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Risk Management and Collaborative Innovation: Intervention of Communication Intensity

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ABSTRACT

This study investigates the influence of risk management on collaborative innovation and the intervention of communication intensity in agricultural cooperatives. A survey was conducted with managers of Brazilian agricultural cooperatives listed in the Organization of Cooperatives of Brazil. The structural equation modeling technique was applied to a sample of 103 valid answers. The results show that risk management positively influences collaborative innovation and communication intensity, and that communication intensity positively influences collaborative innovation. Furthermore, a mediating effect of communication intensity was observed in the relationship between risk management and collaborative innovation. Theoretical implications arise from the observation of the intervention of communication intensity in this relationship, mainly by providing insights to expand research in this direction. Practical implications also arise from observing the intervention of communication intensity in this relationship, such as alerts to the managers of these organizations about the relevance of aligning communication and risk management to the purpose of collaborative innovation.

KEYWORDS

Risk management, Collaborative innovation, Communication intensity, Agricultural cooperatives

Gerenciamento de Riscos e Inovação Colaborativa: Interveniência da Intensidade de Comunicação

RESUMO

Este estudo investiga a influência do gerenciamento de riscos na inovação colaborativa e a interveniência da intensidade de comunicação em cooperativas agropecuárias. Uma *survey* foi realizada com gestores de cooperativas agropecuárias brasileiras listadas na Organização das Cooperativas do Brasil, e na amostra das 103 respostas válidas aplicou-se a técnica de modelagem de equações estruturais. Os resultados mostram que o gerenciamento de riscos influencia positivamente a inovação colaborativa e a intensidade de comunicação, e que a intensidade de comunicação influencia positivamente a inovação colaborativa. Ainda, foi observado efeito mediador da intensidade de comunicação na relação entre gerenciamento de riscos e inovação colaborativa. Implicações teóricas decorrem da observação da interveniência da intensidade de comunicação nessa relação, principalmente por fornecer *insights* para aprofundar pesquisas nessa direção. Também implicações práticas advêm da constatação da interveniência da intensidade da comunicação nessa relação, como alertas aos gestores dessas organizações sobre a relevância de alinhar a comunicação e o gerenciamento de riscos ao propósito da inovação colaborativa.

PALAVRAS-CHAVE

Gerenciamento de riscos, Inovação colaborativa, Intensidade de comunicação, Cooperativas agropecuárias

1. INTRODUCTION

Innovation is considered one of the main sources of competitive advantage and improved performance of organizations (Henri, 2006; Lopes, Beuren & Martins 2018). Innovation in interorganizational relations, called open innovation or collaborative innovation (Chesbrough, 2003), is indicated as a business strategy of several organizations (Rosas et al., 2015; West et al., 2014). Collaborative innovation, a form of co-innovation, consists of the use of internal and external ideas and resources to leverage innovation, which implies exchange of resources and openness of the organization (Chesbrough, 2003).

Organizations can obtain benefits by opening their borders, such as saving time and innovation costs, forming partnerships, exploiting complementary assets and knowledge of their partners, attracting new customers, and combining internal and external resources (Dahlander & Gann, 2010; West et al., 2014). On the other hand, intrinsic risks are present in the sharing and opening of borders, which must be managed to direct the organization to innovation (Rosas et al., 2015). Anand and Khanna (2000) point out that organizations must educate themselves to manage their partnerships and networks to cope with relational contingencies. Caglio and Ditillo (2008) point out the failures and risks presented in resource exchanges, such as the lack of management and control.

Risk management requires analysis of organizational and/or interorganizational risks to identify which risks should be faced or ignored (Damodaran, 2009), as well as assessing, monitoring, and controlling the risks to which organizations expose themselves (Dionne, 2013). Risk management is not only relevant to the organization itself but allows links between organizations and the environment in which they are inserted (Silva & Beuren, 2020; Soin & Collier, 2013). The management literature emphasizes that organizations focused on innovation seek to assess, monitor, and control future events to mitigate inherent risks (Etges & Cortimiglia, 2019). Rosas et al. (2015) highlight that risk management can be effective for collaborative innovation. This suggests an active role for risk management in collaborative innovation.

Communication stands out in collaborative innovation, present in interorganizational relationships. Interorganizational communication is established by the structures, forms, and processes arising from the exchange of messages between organizations (Shumate et al., 2017). The processes of interaction via communication can help organizations in learning, in the development of ideas, and in the joint resolution of problems (Paulraj et al., 2008). Communication intensity is measured by the frequency of conversation between networked parties (Yan & Dooley, 2013). It is indicated by Ernst (2002) as one of the five success factors linked to the process of developing new products.

