▪ Advances in Scientific and Applied Accounting, ▪ ISSN 1983-8611 ▪ São Paulo ▪ v.14, n.2 ▪ p. 179-192 ▪ May. / Aug. 2021.
▪ DOI: 10.14392/asaa.2021140207

ASAA

Influence of Network Capacity and Information and Knowledge Sharing on Open Innovation

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Summary

Objective: This article analyzes the influence of network capacity and information and knowledge sharing on open innovation in startups related to large companies.
Method: A survey was carried out with managers of startups ranked on the 100 Open Startups platform. The survey population comprises 324 startups and the sample contains 144 valid responses. For data analysis, structural equation modeling by partial least squares was applied.
Results: The results revealed a direct and significant influence between information sharing and open innovation, as well as between knowledge sharing and open innovation. Although the direct influence of network capacity in open innovation was not found, mediation of information and knowledge sharing was observed in this relationship, which indicates that network capacity can be an important antecedent and indirectly impact the performance of open innovation. It is concluded that the investigated variables are important drivers of open innovation performance, in order to reduce risks and bring benefits to startups in interorganizational relationships.
Contributions: The results contribute to the literature by revealing the mediating effect of information and knowledge sharing on the relationship between network capacity and open innovation performance, an advance in the understanding of shared resources. They also have practical and social implications, as they provide information about interorganizational relationships. It is expected that the findings help managers in conducting the relationship, with the purpose of reducing asymmetries between those involved and directing towards a beneficial relationship for both parties.

Keywords: Network capacity, Information sharing, Knowledge sharing, Open innovation.

How to cite:

Mannes, S., & Beuren, I. M. (2021). INFLUENCE OF NETWORK CAPACITY AND INFORMATION AND KNOWLEDGE SHARING ON OPEN INNOVATION. Advances in Scientific and Applied Accounting, 14(2), 164–178. https://doi.org/10.14392/asaa.2021140207

Received: June 12, 2021
Required revisions: September 20, 2021
Accepted: October 14, 2021

Introduction

Resource Dependence Theory (TDR) emphasizes how companies deal with and adjust to external contingencies and the ability to maintain and acquire resources that can contribute to their survival (Pfeffer & Salancik, 1978). A basic assumption is that the dependence on critical resources directs the actions, behaviors and decisions of organizations (Pfeffer & Salancik, 1978). This theory provides a lens that allows us to focus on the way in which interorganizational relationships (RIOs) are formed (Klein & Pereira, 2016).

A fertile field in this direction is that of startups, as they lack infrastructure and market knowledge and have limited resources (Fabrício et al., 2015). RIOs and collaboration networks have been adopted by startups to obtain more efficiency and results (Klein & Pereira, 2016) and as a strategy to ensure their continuity.

Involvement in cooperative networks or alliances can provide competitive advantage (Porter, 1990; Singh et al., 2019), but it can also bring challenges and opportunistic behaviors in relationships (Parida & Örtqvist, 2015). In order to try to reduce dependence, organizations need to manage and build marketable environments favorable to the company and effective strategies to obtain these resources (Pfeffer & Salancik, 1978).

Network capacity plays a significant role in network success (Parida et al., 2017), characterized as the ability to initiate, maintain and utilize relationships with external partners (Walter et al., 2006). From this perspective, this study focuses on the analysis of network management, through the interconnected dimensions of network capacity.

Research focused on answering questions related to network capacity, innovation and performance, and found positive results in the effects of network capacity on innovation and this on performance (Mitrega et al., 2017; Parida et al., 2017). It is believed that the network capability can explain the fact that some companies achieve the goals in relation to innovation and others do not, especially open innovation, as such capabilities help companies in managing the relationship (Walter et al., 2006). Networking capacity allows for greater bonding, which favors managing risks and bringing trust in the relationship with partners (Walter et al., 2006; Parida et al., 2017).

One of the essential aspects of collaboration between partners is the sharing of information and knowledge. Sharing information and knowledge is considered valuable for strengthening relationships and providing cooperation and collaboration in the network (Kim & Chai, 2017). Ipe (2003) argues that this sharing is more easily accomplished when there is trust and bond with partners.

The sharing of information and knowledge has been studied in different scopes, including open innovation (Chesbrough, 2003; Gupta & Polonsky, 2014). Previous research indicates the positive influence and benefits of sharing information and knowledge in open innovation (Gupta & Polonsky, 2014; Singh et al., 2019). They also highlight the relevance of managing relationships with external partners in open innovation (Popa et al., 2017).

Open innovation, as one of the practices that insert organizations into networks, traditionally had as its main strategy the interaction with universities, research and technology centers, however, there is a growing tendency to promote relationships between large companies and startups (Chesbrough, 2003; Stal et al., 2014). The literature reveals that the focus of open innovation prevails in large companies, but data referring to open innovation in startups, especially at the national level, are still incipient (Popa et al. , 2017; Cajuela & Galina, 2020).

The small businesses can gain from open innovation, as they already have efforts focused on outside of the organization because of its markets and limited resources (Lee et al., 2010). However, due to limited resources, smaller companies have difficulties in maintaining and developing collaborative RIOs (Fabrício et al., 2015). Startups on the one hand lack space in the market, infrastructure and experience, on the other hand have the flexibility and agility and are made up of good ideas and inventions (Fabrizio et al., 2015).

