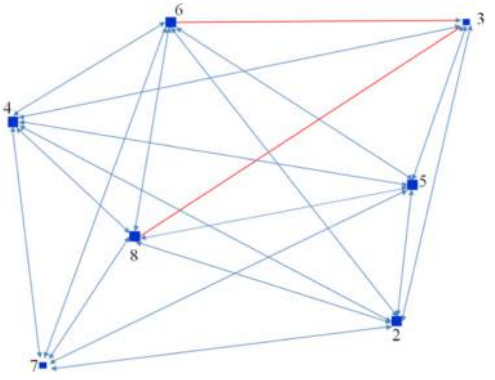
The measures of the centrality of incubator Zeta indicate that team member number 6 has a low degree of centrality; that is, he/she has low contact with the other members of the network. Person number 6 is an intern. He/she has very restricted working hours and has well-defined activity, which might explain the lower levels of average centrality. Working hours and restricted activities can constrain the flow of information to other team members, indicating that his/her behavior in the network is critical. Regarding the measurements of proximity among the actors of the network, the results show that team member 4 is the most distant of them, which can be a consequence of his job description, working hours, and the physical distance from the incubator. Person number 4 is the advisor of innovation and enterprise and his/her activity is related to communication and legal issues (Table V).

Finally, the measures of intermediation indicate that team members 1 and 4 have a greater influence on the mediation of the flow in the incubator environment, which may be explained by the activity and the working hours at the incubator. Person 1 is the operational and administrative manager. However, although the measurements of proximity indicate

Member	Centrality input*	Centrality output*	Average* centrality	Closeness input*	Closeness output*	Average* closeness	Intermediation*
1	60	80	70	100	100	100	3
2	88	72	80	100	100	100	3
3	88	72	80	80	100	90	3
4	88	84	86	100	100	100	0
5	88	96	92	80	100	90	0

Note: *Normalizes values
Source: Research data

Table IV.
Measurements of centrality of the incubator Beta



Source: Research data

Figure 5.
Graph of incubator Zeta

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team member 4 is distant from the others, the intermediation index shows that he/she has a high potential to mediate relationships, the flow of communication, and resources in the network.

5. Implications

The results of the social network created within technology-based incubators show three different types of shapes: two-team distribution, centralized and decentralized. In the two-team distribution type, the incubator has two teams with distinct activities and responsibilities, one focused on the incubated initiatives (internal activities) and the other focused on administrative work (external activities), such as marketing and search for new ventures. It is the case of the incubators Gama and Sigma. The consulting teams are composed of students of the universities who receive scholarships to help incubated initiatives to launch their businesses. These teams are closely supervised by the coordinator. The second team is composed of technical administrative assistants or advisors from the universities or even external consultants who are responsible for capturing new projects, organizing events and expanding the network of external relationships, for example.

The second type of configuration is the centralized one. An administrative technician or a professor of the university is the coordinator or manager and the other team members are students. Incubators Omega and Zeta present this type of distribution. These incubators are the largest in number of members and they perform specific tasks with well-structured responsibilities. Finally, the third type of configuration is the decentralized one, which is the case of the Beta incubator. The members of the incubator are physically distributed in different cities and enjoy full autonomy to run their subunits.

The strong delegation of tasks and processes, the high demand because of the incubator's growth, and the level of investments make the interaction among incubator team members more difficult. The results also show that the centrality levels are high in all incubators for both proximity and degree of contact, suggesting that all team members of the social networks formed within the incubators have proximity, as suggested by Iacono (2014) and Petrin *et al.* (2014). These findings support proposition one, which states that social networks within incubators tend to present high degree of centrality. Technology-based incubators are knowledge intensive enterprises that demand frequent contact and proximity (Lagemann and Loiola, 2013). Moreover, the integration of proximity with direct contact between individuals, as analyzed in this research, increases the trust between them, a fundamental characteristic for a greater share of knowledge. As Wasko and Faraj (2005) point out, the individuals with the highest frequency of contact with other members of the

Member	Centrality input*	Centrality output*	Average* centrality	Closeness input*	Closeness output*	Average* closeness	Intermediation*
1	69	74	71	50	100	75	6
2	63	40	51	50	100	75	2
3	60	63	61	50	88	68	3
4	69	91	80	47	70	58	6
5	60	51	56	47	88	67	0.476
6	49	49	48	47	78	62	0
7	51	77	64	47	88	67	0.476

Note: *Normalized values
Source: Research data

Table V.
Measurements of centrality of the incubator Zeta

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network are the ones who share knowledge and engage in a cooperating habit toward co-workers. Therefore, the measurements of the degree of contact indicate how a team member of the network relates to other members, upon the perception of all the network team members (Wasserman and Faust, 1994). Some individuals occupy privileged positions in the network by working physically full time at the incubator, thereby connecting with all workers, including those with reduced working hours (Wasko and Faraj, 2005).