Previous research indicates that risk management can intensify communication and cooperation between the parties by mitigating risks present in the relationships (Martini et al., 2013; Paulini et al., 2013). Thus, it is assumed that communication intensity can mediate the relationship between risk management and collaborative innovation. Although the relevance of risk management, communication, and innovation in interorganizational alliances is recognized, little is known about the interaction of these constructs, especially in cooperative organizations. Studying risk management in the context of cooperatives, especially in agribusiness, is defensible due to the diverse risks inherent in the activities of this economic sector (Behzadi et al., 2018).

Agricultural cooperatives disseminate technology and management of rural properties, which affects the quality, competitiveness, and scale of production (Silva et al., 2022). In addition to their social function, cooperatives must be competitive to face challenges (Beber et al., 2018; Silva et al., 2022). Despite all this, agricultural cooperatives have specificities that still require research

and deserve to be investigated, such as the connections of risk management with collaborative innovation and the effects of communication intensity in this context.

In this sense, we seek to answer the following research question: What is the role of risk management in collaborative innovation and communication intensity in agricultural cooperatives? Thus, this study investigates the influence of risk management on collaborative innovation and the intervention of communication intensity in agricultural cooperatives. Positive influence of risk management can be observed in collaborative innovation and communication intensity and of the latter in collaborative innovation, in addition to mediating effect of communication intensity in the relationship between risk management and collaborative innovation.

The relevance of this study is embodied in the growing flow of organizations that seek to work in networks instead of acting in isolation (Wu et al., 2017). Cooperatives already have a long-established way of cooperation and are an alternative means to the traditional one, revealing themselves to be drivers of innovation (Figueiredo & Franco, 2018). Research that shows that cooperatives can increase competitiveness through collaborative innovation (Borgen & Aarset, 2016). Gallardo-Vázquez, Sánchez-Hernández and Castilla-Polo (2014) highlight that cooperatives deserve to be studied since they present specificities in addition to their relevant role worldwide (Ruostesaari & Troberg, 2016). Behzadi et al. (2018) point out the lack of research on risk management in agribusiness and the importance of this management in agricultural supply chains.

Keers and Van Fenema (2018) emphasize the relevance of studying risk management in partnership networks, where simultaneous exchanges occur. In this perspective, risk management in co-innovation deserves further study since there is a limited amount of theoretical and empirical research on this subject (Abhari et al. 2017; Coras & Tantau, 2014; Rosas et al., 2015). The present study also answers the call for more research on open/collaborative innovation (Lefebvre et al., 2013; Radziwon & Bogers, 2019). Finally, the study is justified by analyzing the mediating role of communication intensity in the relationship between risk management and collaborative innovation.

This study contributes to the literature by discussing aspects that can boost collaborative innovation, and, in the case of cooperative organizations, an economic sector guided by collaborative principles. It also expands the theoretical circumscription related to the discussion around the effects of risk management on collaborative innovation, in addition to adding to the gaps identified regarding risk management in agribusiness, especially in the collaborative context. From the perspective of management practice, this paper contributes by providing a greater understanding to agricultural cooperative organizations about the principles involved in risk management and collaborative innovation to leverage their performance, highlighting the promotion of communication between partners.

2. THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESES

2.1. Risk management and collaborative innovation

Innovation has received different classifications over time. Among them, Chesbrough (2003) highlights open/collaborative innovation as the use of internal and external ideas and resources to leverage innovation. Open innovation is an important collaborative strategy (Beuren et al., 2020; Rosas et al., 2015).

Santoro et al. (2018) propose three focuses of open/collaborative innovation analysis: the variety of openness, consisting of the number of external sources involved (Santoro et al., 2018); the intensity of the partner, which refers to the depth of these relationships focused on innovation

(Aloini et al., 2015); and the readiness to collaborate, which is the ability of the organization to open itself to the most diverse forms of collaboration (Ahn et al., 2016; Santoro et al., 2018). These analyses weave through the risk management of open/collaborative innovation.

Risk management can inhibit innovation to the point that the organization has an aversion to the assumption of uncertainty (Berglund, 2007). On the other hand, there are arguments in the literature that organizations focused on innovation seek to assess, monitor, and control future events in order to mitigate inherent risks (Etges & Cortimiglia, 2019). Rosas et al. (2015) highlight the relevance of risk assessment to benefit from open innovation. According to this research flow, it is assumed that risk management can positively impact collaborative innovation, which leads to the following proposition:

- **H₁:** There is a positive influence of risk management on collaborative innovation.