This attracts big companies and partners to RIOs. Therefore, research on open innovation in small companies has been gaining increasing interest (Radziwon & Bogers, 2019). However, an understanding of management and the conditions under which smaller companies can succeed in open innovation is still lacking (Radziwon & Bogers, 2019).

In view of the reported notes, the objective of the study is to analyze the influence of the network capacity and the sharing of information and knowledge on open innovation in startups related to large companies. This study is in line with the flow of research on shared resources in RIOs, answering literature calls. Usman and Vanhaverbeke

(2017) highlight the dependence of startups on external partners, but little is known about which mechanisms they use to manage their external partnerships.

An issue focused on the survival of startups is the impact of their strategic choices, which is still poorly investigated. Spender et al. (2017) highlight the need for a deeper analysis of open innovation and the management practices of startups in RIOs. Nationally, there is still a lack of studies on the relationship of open innovation practices between large companies and startups, which is a research opportunity.

Although researchers have investigated the antecedents of open innovation in companies, there are incentives to expand studies (Lefebvre et al., 2013; Radziwon, & Bogers, 2019), especially on open innovation in small companies, such as startups (Spender et al., 2017; Radziwon, & Bogers, 2019). Although studies emphasize the importance of network capacity, most have not investigated multidimensional scales, nor approaches to measuring this capacity linked to empirical models (Hagedoorn et al., 2006; Parida et al., 2017).

Thus, this research extends the literature related to network capacity and organizational success factors (Walter et al., 2006; Parida et al., 2017; Mitrega et al., 2017), by investigating their influence on open innovation. The study also contributes to the accounting literature by investigating antecedents and consequences of information and knowledge sharing in RIOs, highlighting the benefits arising from social interactions for the strengthening of interorganizational relationships.

Practical and social contributions come from new understandings about the sharing of information and knowledge, its drivers and consequences in RIOs. Relationship management allows companies to align their resource base with their open innovation needs, as this is characterized as more challenging compared to closed innovation (Wu et al., 2019).

High RIO discontinuity rates have been attributed to management problems (Parida et al., 2017), so investigating network capacity implications in startups is important to network competitiveness and survival, since startups' open innovation practices are considered its strategic asset in obtaining competitive advantage (Singh et al., 2019). By identifying positive influences of the dimensions of network capacity as antecedents of these relationships, it is pointed out where startups should focus their efforts to manage the power imbalance in RIOs with large companies.

2 Theoretical Review and Hypotheses

2.1 Network capacity and open innovation

Network capacity can be defined as the capacity oriented towards managing relationships at all stages of development (Mitrega et al., 2017). According to Walter et al. (2006), network capability includes four dimensions: partner knowledge; relationship skills; coordination between collaborating companies; and internal communication. Partner knowledge allows for the management of specific situations, which can deal with instabilities in their relationships and stabilize the company's position whenever necessary (Walter et al., 2006; Partanen et al., 2020).

Relational skills are focused on conflict management, sense of justice, self-reflection and empathy in relation to the partner (Walter et al., 2006). Coordination between companies encompasses borders and boundaries that connect the company to other companies (Walter et al., 2006). Internal communication translates into communication between individuals within the company and has the ability to assimilate information distributed in networks, reduce internal informational asymmetry and obtain internal learning with partnerships (Walter et al., 2006).

Companies with the capacity to maintain relationships, with knowledge of the partner, competent coordination and internal communication, can increase their ability to face risks and leverage innovation (Parida & Örtqvist, 2015). With the network ability, the company identifies partners using relational skills, coordinates relationships and accesses knowledge about the partner, managing and encouraging a joint innovative attitude (Parida et al., 2017). The ability to network provides mutual benefits to partners, supports the risk of learning and being learned in relationships (Walter et al., 2006).

In this direction, Chesbrough (2003) proposed a new innovation model, open innovation, defining it as the use of internal and external ideas and resources to leverage innovation, that is, make the organization's boundaries more flexible, breaking down barriers to the development of new products and processes via interaction with partners. Chesbrough (2003) considers that the resources and knowledge useful for innovation are distributed, and it is not possible for the organization to reproduce them alone, which encourages identifying and exploring external sources. However, one of the challenges for companies that adhere to open innovation is how to reduce the risk of external engagement (Kaufmann & Shams, 2015). Such innovation depends on the efficient management of relationships with external partners (Popa et al., 2017).

The formation and management of external relationships

direct companies to seek new areas of cooperation, providing opportunities for open innovation (Ritter & Gemünden, 2003). Usman and Vanhaverbeke (2017) highlight that the management of partnership networks is crucial for the success of startups in open innovation environments. However, small companies, such as startups, are more prone to relational risks of open innovation, which is a concern that managers of these must have (Dushnitsky & Shaver, 2009). Therefore, startups are less willing to share their business data when they do not have an effective system to protect their innovation (Dushnitsky & Shaver, 2009).

Previous studies between network capacity and innovation attest to the relationship (Mitrega et al., 2017; Parida et al., 2017; Rakthai et al., 2019; Costa & Didonet, 2020). Parida et al. (2017) and Mitrega et al. (2017) observed a positive relationship between network capacity and product innovation. Rakthai et al. (2019) identified a positive relationship between network capacity and innovation capacity in companies that went through an incubation process. Costa and Didonet (2020) observed that network capacity was the factor that stood out among the positive impacts on marketing innovation.

