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The impact of collaboration networks on technological innovation in firms

El impacto de redes de colaboración en la innovación tecnológica en empresas

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Abstract

Latin American manufacturing firms must develop innovations to be competitive. For this reason, this research has two objectives: first, to analyze how connections with customers, suppliers, competitors, and research institutes are related to absorptive capacity, and, second, to demonstrate the existing relationship between absorptive capacity and technological innovation. A theoretical model was developed to show the relationship among the variables. The structural equation modelling was applied through AMOS software to a sample of 1,098 Peruvian manufacturing firms that participated in the second national innovation survey carried out in 2015. This study contributes to the literature on how firms relate with collaboration networks to improve their innovation capacity. In this way, firms obtain knowledge by applying the inbound open innovation approach. This knowledge is processed through each firm's absorptive capacity and will improve its innovation capacity.

Low or medium-low tech manufacturing firms that make investments in machinery, hardware, and software are more able to carry out product and process innovations. Product innovations allow firms to maintain or increase their position in the market and have more satisfied customers, while process innovations reduce their operating costs and make them more efficient.

Resumen

Las empresas manufactureras latinoamericanas deben desarrollar innovaciones para ser competitivas. Por ello, esta investigación tiene dos objetivos: primero, analizar cómo se relacionan las conexiones con clientes, proveedores, competidores e institutos de investigación con la capacidad de absorción, y, segundo, demostrar la relación existente entre la capacidad de absorción y la innovación tecnológica. Se desarrolló un modelo teórico para mostrar la relación entre las variables, a las cuales se les aplicó el método de ecuaciones estructurales, utilizando el software AMOS, a una muestra de 1098 empresas manufactureras peruanas que participaron en la segunda encuesta nacional de innovación realizada en 2015. Este estudio contribuye a la literatura sobre cómo las empresas se relacionan con las redes de colaboración para mejorar la capacidad de innovación, de esta manera obtienen conocimiento aplicando el enfoque de innovación abierta entrante, este conocimiento procesado a través de la capacidad de absorción de la empresa mejorará su capacidad de innovación. Las empresas manufactureras de intensidad tecnológica baja o media-baja realizan inversiones en maquinaria, hardware y software y tienen más capacidad para realizar innovaciones de productos y procesos. Las innovaciones en producto permiten a las empresas mantener o incrementar su posición en el mercado o tener clientes más satisfechos, al tiempo que realizan innovaciones en los procesos para reducir sus costos operativos o ser más eficientes.

Keywords | palabras clave

Networks, collaboration, capacity, absorption, innovation, emerging, manufacturing, model.
Redes, colaboración, capacidad, absorción, innovación, emergentes, manufactura, modelo.

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1. Introduction

Innovation is a topic that has captured the attention of scholars and managers. Through developing innovation capability, firms are able to become more competitive (Coccia, 2017), reach higher levels of exportation (Love & Roper, 2015), and introduce products and services to the market that satisfy the demands of their customers (King & Baatartogtokh, 2015). In this sense, firms seek partners with whom they can connect and, in this way, improve their innovation capability (Scuotto et al., 2017).

Because connections with business associates like customers, suppliers, competitors, universities, or industry associations help firms to develop innovations (Lai, Hsu, Lin, Chen, & Lin, 2014) and because of the benefits that a firm with this capability can generate, it is necessary to carry out studies that show how connections with key associates are related to absorptive capacity, which is a dynamic capability (Eisenhardt & Martin, 2000) useful for firms that wish to compile knowledge from other sources in order to make their level of technological innovation capability stronger.

Collaboration networks have captured the attention of policymakers because the firms that are able to create the most connections through collaboration networks are also more able to develop their innovation capability (Marrocu et al., 2013). However, at the same time, managers recognize that connections with customers provide ideas for new products, just as connections with suppliers and universities provide knowledge to develop technological innovations and connections with competitors provide ideas and the motivation to keep innovating (Baker et al., 2016).

On the other hand, Cohen and Levinthal (1990, p.128) specify that "absorptive capacity is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it" to strengthen its technological innovation capability. Indeed, abundant studies show how technological innovation evolves more readily in the presence of absorptive capacity (Martín-de Castro, 2015), but also it is important to mention that these studies focus on high-tech firms (Tzokas et al., 2015), that is to say, those firms that dedicate important financial resources to carrying out research and development in developed economies. These studies largely ignore firms in emerging economies that, despite not dedicating large quantities of resources to research and development, also carry out technological innovations, investing in the purchase of machinery, hardware, and software (Goedhuys et al., 2014).