2.2. RISK MANAGEMENT AND COMMUNICATION INTENSITY

Risks represent the ability of an action to provoke negative, unfavorable, or positive impact, an opportunity (Leitch, 2010). However, risks are usually associated with negative things (Wagner & Bode, 2008). Risk management directs organizations in the face of risks, in the sense of identifying them and assisting in the decision of which ones should be ignored and which should be exploited, through systematic processes of identification, monitoring, and assessment (Damodaran, 2009; Tang et al., 2007).

Risks can vary in how they occur, or in their intensity, in very different organizations (Kim & Vonortas, 2014), or between partner organizations (Silva & Beuren, 2020). Considering risks in the interorganizational perspective, it is emphasized that risks can influence cooperation management procedures between organizations that maintain relationships (Dekker et al., 2013).

Involvement in network relationships implies cooperation. Thus, the exchange of both sides can occur through communication (Chesbrough & Appleyard, 2007). Interorganizational communication is a process of conversation between organizations in a network (Kapucu, 2006), established by the structures, forms, and processes arising from the exchange of messages between organizations (Shumate et al., 2017), which encompasses the sharing of timely and relevant information (Nolli & Beuren, 2020) to assist parties in learning and gaining strategic advantages (Paulraj et al., 2008).

Communication intensity indicates the frequency, richness of media, and intensity with which organizations communicate with each other (Yan & Dooley, 2013). Surveys, such as Martini et al. (2013) and Paulini et al. (2013) indicate that risk can limit communication between actors involved in innovation processes. In this sense, risk management can be a form of mitigating risks (Silva & Beuren, 2020) and intensifying communication between partners (Yan & Dooley, 2013). Thus, it is conjectured that:

- **H₂:** There is a positive influence of risk management on communication intensity.

2.3. COMMUNICATION INTENSITY AND COLLABORATIVE INNOVATION

Communication intensity encourages cooperation, improves coordination, prevents misalignment of activities, and helps in the detection of opportunism, which tends to facilitate integration (Yan & Dooley, 2013). Thus, by communicating frequently, actors can observe and detect eventual

uncooperative behavior (Yan & Dooley, 2013). In addition, frequent communication, through the collection and exchange of information, helps avoid conflicts and interventions (Kahn, 1996).

Collaborative innovation requires interaction and exchange on both sides. This can be achieved through information sharing (Chesbrough & Appleyard, 2007) and communication (Nolli & Beuren, 2020). Yan and Dooley (2013) found that, in high-uncertainty projects, communication intensity leads to better outcomes through positive coordination efforts. Ernst (2002) noted that successful new product development projects are characterized by intensive communication. Paulraj et al. (2008) found that communication helps the parties in learning.

Donaldson et al. (2011) warn that the involvement of parties in order to promote innovation requires communication—that is, collaborative innovation involves communication. These authors highlight relational communication as timely to provide a favorable environment for innovation, namely the process of dialogue between partners. For O'Toole and Holden (2013), communication facilitates collaborative innovation with interaction between the parties. In this sense, it is assumed that:

- **H₃:** There is a positive influence of communication intensity on collaborative innovation.

2.4. Mediating effects of communication intensity between risk management and collaborative innovation

Collaborative innovation involves interactions between actors, both internal and external, whether in problem solving or in the exchange of ideas and resources (Abhari et al., 2017; Piller et al., 2012). The loss of resources or time are some of the examples of risks associated with these efforts (Mishra & Saji, 2013). Although it is recognized that communication and information sharing are essential to innovation activities, risks can limit communication between agents (Martini et al., 2013; Paulini et al., 2013). Risk management can then mitigate this problem by intensifying communication between the parties. In this line, intensive communication can be timely and provide a favorable environment for collaborative innovation, which implies communication (Chesbrough & Appleyard, 2007; Donaldson et al., 2011; O'Toole & Holden, 2013).

In this perspective, the mediating role of communication intensity in the relationship between risk management and collaborative innovation is assumed. Such a presumption stems from the evidence that risk management is timely for communication intensity (Martini et al., 2013; Paulini et al., 2013), and that communication intensity positively influences collaborative innovation (Donaldson et al., 2011; O'Toole & Holden, 2013). Following the flow of research that characterizes communication intensity as a promoter of innovation (Chesbrough & Appleyard, 2007; Donaldson et al., 2011), it is assumed that communication intensity plays an active role in the relationship between risk management and collaborative innovation, as follows:

- **H₄:** There is a mediating effect of communication intensity on the relationship between risk management and collaborative innovation.