Networking ability was also positively related to knowledge creation and innovation (Ritter & Gemünden, 2003; Parida et al., 2017). Yuan (2019) found evidence in the Chinese context that the focal firm's network capacity has a direct effect on the cluster's collaborative innovation. Asemokha et al. (2020) found a positive relationship between network capacity and business model innovation, as well as mediation of business model innovation in the relationship between network capacity and international performance.

In this way, having open innovation as a variable also focused on external relationships, it is assumed that companies with network capacity have the capacity to manage this variable. Thus, it is assumed that:

H_1: Network capability has a positive influence on open startup innovation.

2.2 Sharing information and knowledge and open innovation

The sharing of information and knowledge are forms of communicative and collaborative activities, both in the intraorganizational and interorganizational scope (Trkman & Desouza, 2012). Sharing information can create knowledge and learning in relationships (Cheng, 2011). Sharing knowledge implies exchanging experiences, knowledge and skills (Lin, 2007). Both are considered important drivers of innovation (Belso & Diez, 2018; Kremer et al., 2019).

At the intraorganizational level, sharing occurs between individuals within the organization itself and is important for the development of new ideas and innovations (Kremer et al., 2019). In the interorganizational context, the sharing of information and knowledge contributes to increasing companies' capacity for innovation (Belso & Diez, 2018).

A reciprocal exchange of information applies in cooperation aimed at open innovation, with positive options for both parties (Chesbrough, 2003). By sharing information, organizations start to develop ideas, knowledge and joint innovations, resulting in open innovation. Chesbrough (2003) highlights that a driver of open innovation is the bidirectional flow of information. Rakthai et al. (2019) point out that open innovation requires the mutual exchange of information between internal departments and external organizations. Beuren et al. (2020) found a positive relationship between information sharing and collaborative innovation in cooperatives with strategic alliances.

Another variable that impacts open innovation is the sharing of knowledge, which, as information is processed and considered valuable (Trkman & Desouza, 2012), companies are often afraid to share it. Although it presents risks of bad faith and misuse of shared knowledge (Trkman & Desouza, 2012), sharing knowledge can be important in open innovation (Gupta & Polonsky, 2014), as it is the central resource of open innovation (Gupta & Polonsky , 2014).

Consistent with the TDR, which provides that RIOs are established as organizations also need external resources, given the dependence on the external environment to stay alive in the market (Pfeffer & Salancik, 1978), it is relevant that there is knowledge sharing, because only then will it be possible to achieve common goals, such as collaborative innovation and operational efficiency (Trkman & Desouza, 2012).

Research shows that knowledge sharing between companies provides mutual learning and allows them to work together to create value and innovations (Tan et al., 2016; Singh et al., 2019). Lin (2007) highlights knowledge sharing as essential to learning, as it allows the creation of market innovation activities. Singh et al. (2019), when investigating the relationship between knowledge sharing practices and open innovation, found that companies that share knowledge more intensely have more efficient open innovation. Hameed et al. (2021) observed a positive influence of external knowledge on open innovation performance in Pakistani hotels.

In the context of startup relationships, it is assumed that there is a need to share their ideas and knowledge to be able to establish these relationships. Sharing usually happens when there are mutual interests, that is, when there is a need to receive something in return (Ipe, 2003). Despite having different characteristics, large companies

and startups can be complementary, as one has what is limited in another (Kohler, 2016). From the above, it is assumed that the sharing of information and knowledge favors cooperation between partners, stimulating new ideas/technologies and collaborative projects. Thus, it is assumed that:

H_2: Information sharing has a positive influence on open innovation for startups.

H_3: Knowledge sharing has a positive influence on open innovation startups.

2.3 Effects of information and knowledge sharing between network capacity and open innovation

A TDR aponta que todas as organizações dependem de TDR points out that all organizations depend on some external resource (Pfeffer & Salancik, 1978), and this dependence is responsible for the creation of RIOs. The literature suggests that the companies most dependent on external resources are small companies, as they have limited resources (Parida et al., 2017) and the need to establish relationships with partners to progress in the market (Parida & Örtqvist, 2015; Parida et al., 2017). In this sense, Morrissey and Pittaway (2006) warn that they need relational skills and confidence in managing their relationships, to avoid power asymmetry and excessive dependence.

Tehseen and Sajilan (2016) analyzed the network competency under the resource-based view and TDR, and concluded that the network competency is an important organizational competency, which mainly favors small businesses. Hagedoorn et al. (2006) suggest that companies can advance their position in the network when they have network capacity. Businesses tend to feel more confident in cooperating with partners when they realize an adequate level of control and relationship management (Das & Teng, 1998). These authors point out that to ensure the achievement of objectives and build trust in collaboration between partners, effective management is necessary.

With the network ability, the company manages and encourages a joint innovative attitude (Parida et al., 2017), which is an important variable in the face of the challenge of reducing the risk of external engagement that small companies face when adhering to open innovation (Kaufmann & Shams, 2015).

Studies on network capacity and interorganizational performance should consider possible intervening/ mediating variables, as there are several factors that contribute to such a relationship (Fang et al., 2019; Yuan, 2019). Fang et al. (2019) suggest that the impact of network capacity on innovative performance is exerted by the mediating effect of resources on network configurations. Yuan (2019) found that the networking capability of the focal firms affects the cluster's collaborative innovation through dual-network integration; and that the dynamics of the environment and the knowledge integration capacity of the companies in the cluster have a mediating effect on the relationship between the network capacity of the central companies and the collaborative innovation of the cluster.