The literature to review is abundant when the phenomenon being studied is the innovation capability of firms with a higher technological intensity in developed economies (Conte & Vivarelli, 2014). Nonetheless, fewer studies have focused on emerging economies and the low-tech and medium-low tech firms in them; indeed, not many researchers have focused on the Latin American region (Del Carpio & Miralles, 2018; Ponce-Espinosa et al., 2017; Zapata-Rotundo & Hernández-Arias, 2018; Romero et al., 2021). However, the lower-tech manufacturing firms in these countries pour great effort into developing innovation capability, which contributes to their being more competitive on the global market.

The present study poses the following research question: What factors influence the innovation capability of low-tech firms in emerging economies? Its specific objectives are the following: first, to analyze how connections with customers, suppliers, competitors, and research institutes are related to absorptive capacity (Nicotra et al., 2014), and, second, to demonstrate the existing relationship between absorptive capacity and technological innovation (Del Carpio & Miralles, 2018). The information used in this research corresponds to the second innovation survey of the manufacturing

industry carried out in Peru in 2015. The unit of analysis is the low-tech or medium-low tech manufacturing firm that participated in said survey.

The structure of the study is as follows: after this introduction, the theoretical framework is presented, and the hypotheses are formulated. The third section explains the methodology, describes the data, defines the study variables, and explains the statistical procedures used to analyze the data. The fourth section shows the results, and then the fifth section presents the discussion of the results. Finally, the conclusions, study limitations, and future lines of research are presented.

1.1. Theoretical framework and the formulation of the hypotheses

This study is carried out under the theory of dynamic capabilities, which are "a set of specific and identifiable processes such as product development, strategic decision making, and alliancing" (Eisenhardt & Martin, 2000, p. 1105). It is important to note that "the dynamic capabilities approach has been built on Schumpeter's ideas" (Breznik & Hisrich, 2014, p.374).

1.1.1. Collaboration networks and absorptive capacity

Collaboration networks have been linked to the development of manufacturing firms' absorptive capacity (Agramunt, Berbel-Pineda, Capobianco-Uriarte, & Casado-Belmonte, 2020). Tsai (2001) makes this observation in his study on food producers, finding a link between these firms' position in their respective collaboration networks and their level of absorptive capacity. Also, Spithoven, Clarysse, and Knockaert (2010) indicate that firms that belong to mature industries develop absorptive capacity to implement so-called "inbound open innovation activities"; that is to say, they interact with customers, suppliers, and other actors so that these actors will provide them with the information needed to improve their innovation capability. On the other hand, Cantner and Joel (2011) indicate that interaction with different actors belonging to collaboration networks leads to the generation of knowledge that, with the help of absorptive capacity, leads to the firm's improved innovation capability. Along these lines, Hurmelinna-Laukkanen et al. (2012) argue that absorptive capacity and the stability of collaborative networks help firms to improve their innovation capability. The relationships in these collaborative networks can be formal, through the signing of contracts, or informal, based on participants' mutual trust, as what they seek is to share knowledge.

Also, it is important to point out that Najafi-Tavani et al. (2013) observed a link between absorptive capacity, product innovation developments, and suppliers' involvement. Two of the factors that depend on the involvement of the suppliers are the sharing of technical information and the suggestions that suppliers can provide in the first stages of the development of new products. Furthermore, Saenz et al. (2014) mention the crucial way the supplier-buyer relationship is affected by absorptive capacity. Managers do not just want to be careful in the selection of their suppliers; they should also develop absorptive capacity to improve their innovation capability. It is also important to mention that Scuotto et al. (2017) found that when firms have higher levels of absorptive capacity, their interaction with collaborative networks increases their innovation capability as a result.

These arguments have allowed for the formulation of the following hypothesis:

H1: Collaboration networks are related to absorptive capacity in low-tech and medium-low tech firms.

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1.1.2. Absorptive capacity and product innovation

Absorptive capacity allows firms to improve their innovation capability with regard to their products (Coronado-Medina et al. 2020). Murovec and Prodan (2008) analyzed the strong relationship between Slovenian firms' absorptive capacity and their ability to develop product innovations. Moreover, Zhou and Wu (2010) indicate that firms interact with their customers, suppliers, competitors, and others to obtain information to be processed through absorptive capacity and, in this way, to carry out product innovations. Also, Huang and Rice (2012) argue that absorptive capacity is an indispensable requisite for firms that wish to carry out product innovations.