Figure 1 presents the theoretical model of the research and highlights the hypotheses.
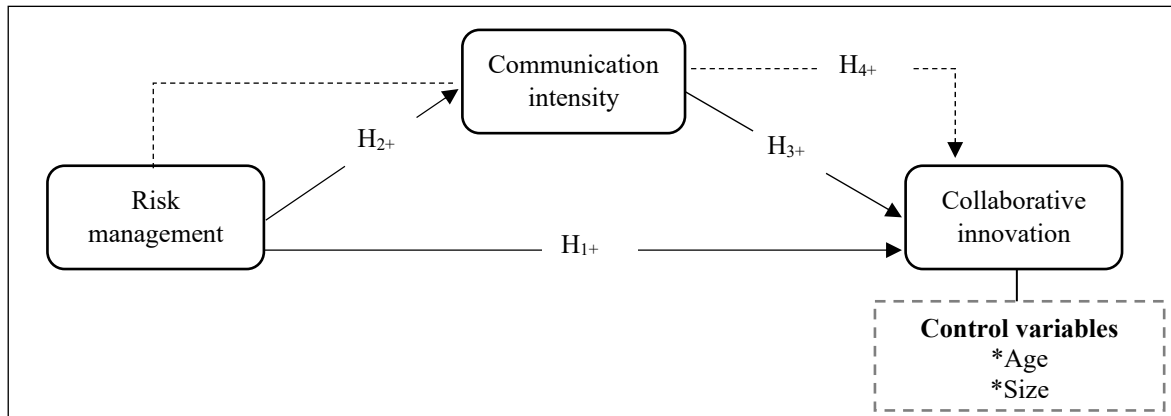
Figure 1. Theoretical research model
Note: The dotted line indicates mediating effect of communication intensity variable in the relationship between risk management and collaborative innovation (H$_4$).
Source: Own elaboration.

Figure 1 shows that risk management positively influences collaborative innovation (Rosas et al., 2015) and communication intensity (Martini et al., 2013). Also, communication intensity promotes higher levels of collaborative innovation (Donaldson et al., 2011; O'Toole & Holden, 2013). Furthermore, communication intensity mediates the relationship between risk management and collaborative innovation (Mishra & Saji, 2013; Paulini et al., 2013). It also assumes that companies different in size or age differ in their resources and competencies, which may reflect in the proposed relationships (Hui et al., 2013; Jiménez-Jiménez & Sanz-Valle, 2011). Studies indicate effects of size and age on project management and innovation (Hui et al., 2013; Jiménez-Jiménez & Sanz-Valle, 2011; Turner et al., 2012).

3. METHODOLOGICAL PROCEDURES

3.1. POPULATION AND SAMPLE

The research population comprises Brazilian agricultural cooperatives listed in the Organização das Cooperativas do Brasil (OCB, Organization of Cooperatives of Brazil). Cooperatives can integrate various interested parties (e.g., suppliers, employees, customers) as partners (Beuren et al., 2020). Cooperatives are an alternative to traditional means, being important drivers of innovation (Figueiredo & Franco, 2018). In particular, the option for agricultural cooperatives was due to the representativeness of the agricultural branch in the national economic scenario, being the largest Brazilian cooperative branch. Moreover, Behzadi et al. (2018) point out the context of agribusiness as one of the most exposed to risks, such as seasonality, perishability, market risks, institutional risks, and collaborative risks. This instigates investigating the risk management of agricultural supply chains (Behzadi et al., 2018).

OCB identified a total of 990 listed agricultural cooperatives on its website, which include agricultural, extractive, agro-industrial, and aquaculture, or fishing, activities. Subsequently, we sought to identify these cooperatives and professionals linked to them with more strategic positions in the *LinkedIn* professional network, in which 1,575 professionals were identified, with a maximum of three respondents per cooperative to avoid polarization. The connection invitation was sent, and 701 accepted the invitation, to which the link to the questionnaire was sent the by the *QuestionPro* platform. This collection, carried out from December 2019 to

May 2020, with monthly reminders, resulted in 103 valid questionnaires. The sample size to analyze the proposed structural model was determined according to the parameters and criteria outlined by Faul et al. (2009), by the *G*Power software*, which resulted in a minimum sample of 68 responses. Therefore, the sample of 103 respondents allows the application of the structural equation modeling technique.

Regarding the profile of the cooperatives responding to the survey, the number of employees is mostly between 500 and 3,000 (45%), and they have been mostly (55%) operating for more than 50 years, therefore, they are consolidated in the market. Concerning the professionals responding to the survey, 91% are male and most have a graduate course at the level of specialization or *Master of Business Administration* (MBA). Regarding the positions of these respondents, most (49%) indicated being a manager and in the position from 1 to 5 years. There was a large variation in relation to the age of the participants, the youngest being 24 years and the oldest being 72, having 38 years as the mode.

3.2. Constructs and research instrument

The theoretical model of the research comprises three constructs: risk management, communication intensity, and collaborative innovation, measured by multiple items. The constructs were anchored by means of research instruments from previous studies, with assertions in *Likert* scale type of 7 points.