The importance of information sharing for a successful external relationship was highlighted by Trkman and Desouza (2012). Ritter and Gemünden (2003) point out that it is possible for the company to obtain information through the formation of external relationships, which leads to new horizons of cooperation and enables open innovation. Knowledge sharing is also important to open innovation (Gupta & Polonsky, 2014).

However, open innovation activities may not present advantages if they are only based on transactional relationships and distant from the partners, mainly in the context of small companies (Partanen et al., 2020). Thus, companies that are better connected with their partners can benefit from innovation networks by sharing knowledge among themselves (Fang et al., 2019).

Knowledge sharing practices have already been shown to mediate the relationship between the value of senior management knowledge and open innovation (Singh et al., 2019). Thus, in the present study, it is assumed that there is a mediating effect of information and knowledge sharing in the relationship between network capacity and open innovation. This proposition stems from the evidence that network capacity influences the sharing of information and knowledge (Ritter & Gemünden, 2003; Partanen et al., 2020) and that these shares influence open innovation (Chesbrough, 2003; Gupta & Polonsky, 2014; Singh et al., 2019). Thus, it is assumed that:

H4: Information sharing has a mediating effect on the relationship between network capacity and open innovation startups.

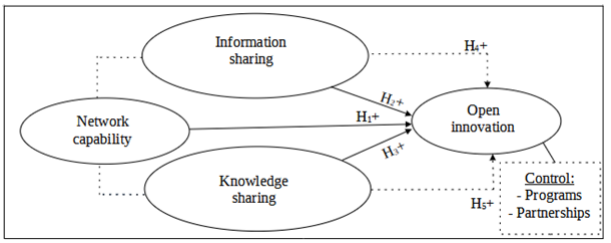
H5: Knowledge sharing has a mediating effect on the relationship between network capacity and open innovation of startups.

Supported in the literature, control variables were added to the model. Authors highlight that acceleration, competition and incubation programs provide startups with market access. Accelerators combine entrepreneurial startups with large companies, which seek to support the development and acceleration of startups through training, support services, and even opening up market access opportunities (Kohler, 2016). Competition programs, on the other hand, offer mentoring, insert startups in competitions, plus the opportunity to establish contacts with companies,

entrepreneurs and investors, so that large companies can identify potentially beneficial external innovations for their business (Urbaniec & Zur, 2020). Finally, incubators have as a central attribute the provision of network opportunities for incubated startups to form cooperative relationships with other companies (Sá & Lee, 2012).

The literature also highlights that the number of partners can impact open innovation, as a greater number of partners can provide ideas and resources that are beneficial to innovation, but an excessive number of external partners can affect the performance of innovation (Laursen & Salter, 2006).

In Figure 1, the conceptual model of the research and the hypotheses are presented.



Note: Dotted arrows refer to mediation hypotheses.
Figure 1. Theoretical research model

In Figure 1, the theoretical model of the research predicts a positive relationship between network capacity and open innovation, between information sharing and open innovation, and between knowledge sharing and open innovation. In addition to testing the direct relationships between the variables mentioned, it proposes to identify the mediating effect of sharing information and knowledge. Control variables are also part of the model.

3 Methodological Procedures

3.1 Population and sample

A survey was carried out with startups ranked on the 100 Open Startups platform, in the period from 2016 to 2020. This ranking started in 2016, which justifies the initial time cut, while its completion is limited to the year of operation of this research. The choice of these startups stems from the fact that they are companies engaged in open innovation and maintain relationships with large companies. The mapping of startups was carried out on the openstartups website, which provides the ranked startup, category and points achieved in open innovation. Therefore, the survey population comprises the 324 startups ranked from 2016 to 2020 on the 100 Open Startups platform.

From this list, we sought to establish contact with professionals in strategic positions (e.g. CEO, managers) on LinkedIn under the premise that they are engaged in the management of their company's RIOs. An invitation to connect was sent to the 837 professionals and, to the 471 who accepted the invitation, the questionnaire link was sent through the QuestionPro platform. Care was taken not to polarize respondents from a single startup, limiting a maximum of three respondents per company. From December 2020 to January 2021, a total of 144 valid responses were obtained (17.2%).

3.2 Constructs and research tool

The constructs and variables of this study were measured using a questionnaire (Appendix A), based on previous studies and validated in previous research. The questionnaire comprises assertions from multiple scales, measured on a seven-point Likert scale.

Network capacity was measured using the research instrument by Partanen et al. (2020), adapted from Walter et al. (2006). We sought to measure the degree of availability of four dimensions of network capacity: (i) coordination between companies; (ii) relationship skills; (iii) knowledge of the partner; and (iv) internal communication. Respondents were asked to what extent the assertions apply in the organization in relation to the form, care and use of relationships with its main open innovation partners (large companies that selected their startup to develop innovations), on a scale of 1 = does not apply to 7 = fully applies.

In the information sharing construct, assertions from the research instrument by Cheng (2011) and the assertion "We and our business partners and/or other external parties exchange information that help in business planning" by Tan et al. (2016). We questioned the degree of agreement with each of the statements about information sharing in the context of the relationship between the organization and its main open innovation partners (large companies that selected their startup to develop innovations), on a scale of 1 = Strongly Disagree to 7 = Strongly Agree.

For knowledge sharing, the research instrument by Wang and Hu (2020) was adapted, regarding the relationship between startups and their partners (large companies). The original assertions sought to raise the reality of relationships with members of the supply chain. Respondents were asked about the degree of agreement with each of the statements about knowledge sharing in the context of the organization's relationship with its main open innovation partners (large companies that selected their startup to develop innovations), on a scale of 1 = Strongly Disagree to 7 = Strongly Agree.