On the other hand, Ritala and Hurmelinna–Laukkanen (2013) focus on the collaboration between firms and their competitors, highlighting the role of absorptive capacity in assimilating knowledge and converting it into product innovations, as well as its role in protecting firms' innovations so they are not imitated by competitors. It is important to mention that, in addition, Moilanen et al. (2014) analyzed the mediating role of absorptive capacity between the flows of knowledge that come from the interaction of firms with their collaborative networks and their innovation performance. Martinez-Senra et al. (2015) empirically verified that firms that face a solid appropriability regime, that is to say, firms that can protect their intellectual property, are more able to develop product innovations despite having a low level of absorptive capacity.

Thus, the following hypothesis is formulated:

H2: Absorptive capacity is related to product innovation in low-tech and medium-low tech firms.

1.1.3. Absorptive capacity and process innovation

Absorptive capacity is related to process innovation capability (Aliasghar et al., 2020), and, in this sense, Murovec and Prodan (2008) analyzed the strong relationship that exists between Slovenian firms' absorptive capacity and their ability to develop process innovations. Also, Segarra-Blasco and Arauzo-Carod (2008) indicate that Spanish firms present low levels of absorptive capacity and thus seek out agreements with universities and research centers to improve their ability to develop process innovations. Hervas-Oliver et al. (2016) believe that firms are more likely to develop process innovations when they have higher levels of absorptive capacity and organizational innovation capability.

Finally, Jespersen et al. (2018) demonstrated how it is more likely for process innovations to be developed by firms able to synthesize their associates' knowledge. Bayona-Saez et al. (2017) found that absorptive capacity is more determinant of product innovation than of process innovation. Additionally, Del Carpio and Miralles (2018), analyzing low-tech Peruvian manufacturing firms, identified a link between technological innovation, that is to say, product and process innovation, and absorptive capacity.

Based on the aforementioned, the third hypothesis is formulated:

H3: Absorptive capacity is related to process innovation in low-tech and medium-low tech firms.

1.1.4. Technological acquisition and product innovation

Various studies indicate that technological acquisition, that is, firms' acquisition of software, hardware, and machinery, helps increase firms' innovation capability (Frigon et al., 2020). Along these same lines, Conte and Vivarelli (2014) analyzed the data from an innovation survey of more than 3,000 Italian firms and found that the acquisition of machinery had a positive relationship with process innovation but not with product innovation. Also, Filippetti (2011), using data from the European sur-

vey Innobarometer 2009, found that firms that focused on cost reduction and were, in general, low-tech or medium-low tech firms were more likely to develop product innovations. On the other hand, Goedhuys and Veugelers (2012) showed that Brazilian firms improved their technological capability through the acquisition of machinery and equipment that helped them carry out product and process innovations.

Along these lines, Pellegrino et al. (2012), using the database of the third communitarian innovation survey of Italian industry, found that the acquisition of machinery, software, and hardware has a positive relationship with product innovation for young firms but not for mature firms. Even more importantly, Liao and Barnes (2015) found that information from machinery and equipment suppliers made product innovation capability more flexible for firms that had fewer than 250 employees. However, Frank, Cortimiglia et al. (2016) indicate that even when investment in machinery acquisition is one of the innovation activities most frequently carried out by Brazilian firms, this activity is not reflected in their innovation results.

According to what is mentioned above, the fourth hypothesis is formulated:

H4: The acquisition of machinery, hardware, and software is related to product innovation in low-tech and medium-low tech firms.

1.1.5. Technological acquisition and process innovation

Technological acquisition and its relationship with process innovation have been analyzed in different circumstances (Murmura et al., 2021). Also, Reichstein and Salter (2006) analyzed an innovation survey of English firms and found that process innovation is related to the incorporation of new machinery. Rouvinen (2002), analyzing information from a Finnish innovation survey, found that acquisition of machinery and connections with machinery suppliers facilitated process innovation. Also, Vaona and Pianta (2008), analyzing the second communitarian innovation survey of the manufacturing industry in eight European countries, found that the acquisition of machinery, hardware, and software has a positive relationship with process innovation, independent of firm size.

Several years later, Piening and Salge (2015), analyzing German industry, found that low-tech firms, through the purchase of machinery, hardware, and software, acquire knowledge that helped them develop process innovations. In the same way, Hervas-Oliver et al. (2016), analyzing the 2006 Spanish communitarian innovation survey, found that firms that carry out process innovations also carry out acquisitions of machinery, hardware, and software. Also, Martino et a. (2017) analyzed firms in the Italian olive oil industry and found that those firms that carried out investments in machinery, hardware, and software were better able to carry out process innovations.