The risk management was measured from the research instrument developed by Wieland and Wallenburg (2012), composed of four assertions. Survey respondents were asked to answer the extent to which risk management of material flow disruptions along the supply chain is practiced in the organization, on a scale of 1 (no extent) to 7 (a large extent).

Communication intensity was measured using the research instrument adapted from Yan and Dooley (2013), with five assertions. Survey respondents were asked to indicate their degree of agreement with each of the assertions regarding the frequency and richness of their organization's communication media with partners, in the last three years, considering the scale from 1 (fully disagree) to 7 (fully agree).

Collaborative innovation was measured using the research instrument developed by Santoro et al. (2018), supported by the studies of Ahn et al. (2016) and Aloini et al. (2015). The questionnaire contains five assertions for the partner intensity variable, three for variety of openness and three for readiness to collaborate. The respondents were asked to indicate the degree of importance of open/collaborative innovation in their organization in each of the statements, on a scale of 1 (low importance) to 7 (high importance).

Organizational characteristics integrate the model as control variables. The literature on innovation and management has highlighted associations between age and organization size (Hui et al., 2013; Jiménez-Jiménez & Sanz-Valle, 2011; Turner et al., 2012). In this perspective, we questioned when the agricultural cooperative was founded and the number of employees, to assess the age and size of the organization, respectively.

The following parameters were used to classify cooperatives by age: younger organizations, up to 30 years old (27% of the sample), and older organizations, over 30 years old (73% of the sample). The number of employees was considered as a parameter to establish the size of the cooperative, according to the classification of the Serviço Brasileiro de Apoio às Micro e Pequenas Empresas or SEBRAE (Brazilian Service for the Support to Micro and Small Enterprises in English): (i) small and medium cooperatives, with up to 500 employees (42% of the sample); and (ii) large cooperatives, with more than 500 employees (58% of the sample).

3.3. ANALYSIS PROCEDURES

Descriptive analysis techniques and Partial Least Squares Structural Equations Modeling (PLS-SEM) were used. Initially, the factorial load of the indicators of each construct was verified. The factorial analysis of risk management presented acceptable measures of adequacy. Communication intensity presented adequate levels, after the exclusion of two assertions with low commonality. An assertive was excluded in the collaborative innovation construct for the same reason. After these exclusions, good measures of adequacy were found, with factorial loadings greater than 0.70, as proposed by Hair Jr. et al. (2017).

The PLS-SEM technique, applied to test the relationships proposed in the hypotheses, is characterized in two main stages: measurement model and structural model. The internal consistency and validity of the model are tested in the measurement model, while the proposed hypotheses are examined in the structural model, in which the direct relationships are analyzed by the path coefficients (*path*) and its significance level, and the indirect relationships by the total indirect coefficients (Hair Jr. et al., 2017). The precepts of Bido and Silva (2019) were followed in the mediation analysis of communication intensity, in which the antecedent variable should influence the mediator, which should, in turn, influence the subsequent one.

The collaborative innovation construct was analyzed jointly (second order) since it contains more than one first-order construct (partner intensity, variety of openness, and readiness to collaborate), treated with a repetition approach of the indicators, of the reflective-reflective type. Bido and Silva (2019, p. 509, our translation) explain that "a second-order latent variable is measured by two or more first-order latent variables".

The method of data collection employed may have led to the bias of the common method (*Common Method Bias - CMB*), characteristic of cross-sectional studies, in which the answers are collected in the same period and from the same source. To mitigate this problem, respondents were warned that they would not have right or wrong answers, and that they should respond according to their perception. It was also verified, by Harman's single factor test, that the first factor did not exceed 50% of the total variance recommended by Podsakoff et al. (2003), which suggests that the data have no representative bias limitations of the common method.

4. RESULT DESCRIPTION AND ANALYSIS

4.1. MEASUREMENT MODEL AND DESCRIPTIVE STATISTICS

Table 1 shows the information on the internal consistency (*Cronbach* alpha and composite reliability) and validity (convergent and discriminant), tested in the first stage by the measurement model, in addition to descriptive statistics of the data.

The composite reliability and *Cronbach* alpha indicate that the assertions are reliable, presenting values higher than the minimum indicated (>0.70) (Hair Jr. et al., 2017), thus indicating internal consistency of the model. The convergent validity tested by AVE, which determines how much the assertions are correlated with its variables, has values above the minimum recommended (0.50) by Hair Jr. et al. (2017), allowing us to attest to the validity and reliability of the constructs. The discriminant validity, assessed by the Fornell-Larcker criteria in which the values of the square roots of the bird must be greater than the correlations between the variables, indicated the absence of a high correlation between the assertives (Hair Jr. et al., 2017).