In the open innovation construct, the research instrument by Hameed et al. (2018) was used. We asked about the degree of agreement with each of the assertions related to the performance of open innovation (with large companies that selected their startup for innovation development) in the organization, on a scale from 1 = totally disagree to 7

= totally agree.

On the premise that organizational characteristics (number of relationships and participation in acceleration, competition or incubation programs) can affect open innovation (Laursen & Salter, 2006; Sá & Lee, 2012; Kohler, 2016; Urbaniec & Zur, 2020), control variables were entered into the questionnaire. The number of relationships, operationalized as a continuous variable, was measured by asking: "How many partnerships does your organization have approximately?". As for the programs, the question was: "Have you ever participated in any acceleration, incubation or competition programs?". The result for this question was: 73.6% yes and 26.4% no.

3.3 Data analysis procedures

Descriptive analysis procedures and structural equation modeling (SEM-SmartPLS), estimated by Partial Least Squares (PLS), were used. In SEM-PLS, direct relationships were analyzed by path coefficients (path), and indirect relationships by total indirect coefficients (Hair et al., 2017). In the analysis of mediation, the precepts of Hair et al. (2017) and Bido and Silva (2019), that the antecedent variable should influence the mediator and the mediator should influence the consequent. Bido and Silva (2019) emphasize that for confirmation of full mediation, the direct effect must not be significant, and the indirect effect must be significant.

Network capability was treated as a second-order construct. Thus, its first-order constructs (coordination between companies, relationship skills, knowledge of the partner) were treated with an approach of repetition of indicators, of the reflexive-reflective type.

3.4 Bias Tests

The data collection method can lead to the bias of the common method (Common Method Bias), characteristic of cross-sectional studies, in which responses are collected in the same period and by the same source (Podsakoff et al., 2003). To mitigate this problem, respondents were warned that there are no right or wrong answers, so that they would answer according to their perception. The Harman single-factor test was also applied, which checks whether the data have representative bias limitations of the common method, following the assumptions of Podsakoff et al. (2003). The test results indicated that the total explained variance was 64.86%, with the first factor explaining only 32.34% of the total variance, therefore, no single factor individually represents a large part of the variance (>50%), and that the survey data do not have limitations related to common method bias.

Possible distortions in the sample were also investigated through the non-response bias test, using the first-lasts comparison criterion, due to the impossibility of identifying those who chose not to answer the questionnaire (Mahama & Cheng, 2013). Thus, the t test for independent samples was applied as a way to compare the responses of the assertions in the study of the first and last 10% respondents (14 first and last). At the 5% significance level, no significant differences were found between the groups. Thus, it is assumed that the non-response bias is not representative (Mahama & Cheng, 2013). Together, the test results mitigate the apprehension of possible biases that could reproduce noise in the data analysis.

4 Description and Analysis of Results

4.1 Profile of companies and respondents

Most respondents (80.56%) are male and 68.06% are aged up to 40 years. A large part (40.97%) has a postgraduate degree at the level of specialization and/or Master of Business Administration (MBA), and 29.86% have a degree in administration/business/management. As for the position in the company, most are in top management (59.03%) and for less than 1 year (30.56%). This profile is consistent with the reality of startups, as they are new companies and start with few high-level and multidisciplinary founders (Ries, 2011).

About startups, half have been in operation for 5 to 7 years (50%), followed by 1 to 4 years (25%); and 43.06% have fewer than 20 employees. These numbers are consistent with the reality of startups, which are generally young, operate with a high degree of technology and lean teams (Ries, 2011). As for the stage of startups, it was pointed out that 84.72% are already in the final stages (paying customers, launched on the market) of innovation, when they can take advantage of the marketing channels that large companies open (Hogenhuis et al., 2016). In general, the characteristics of the responding startups are convergent with other studies carried out in the same context (Ries, 2011; Hogenhuis et al., 2016).

4.2 Measurement model

In the measurement model, the reliability indexes (internal and composite) and validity (discriminating and convergent) of the constructs are verified (Hair et al., 2017). For the reliability of the indicators of the constructs, values greater than 0.70 are recommended, but loads between 0.40 and 0.70 should only be excluded if they lead to an increase in the Average Variance Extracted (AVE) and in the Composite Reliability (CR) (Hair et al., 2017). Thus, an assertion of network capacity (in internal communication – CI2) was excluded to adjust the model. Table 1 shows the results of the model.

Table 1. Reliability and validity of the measurement model

latent variables / Indicators	1	2	3	4	5	6
1. Network capability	**0,640**					
2. Information sharing	0,589	**0,776**				
3. Knowledge sharing	0,487	0,424	**0,841**			
4. Open innovation	0,427	0,398	0,551	**0,756**		
5. Programs	0,126	0,244	0,088	0,016	**1**	
6. Partnerships	0,123	0,115	0,107	0,000	-0,034	**1**
Median	6	6	5	5		
Average	5,87	5,35	5,00	5,17		
Standard deviation	1,19	1,54	1,74	1,61		
AVE >0.50	0,573	0,602	0,707	0,571	1	1
Cronbach's Alpha >0.70	0,852	0,781	0,781	0,874	1	1
CR >0.70	0,842	0,857	0,879	0,903	1	1

Note: VIF (Variance Inflation Factors): Network capacity = 1.717; Information sharing = 1.671; Knowledge sharing = 1.366; Programs = 1.068; Partnerships = 1.024.