According to these findings, the fifth hypothesis is formulated:

H5: The acquisition of machinery, hardware, and software is related to process innovation in low-tech and medium-low tech firms.

1.1.6. Process innovation and product innovation

Process innovation and its impact on product innovation in the manufacturing industry have been analyzed several times in the past. For example, Gunday et al. (2011) researched 184 Turkish manufacturing firms and found that the greater the levels of process innovations, the greater the levels of product innovations. In the same way, Hassan et al. (2013) found that process innovation has a positive relationship with product innovation. Also, Roldan and Bastos (2019), who studied more than 230 technology-oriented firms in Brazil, identified that product innovation and process innovation are related.

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Additionally, Camisón and Villar-López (2014) found that process innovation reduces costs and changes the way new products are generated, which favors product innovation. Ballot, Fakhfakh et al. (2015), analyzing the data from the fourth communitarian innovation survey, which included French and English firms, found complementarity between process and product innovation, as the introduction of new products also demands changes in production processes. Also, Doran (2012) conducted a literature review on the complementarity between process and product innovation and found that many authors did consider them complementary; that is to say, these authors believed that process innovation leads to product innovation and vice versa.

Based on the aforementioned, the sixth hypothesis is formulated:

H6: Process innovation is related to process innovation in low-tech and medium-low tech firms.

1.1.7. The mediating role of absorptive capacity on the relationship between collaboration networks and technological innovation

The mediating role of absorptive capacity has motivated many studies, including research by Tsai (2001), who found that the interaction between absorptive capacity and collaboration networks favored the development of firms' innovation capability. Along these same lines, Grimpe and Sofka (2009) argue that absorptive capacity contributes to the improvement of firms' innovation performance if they are able to connect with customers and competitors, which gives them access to market information, or with suppliers and universities, which provides them with technology-related information. Also, Liao et al. (2010) mention that the relationship between innovation capability and knowledge acquisition is mediated by absorptive capacity. Moreover, they indicate that acquiring knowledge can be facilitated through relationships with suppliers, customers, universities, and even competitors.

On the other hand, Kostopoulos et al. (2011), interested in how absorptive capacity mediates innovation performance and the flow of knowledge, highlighted that the flow of knowledge is the result of interaction with agents outside of the firm. Moreover, Moilanen et al. (2014) analyzed small firms that invest little to nothing into research and development and found that their absorptive capacity fulfilled a complete mediating role in the relationship between the flow of knowledge and those firms' innovation performance.

Because of this, the following hypothesis is proposed:

H7a: Absorptive capacity mediates the relationship between collaboration networks and product innovation.

H7b: Absorptive capacity mediates the relationship between collaboration networks and process innovation.

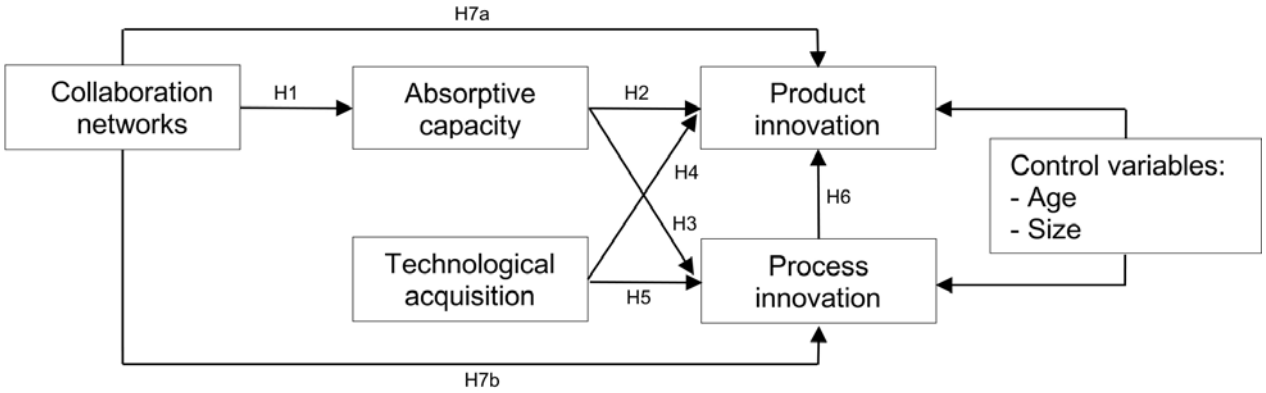
2. Methodology

2.1. Data

For this research, data from the 2015 National Innovation Survey in the Manufacturing Industry were used. The data collection took place during the reference period of 2012-2014; the representative sample was of 1,452 large, medium, and small firms; however, for the purposes of this study, only 1,098 low-tech and medium-low tech manufacturing firms are considered due to the fact that Peru, as an emerging country, has a higher percentage of low-tech and medium-low tech firms.