In general, the distribution of job positions in incubators considers that the managerial or coordination positions must be occupied by a member of the university staff. Other team members are undergraduate students and interns of the university. Undergraduate students and interns carry out job functions related to their courses. In some cases, advisors or coordinators, who are located physically in an environment outside the incubator, are responsible for the financial resources and the allocation of projects, processes and training, thereby supporting proposition two. Incubator members who work on activities directly related to incubated initiatives present higher degree of contact and proximity than those who work on external activities or administrative routines that are not related to incubated initiatives. Incubators Omega and Zeta show how their social networks get somehow divided into two teams because of the nature of the hierarchical distribution. On the other hand, in all the three types of configuration, the exchange of information among team members in incubators is intense. In general, it occurs specifically when there is a request from a team member of the incubator. Team members are assigned to perform specific processes, mainly related to technical training, skills and abilities they already have.

The socialization that takes place in this context allows the exchange of resources, information, and knowledge among the members of the social network (Evans *et al.*, 2015). The diversity of knowledge and division of processes into specific tasks result in constant contact for exchange of information and experiences. Personal contact is relevant in this environment because informal conversations help to build trust and enhance the likelihood of knowledge sharing (Borges, 2012). However, in this context surrounded by timely tasks and rigid routines, personal relationships tend to be less important. Thus, the main contact occurring during work hours happened almost exclusively to professional issues. The highly hierarchical procedures have been highlighted as a barrier in the contact between coordination and team members because team members look for managerial assistance only for solving problems and discussing specific situations strictly related to their daily activities. Just in rare moments there is a spontaneous contact for the exchange of ideas, information, and experiences.

There is also an intense use of applications and software that facilitate fast and timely communication for the exchange of information. The use of applications and software is justified by the participants because these tools are agile, fast, easily accessible, helping to overcome the physical absence of some team members in incubators. E-mail is mainly used as a way to formalize and exchange documents, especially when the subject is relevant for the performance of some process or projects of the incubator. In general, bonding occurs when clarification is required and cannot be accomplished by other means.

6. Conclusion

This study sought to understand how innovation-oriented social networks are shaped in technology-based incubators. In a Brazilian southeastern university context, it was possible to analyze different business incubators and their configuration as a formal and informal structure. We identified three different types of configurations: two-team based, centralized and decentralized. The two-team configuration presented by incubators Gama and Sigma is divided into administrative and operational. The centralized configuration is the traditional

hierarchical structure formed by one coordinator or manager and students or technical assistants who are responsible for activities related to incubated initiatives, as the distribution presented by incubators Omega and Zeta. Finally, the decentralized configuration presented by incubator Beta is characterized by team members who are physically distributed and highly autonomous in their subunits.

The results also indicate that the hierarchy determined by organizational charts is not strictly followed in the flow of information. The incubators are administratively linked to Innovation and Technology Centers of the universities or, in some cases, to specific departments. The formality prevails in the relationships with advisors and coordinators, who are in an environment outside the incubator. The coordination is carried out by university professors, who also perform other tasks (e.g. teaching, research, administration or coordination) besides those related to the incubators. However, to ensure performance and coordination, the contact between team members is intermediated by managers or coordinators who participate in the daily activities of the incubator, as five of the six incubators showed. When the incubator needs to contact external companies or other sectors of the university, the hierarchical structure is followed since only those in managerial positions are able to request and control the resources. The results indicate that in technology-based incubators studied herein, the distribution of tasks and responsibilities are rigid and traditional. Moreover, managers and coordinators tend to centralize information and decision-making, constraining the flow of information across the network.

The main limitation of this study is in the methodological cutout regarding sample selection and the social network measurements. It was possible to identify the development of the intra-organizational network from measurements of frequency and intensity in relationships. Future research can investigate the quality of information exchanged among network members to distinguish whether there are exchanges of information or exchanges of knowledge. In addition, other studies may analyze the depth of the bonds formed within the incubator network to understand the dynamics of each group, as well as the level of trust. This research could be replicated in larger, more stable, and more competitive environments to understand the relationship among the attributes of the network, and possibly the flow of knowledge sharing in a Brazilian context.

In summary, the incubators of technology-based companies linked to universities located in the state of Minas Gerais in Brazil present different configurations regarding the social networks created within these environments. However, all of the incubators analyzed herein show dense social networks, representing a high degree of contact and high proximity among team members. Those characteristics contribute to facilitate official and informal communication between co-workers to enhance the flow of information. The results of this research suggest that incubators should stimulate social interaction other than those related to specific routine activities. As Barbosa and Hoffmann (2013) state, there is a high correlation between the support given by the company and the success in its consolidation. The exchange of knowledge is constrained by the timely tasks, daily pressures, activities performed outside the incubator and high turnover rates.

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