Source: research data.

The results of the descriptive analysis show that the respondents perceive a high presence of the variables in this research (standing above the midpoint 4), especially the network capacity (mean 5.87; median 6).

All variables observed presented Cronbach's alpha and CR values greater than 0.70, which indicates that the assertions as a whole are reliable. As for the convergent validity, the AVE demonstrates that each variable explains more than half of the variance of its indicators, therefore, above the minimum established in the literature to attest to the convergent validity of the variables. Discriminant validity was analyzed using the Fornell-Larcker criterion, in which all variables present values higher than the coefficients of the correlation matrix, which suggests acceptable discriminant validity.

As a way to ensure the absence of multicollinearity between the latent variables, the analysis of Variance Inflation Factors (VIF) indicators was performed, whose values should be less than 3 (Hair et al., 2017). The absence of multicollinearity between the variables is confirmed, which presents values below 2. Therefore, the analyzes indicate that the measurement model is adequate, which allows for the analysis of structural relationships.

4.3 Structural model and hypothesis testing

To test the structural model, the bootstrapping technique was used, with parameters of 5,000 resampling (samples) and 5,000 interactions, confidence interval with corrected and accelerated bias (bias-corrected and accelerated) and two-tailed test at a significance level of 10% (Hair et al., 2017). Table 2 presents the path analysis, beta coefficient (β), t-value, p-value and decision for each hypothesis. Pearson's coefficient of determination (R^2) and Predictive Relevance were considered, using the Stone-Geisser indicator (Q^2), to attest to the validity and accuracy of the model.

Table 2. Structural model results: hypothesis testing

	Hypotheses		t-value	p-value	Decision
	Network capability -> Information sharing	0.589	9.101	0.000*	
	Network capability -> Knowledge sharing	0.487	6.022	0.000*	
H1	Network capability -> Open innovation	0.144	1.419	0.156	Reject
H2	Information Sharing -> Open innovation	0.161	2.064	0.039**	**do not reject**
H3	Knowledge Sharing -> Open innovation	0.429	6.432	0.000*	**do not reject**
M4	Network capacity -> Information sharing open innovation	0.095	1;935	0.053***	**do not reject**
H5	Network capacity -> Knowledge sharing open innovation	0.209	4,112	0.000*	**do not reject**
C1	Programs -> Open innovation	-0.083	1.370	0.171	Reject
C2	Partnerships -> Open innovation	-0.086	1.426	0.154	Reject

*Note1: Significant at the level of *p<0.01; **p<0.05; ***p<0.10.*

Note2: C1 = control 1; C2 = control 2.

Source: research data.

H_1 postulated that network capacity has a direct and positive influence on open innovation. Despite the positive relationship, the results did not show statistical significance (p>0.10). Thus, it cannot be said that the network capacity directly influences open innovation. It is inferred that intervening variables may be present and have impacts on this relationship. On the other hand, positive influences were found between network capacity and information sharing (β=0.589; p<0.01) and between network capacity and knowledge sharing (β=0.487; p<0.01).

H_2, which predicted a direct and positive relationship between information sharing and open innovation, was supported (β=0.161; p<0.05). This indicates that interorganizational information sharing directly and positively impacts open innovation. Likewise, the direct relationship of knowledge sharing with open innovation allows the acceptance of H_3 (β=0.429; p<0.10), which suggests that knowledge sharing directly and positively reflects on open innovation.

Hypotheses H_4 and H_5 predicted mediation of information sharing and knowledge sharing in the relationship between network capacity and open innovation. There was no direct relationship between network capacity and open innovation, but indirect when inserting the mediating variable, thus considering total mediation in both hypotheses. These results provide evidence for the non-rejection of hypotheses H_4 and H_5. Therefore, network

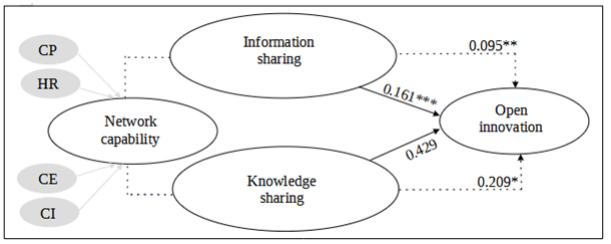
capacity influences open innovation through information sharing (β=0.095; p<0.10) and knowledge (β=0.209; p<0.01).

It was proposed to include control variables in the model highlighted in the literature (Laursen & Salter, 2006; Sá & Lee, 2012; Kohler, 2016; Urbaniec & Zur, 2020) as influential in open innovation. The results did not show statistical significance in relation to the number of partnerships and open innovation (p>0.10), as well as in relation to participation in acceleration, incubation or competition programs and open innovation (p>0.10). Thus, there was no influence of the control variables in the model.

Finally, the general adjustment indicators of the model were evaluated. It appears that the model presents an R^2 of 0.232 for information sharing, 0.343 for knowledge sharing and 0.338 for open innovation, which represents explanatory power of medium and large effect, respectively. Regarding Q^2, the results were above zero, information sharing 0.195, knowledge sharing 0.160 and open innovation 0.191, which confirms the accuracy of the model (Hair et al., 2017).

4.4 Discussion of results

Discussions are outlined based on the results presented in Figure 2, which highlights the significant relationships.