Table 1
Measurement model and descriptive statistics

Latent variables Indicators	Risk management	Collaborative innovation.	Communication intensity
Risk management	**0.916**		
Collaborative innovation	0.466	**0.763**	
Communication intensity	0.376	0.671	**0.855**
Mean	5	5	6
Standard Deviation	1,69	1,36	1,35
Coefficient of variation (%)	33,84%	27,27%	22,49%
Mode	4	5	6
Extracted Mean Variance (AVE) >0.50	0,839	0,798	0,731
Cronbach alpha >0.70	0,936	0,918	0,810
Composite reliability (CR) >0.70	0,954	0,922	0,890

Note: n=103. The diagonal elements represent the square roots of the mean extracted variance and the off-diagonal elements represent the correlations between the latent variables.
Source: Survey data.

Finally, the *Variance Inflation Factors* (VIF) were analyzed, which confirmed the absence of multicollinearity among latent variables (VIF<5), according to the precepts of Hair Jr. et al. (2017). The results presented in the measurement model are appropriate for the next stage (assessment of the structural model) since all variables have sufficient levels of validity and reliability.

The descriptive statistics present the consolidated responses before segmentation between the analysis groups (age and size). The statistics in the constructs indicate mode 4 for risk management, 5 for collaborative innovation, and 6 for communication intensity, values considered medium to high. This indicates a strong presence of the variables surveyed in these organizations.

4.2. STRUCTURAL MODEL

In the structural model, in which the path coefficients are analyzed to test the research hypotheses, the PLS algorithm was analyzed to verify the suitability of the model and *bootstrapping,* which verifies the significance of the relationships between the variables (Hair Jr. et al., 2017), considering 5,000 *bias-corrected resamples and confidence interval.* The values of the structural coefficients, *t-value*, and *p-value* were obtained in *bootstrapping*. The structural model from the *Pearson* coefficient of determination (R^2) was also assessed, indicating the explanatory power of endogenous variables; the predictive relevance (Q^2), which indicates the accuracy of the model; and the size of the effect or Cohen's indicator (f^2). The results are presented in Table 2.

As for the proposed relationships, the results provide statistical support for the acceptance of the hypotheses of the theoretical model of the research. H_1, which predicted a positive relationship between risk management and collaborative innovation, was accepted (p=0.006) with a structural coefficient of 0.249 and a small effect (f^2=0.107) (Cohen, 1988). Although with lesser effect, risk management positively affects collaborative innovation.

Table 2
Structural model results and hypothesis testings

Relationships	Hypotheses	Structural coefficient	f²	t-value	p-value	Result
Risk manag. → Collaborative Inov.	H₁	0,249	0,107	2,735	0,006***	Accepted
Risk manag. → Commun. Int.	H₂	0,376	0,165	3,925	0,000***	Accepted
Commun. Int. → Collaborative Inov.	H₃	0,577	0,575	7,035	0,000***	Accepted
Risk manag. → Commun. Int. → Collaborative Inov.	H₄	0,217	–	3,637	0,000***	Accepted

Note: n=103. Significant at the level of **0.05; ***0.01.
Cohen classification (1988): small effect (f²=0.02); medium effect (f²=0.15); and large effect (f²=0.35).
Assessment of the structural model (R2): Communication intensity = 0.133; Collaborative Innovation = 0.493.
Predictive relevance (Q2): Communication intensity = 0.096; Collaborative Innovation = 0.280.
Source: Survey data.

Hypothesis H_2, which provided for positive and significant influence of risk management on communication intensity, was also accepted. In this relation, the effect size indicates a medium effect ($f^2 > 0.15$) according to Cohen's classification (1988). Therefore, the evidence suggests that risk management has positive impacts on the communication intensity of the investigated cooperatives.

H_3 was accepted at a significance level of 1%, with a structural coefficient of 0.577 and a large effect ($f^2 > 0.35$) for the relationship between communication intensity and collaborative innovation. This indicates a positive influence of communication intensity on collaborative innovation of the studied cooperative organizations.

Finally, the mediation hypothesis (H_4) also presented statistical significance, which indicates that communication intensity mediates the relationship between risk management and collaborative innovation at the significance level of 1%. Partial mediation is highlighted because it also presents significant results in the direct relationships between the variables.

The proposed model presents a coefficient of determination (R^2) of 13.3% for communication intensity and 49.3% for collaborative innovation. Predictive relevance (Q^2), which, to provide accuracy to the model, must present values above zero (Hair Jr. et al., 2017), was satisfactory.