*Note1: Significant at the level of *p<0.01; **p<0.05; ***p<0.10.*
Note2: Variables that make up the network capacity: CP= knowledge of the partner, HR= relationship skills, CE= coordination between companies, CI= internal communication.
Figure 2. Significant results of the structural model

H_1, which predicted a positive and significant relationship between network capacity and open innovation, was rejected as it did not show statistical significance. This differs from Lefebvre et al. (2013), who found direct relationships between network competence and the opening of companies in the food sector in Europe. The study of the original network capacity questionnaire (Walter et al., 2006) identified a positive relationship between network capacity and spin-off performance. Although network capacity is seen as an important variable for open innovation, as it promotes access to partners, boosts openness and has network management capacity (Lefebvre et al., 2013; Parida et al., 2017), intervening variables can influence this relationship (Fang et al., 2019; Yuan, 2019).

A significant positive and direct relationship between network capacity and information and knowledge sharing was confirmed. Although it has not been formulated as a research hypothesis, it can be said that the network capacity supports the sharing of information and knowledge in these relationships (Ipe, 2003; Trkman & Desouza, 2012).

According to Walter et al. (2006) and Parida et al. (2017), this results from the fact that the company is able to: (i) coordinate relationships and situations, which enables a better response to sharing between partners; (ii) having knowledge of the partner, which increases the bond and allows the management of specific situations; (iii) possess relational skills, which directly impact the startups' ability to influence personal exchanges; and (iv) having internal communication, which impacts by having the ability to assimilate distributed information, learning about partnerships and mitigating the risk of forwarding conflicting and confusing messages to its partners.

H_2, which predicted a positive and significant relationship between information sharing and open innovation, was not rejected. The results are consistent with those of Chesbrough (2003), Trkman and Desouza (2012), Rakthai et al. (2019), Beuren et al. (2020), that information sharing has direct impacts on open innovation. By sharing information, there is a beneficial cooperation for open innovation (Chesbrough, 2003), as organizations start to develop joint knowledge, ideas and innovations. The positive association between information sharing and open innovation suggests that information systems support partnerships.

A direct and positive influence of knowledge sharing on open innovation was also found, which supports not rejecting H_3. Thus, it can be said that knowledge sharing stands out in the collaborative context investigated, strengthening relationships, enhancing relationships and fostering innovation. Singh et al. (2019) also found direct effects of knowledge sharing on open innovation in small and medium-sized companies in the UAE. These results are consistent with Trkman and Desouza (2012), Gupta and Polonsky (2014), Singh et al. (2019), that knowledge sharing is a central resource of open innovation, as it provides knowledge to business networks and promotes innovation.

As forms of collaborative and communicative activities, information and knowledge sharing are considered essential to the performance of open innovation. Thus, the non-rejection of hypotheses H_2 and H_3 contributes to a differentiated line of research, addressing the vision of startups in RIOs and highlighting the positive impacts of these shares in open innovation. According to Ipe (2003),

sharing usually happens when there are mutual interests and, therefore, startups need to share knowledge to be able to establish these innovation relationships, despite the risks of sharing.

The hypotheses predicting mediation of information sharing and knowledge sharing in the relationship between network capacity and open innovation (H_4 and H_5) were not rejected. In this way, the interaction of the intervening variables in this relationship is confirmed. Both mediations were proposed based on studies that highlight positive effects of sharing information and knowledge in RIOs (Gupta & Polonsky, 2014; Singh et al., 2019, Beuren et al., 2020).

If sharing is necessary to establish relationships between companies (Ipe, 2003), network capacity can be a significant antecedent in the relationship, as it reduces the risk of engagement (Kaufmann & Shams, 2015). Organizations tend to feel more confident when they perceive an adequate level of management in face of exchanges, as the fear of exploitation and the lack of links between companies can be obstacles to the sharing of information and knowledge (Das & Teng, 1998; O' dell & Grayson, 1998).

The network capacity, by providing the management of specific situations, linking between companies and avoiding excessive power asymmetry between the parties (Morrissey & Pittaway, 2006), is beneficial to startups, as it impacts the sharing of information and knowledge and stimulates in a way indirect open innovation, providing greater performance.

Tehseen and Sajilan (2016) analyzed network competence through the lens of TDR and concluded that it leads to success mainly for small companies, evidence corroborated in the context examined here. It is understood that the sharing of information and knowledge is essential in the relationship, while such sharing is seen as a core resource for open innovation, and the ability to network is essential for adapting and managing situations and risks to which companies are exposed in these open processes.

As the study's control variables had no impact on the proposed model, it is inferred that the companies in the sample equally engage in established relationships and have similar levels of open innovation performance, regardless of the number of relationships and participation in acceleration programs, incubation or competition.

5 Conclusion

Through the lens of TDR, this study analyzed the influence of networking capability and information and knowledge sharing on open innovation in startups related to large companies. The results showed that network capacity does not have a significant direct influence on open innovation in the surveyed startups. These findings may come from the startups' own characteristics, as well as from the analyzed context.

The sharing of information and knowledge had a direct positive influence on open innovation. These results have also been found in other contexts in the literature (Singh et al., 2019; Beuren et al., 2020; Hameed et al., 2021). The research findings indicate that information and knowledge sharing are antecedents of open innovation, thus favoring interaction between organizations and are timely to achieve common goals.

The mediating effect of information sharing and knowledge sharing on the relationship between network capacity and open innovation was confirmed. In line with TDR, it is argued that, by holding network capacity, organizations are able to reduce the asymmetry of power between the parties and the risk of engagement, and this has a positive impact on the sharing of information and knowledge. The sharing of information and knowledge, in turn, is responsible for establishing these open innovation relationships and benefiting the interaction between partners.

It is concluded from the research results that the network capacity indirectly influences open innovation, through the sharing of information and knowledge. The findings indicate that the investigated variables are important drivers of open innovation performance, in order to reduce risks and bring positive impacts to startups in RIOs.

This study brings implications to the literature by revealing that the sharing of information generated in the scope of management accounting and knowledge sharing help to support interorganizational management. By finding significant mediating variables in the relationship between network capacity and open innovation, the understanding of shared resources in RIOs advances. If these mediating factors (information and knowledge sharing) are not highlighted, the direct relationship between network capacity and open innovation performance is not perceived.

Thus, it highlights the relevance of information systems that support the management of RIOs and greater performance of open innovation. In this way, the understanding of information and knowledge sharing in RIOs (Gupta & Polonsky, 2014; Singh et al., 2019, Beuren et al., 2020) of startups related to large companies is expanded.

It also fills the gap observed regarding open innovation in the context of startups (Cajuela & Galina, 2020). While most studies addressed open innovation from the point of view of large companies (Popa et al., 2017; Cajuela & Galina, 2020), this study focused on startups, which usually depend on external resources to achieve your goals. The findings also have social implications, as they

provide information about RIOs.

Although still recent, relationships between startups and large companies are already necessary (Usman & Vanhaverbeke, 2017). It is then expected that the results of this study help managers in conducting the relationship, with the purpose of reducing asymmetries between those involved and directing towards a beneficial relationship for both parties.

By presenting positive results in relationships, the conditions in which startups can successfully perform open innovation are pointed out, and the impacts that the strategic choices adopted by them can bring, reducing the discontinuity of RIOs. Study limitations may represent opportunities for future research. The survey method implies a transversal approach to the problem, so future research can carry out: case studies, in order to clarify aspects that may intervene in the relationship between network capacity and open innovation; experimental studies in order to control variables and measure different scenarios.

The constructs were adapted to measure the relationships between large companies and startups from the perspective of startups, therefore, they only reflect their perception, which provides an opportunity to investigate the other side of the relationship. Future studies can adapt the theoretical model of this study to different contexts, in order to verify whether the proposed relationships are confirmed in other relationships, such as in supply chains, in the relationships in incubators and technology parks.

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Appendix A.
Survey instrument

Network Ability (Partanen et al., 2020; based on Walter et al., 2006).

CP = Partner knowledge; HR = Relationship Skills; CE = Coordination between companies; CI = Internal communication.

*Item excluded for model adjustment.

Indicate the extent to which the statements below apply to your organization regarding the form, care and use of relationships with your main open innovation partners (large companies that selected your startup for innovation development). Scale: 1 = not applicable to 7 = fully applicable.

CP1. In our company, we know our partners' markets.
CP2. In our company, we know the products/procedures/services of our partners.
CP3. At our company, we know the strengths and weaknesses of our partners.
HR1. In our company, we have the ability to build good personal relationships with our business partners.
HR2. In our company, we can flexibly deal with our partners.
HR3. In our company, we almost always solve problems constructively with our partners.
CE1. In our company, we analyze what we would like and want to achieve with which partner.
CE2. In our company, we develop relationships with each partner based on what they can contribute.
CE3. In our company, we regularly discuss with our partners how we can support each other.
CI1. In our company, we have regular meetings for all projects.
CI2. In our company, employees develop informal contacts with each other.*
CI3. In our company, managers and employees often give each other feedback.

Information Sharing (CI) (Cheng, 2011; Tan et al., 2016). Indicate your level of agreement with each of the statements below about information sharing within the scope of your organization's relationship with your main open innovation partners (large companies that selected your startup for innovation development). Scale: 1 = strongly disagree to 7 = strongly agree.

CI1. Our partners share proprietary information with us.
CI2. We provide information to our partner that can help you.
CI3. We provide information to our partner on a frequent and informal basis, not just in accordance with the specific contract.
CI4. We and our partners exchange information that helps with business planning.

Knowledge Sharing (CC) (Wang & Hu, 2020).

Indicate your level of agreement with each of the statements below about knowledge sharing within the scope of your organization's relationship with your main open innovation partners (large companies that selected your startup to develop innovations). Scale: 1 = strongly disagree to 7 = strongly agree

CC1. We share our innovation work reports and technical documents with our partners upon request.
CC2. We share our manuals and methodologies with our partners upon their request.
CC3. We often share our experience, know-how or new ideas with our partners.

Open Innovation (AI) (Hameed et al., 2018).
Indicate your level of agreement with each of the statements below regarding the performance of open innovation (large companies that selected their startup for innovation development). Scale: 1 = strongly disagree to 7 = strongly agree.
IA1. We chose to engage in the open innovation model, believing that it is a way to commercialize the idea.
IA2. Collaborative efforts with partners outside the organization to work on a win-win project is the best description of open innovation.
IA3. We chose to engage in the open innovation model, believing that outsourcing expertise is beneficial to our organization.
IA4. New ideas are always welcome for open innovation in our organization.
IA5. Out-or-in licensing of intellectual property is the best description of open innovation.
IA6. Sharing internal and external knowledge enhances open innovation.
IA7. Licensing the latest ideas promotes open innovation.