Additionally, analyses were performed considering two control variables: (i) age, highlighting younger organizations (<30 years) and older organizations (>30 years); and (ii) size, measured by the number of employees of the cooperatives, considered small and medium (<500 employees) and large (>500 employees). These analyses are important since specific factors can modify the relationships theorized in the research model. The results are presented in Table 3.

The results indicate that, in the case of newer organizations and at the significance level of 10%, only two relationships differ from the original model, the relationship between risk management and collaborative innovation, and in the analysis of mediation. This suggests that newer cooperatives have greater sensitivity in these relationships. One reason may be the difficulty in implementing effective risk management, given that they are less established in the market compared to older organizations.

Table 3
Results of the control analysis by subgroups

Result by Age	Newest (Group 0)			Oldest (Group 1)		
Hypotheses	Beta	*t-value*	*p-value*	Beta	*t-value*	*p-value*
Risk manag. → Collaborative Inov.	**0,249**	**1,159**	**0,246**	0,212	1,922	0,055*
Risk manag. → Commun. Int.	0,395	1,899	0,058*	0,400	3,828	0,000***
Commun. Int. → Collaborative Inov.	0,536	3,297	0,001***	0,618	6,329	0,000***
Risk manag. → Commun. Int. → Collaborative Inov.	**0,212**	**1,536**	**0,125**	0,247	3,365	0,001***
Result by Size	**(Group 1)**			**(Group 2)**		
Hypotheses	Beta	*t-value*	*p-value*	Beta	*t-value*	*p-value*
Risk manag. → Collaborative Inov.	0,223	1,797	0,072*	0,253	1,955	0,051*
Risk manag. → Commun. Int.	0,363	3,032	0,002***	0,425	2,814	0,005***
Commun. Int. → Collaborative Inov.	0,547	4,754	0,000***	0,650	5,868	0,000***
Risk manag. → Commun. Int. → Collaborative Inov.	0,198	2,592	0,010***	0,276	2,800	0,005***

Note: n=103. Significant at the level of *$p<0.10$; **$p<0.05$; ***$p<0.01$.
Source: Survey data.

The study conducted by Turner et al. (2012), regarding project management, indicated that newer companies were less likely to have project or risk managers. Older companies tend to have more resources and capabilities compared to newer ones, which can impact innovation (Hui et al., 2013; Jiménez-Jiménez & Sanz-Valle, 2011). Regarding size, there were no significant differences when compared to the full model, which suggests that smaller companies, as well as larger ones, obtained significant relationships in the model.

4.3. RESULT DISCUSSION

The results of the study provide relevant information on the relationships examined. Figure 2 presents the results of the relationships of the influence of risk management and communication intensity on collaborative innovation in the Brazilian agricultural cooperatives surveyed to provide arguments that explain such relationships.
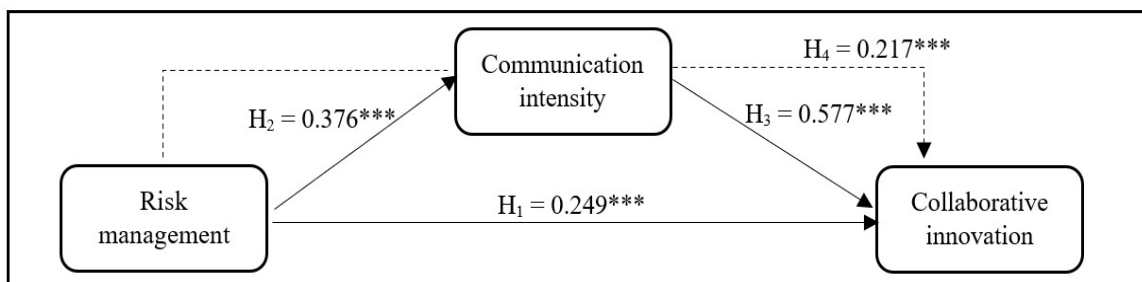

Figure 2. Research results
Note: n=103. Significant at the level of ***$p<0.01$
Source: Own elaboration.

The results of empirical research make it possible to accept the four hypotheses proposed in the theoretical model. H_1, which foresaw a positive relationship of risk management in collaborative innovation, was accepted. This is consistent with the findings of Etges and Cortimiglia, (2019) and Rosas et al. (2015), who found that risk management encourages the openness of organizations, making them feel safer and willing to cooperate in groups, and that, unlike the finding of Berglund (2007), it has not reduced risk-taking in these cooperatives. Risk management assesses, monitors, and mitigates the risks arising from collaboration, enabling more efficient collaborative innovation.

H_2, which shows a positive relationship between risk management and communication intensity, was also confirmed. This finding is consistent with that indicated by Martini et al. (2013) and Paulini et al. (2013), who found that risks can limit communication between organizations and, thus, risk management can intensify communication between actors since they make the exchange environment safer. It is inferred that risk management supports cooperatives in relation to relational risks, thus, they become predisposed to cooperate more strongly with their partners and, consequently, feel safer in communicating, intensifying, and improving the relationship.

H_3 is also consistent with what is stated in the literature (Donaldson et al., 2011; Ernst, 2002; O'Toole & Holden, 2013), that communication intensity positively impacts collaborative innovation, and that communication intensity facilitates collaborative innovation by involving both parties, providing a favorable environment for dialogue between partners. Communication can also be a driver of new ideas and a facilitator of innovation since an environment with intense communication is more prone to faster problem solving and the dissemination of information and knowledge throughout the network (Nolli & Beuren, 2020).

Finally, the analysis of mediation (H_4) showed that communication intensity mediates the relationship between risk management and collaborative innovation. It is argued that risk management encourages greater communication between these organizations (Silva & Beuren, 2020) and, consequently, communication intensity facilitates collaborative innovation among the actors involved (Yan & Dooley, 2013), supported by risk management.

It is also observed that the age of the cooperative may have implications on relationships since younger organizations showed greater sensitivity. It is inferred that the implementation of risk management may represent a certain difficulty, given that they are less established in the market, in addition to the lower probability of having project or risk managers (Turner et al., 2012). Older organizations generally have more resources and capabilities compared to newer ones (Hui et al., 2013; Jiménez-Jiménez & Sanz-Valle, 2011).

5. FINAL REMARKS

5.1. CONCLUSIONS

This study investigated the influence of risk management on collaborative innovation and the intervention of communication intensity in Brazilian agricultural cooperatives. Positive relationships were found between risk management and collaborative innovation and communication intensity. These effects indicated the effectiveness of risk management in the aspects investigated in the cooperative environment. Positive relationships were also found between communication intensity and collaborative innovation. The relevance of communication between related parties for a conducive and healthy environment focused on collaborative innovation is highlighted.

Regarding the mediation of communication intensity, it is understood that risk management encourages greater communication between these organizations and, consequently, communication intensity facilitates collaborative innovation among the actors involved, supported by risk management. It was also observed that newer cooperatives may have difficulties in implementing risk management or having a risk manager, thus presenting sensitivity in the proposed relationships.

5.2. THEORETICAL AND MANAGERIAL IMPLICATIONS

The study presented advances in the managerial literature by identifying implications of a management mechanism (risk management) that promotes actions that allow mitigating risks that distance organizations from their objectives, such as collaborative innovation. Theoretical implications are observed in the research regarding the mediation of communication intensity in the relationship between risk management and collaborative innovation. By studying the risk management associated with collaborative innovation, the call for more research on the topic is answered, such as by Abhari et al. (2017), Coras and Tantau (2014), and Rosas et al. (2015). It also contributes to the line of Investigation for having found positive effects of risk management and communication intensity on collaborative innovation. It also fills the gap in studies focused on risk management in agribusiness partnerships (Behzadi et al., 2018; Keers & Van Fenema, 2018).

The results also have practical implications for agricultural cooperatives by highlighting constructs with effects on collaborative innovation, which can help leverage their performance. In this regard, the managers of the investigated organizations can foster collaborative innovation through aligning risk management and communication intensity in pursuit of such an objective. Knowing the specificities of agricultural cooperatives implies a greater understanding of the main differences in their management and behavior in interorganizational relationships. For management practice, this study provides informative subsidies to cooperative managers by revealing risk management as a mechanism that can assist in the decision-making of managers who direct and control these organizations. Knowing the risk is relevant since it is usually present in the weaknesses of the organization.

5.3. LIMITING FACTORS AND OPPORTUNITIES

Limitations were imposed on the design of the research because of the methodological choices and the cross-sectional view of the research, although the relationships are based on theoretical assumptions and empirical findings. Thus, alternative methods, such as case studies, are recommended, in addition to other variables that may impact this relationship, especially in the context of risk management and collaborative innovation. The results also reflect only the panorama of agricultural cooperatives that, as already highlighted by Gallardo-Vázquez et al. (2014), have specific characteristics. Thus, it is recommended that studies test the proposed relationships in different contexts and, if possible, make comparative analyzes to contribute to the discussion of this theme. Future studies may verify whether the findings of this research are consistent with other types of interorganizational relationships, such as franchises and strategic alliances.

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AUTHOR'S CONTRIBUTION

SM: Research planning; literature review; definition of the methodological procedures; data collection; data analysis and interpretation; writing of the manuscript; and critical review of the manuscript. **IB:** Research planning; definition of the methodological procedure; data analysis and interpretation; writing of the manuscript; and critical review of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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