To analyze the research model in Figure 1, a structural equations model was used to evaluate the hypotheses.

Figure 1. Proposed model



Source: The authors.

2.2. Measurement of the variables

2.2.1. Dependent variables

Product innovation

Product innovation is the result of the dichotomous responses to the following questions: was the firm able to introduce the following to the market: a new good, a new service, a significantly improved good, or a significantly improved service (Gronum, 2012)?

Process innovation

Process innovation is the result of the dichotomous responses to the following questions: was the firm able to introduce the following: a new means of production of goods or provision of services; a new method for logistics, distribution, or dispatch of inputs, goods, or services; a new production support activity, such as maintenance or procurement systems, accounting, or IT; a significantly improved method of production of goods or provision of services; a significantly improved method for logistics, distribution, or dispatch of inputs, goods, or services; a significantly improved production support activity, such as maintenance or procurement systems, accounting, or computing (Gronum, 2012)?

2.2.2. Independent variables

Collaboration networks

According to Nieto and Santamaría (2007), collaboration networks are measured by how they connect the firm with the following agents or institutions: (1) universities, (2) suppliers, (3) customers, (4) competitors, (5) industry associations, and (6) consultants. The variables are dichotomous (YES or NO), according to these actors' connection with the firm.

Absorptive capacity

Absorptive capacity is measured taking Escribano, Fosfuri, and Tribó's (2009) proposals into account. In this sense, three variables are proposed: (1) internal technological research and development expenses, (2) expenses related to training for innova-

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tion activities, and (3) if the firm has a Research & Development department. All of the variables are dichotomous (YES or NO).

Technological acquisition

Technological acquisition is measured according to the proposals of Escribano et al. (2009). Three variables are defined: (1) capital assets purchases, (2) hardware purchases, and (3) software purchases. All of the variables have a logarithmic transformation.

2.2.3. Control variables

The size of the firm is a variable measured by the logarithm of the total number of employees, according to Caloghirou et al. (2004) and Schoenmakers and Duysters (2006), and the age of the firm is measured as the number of years (expressed as a logarithm) from its founding up to present.

Statistical method

AMOS version 27 software was used to carry out the two-step structural equation of covariance to create an estimation model, according to Medrano and Muñoz-Navarro (2017). First, the measurement model was estimated when the relationship between the indicators and the latent construct was determined by Confirmatory Factor Analysis (CFA). Secondly, the estimation of the structural model was performed, in which the relationships between the constructs were obtained using the coefficients and the level of statistical significance.

3. Results

3.1. Measurement model

The research data were analyzed and presented using reliability and convergence indicators. In terms of reliability, the measured composite reliability (CR) values are greater than 0.7, and all of them have average variance extracted (AVE) values greater than 0.5. With regard to multicollinearity, the variance inflation factor (VIF) is controlled, with levels of less than 5. Based on the results of the indicators in Table 1, it was possible to carry out the structural model. Moreover, all of the R^2 values were accepted in the endogenous variables, which indicates the good effect of the model of the low-tech firms. Finally, Table 2 reveals that all of the variables achieve discriminant validity, taking the Fornell-Larcker Criterion (1981) into account.

Table 1. Indicators of reliability and validity

Latent variable	CR	AVE	VIF	R^2
Collaboration networks	0.847	0.535	1.082	
Absorptive capacity	0.792	0.574	1.307	0.520
Technological acquisition	0.826	0.616	1.291	
Product innovation	0.860	0.633		0.230
Process innovation	0.882	0.561		0.434
Referential values	>0.7	>0.5	<5	

CR, Composite reliability; AVE, Average variance extracted; VIF, Variance inflation factor.
Source: SPSS and AMOS software.

Table 2. Discriminant validity

	Collaboration networks	Absorptive capacity	Technological acquisition	Product innovation n	Process innovation n
Collaboration networks	**0.731**				
Absorptive capacity	0.089	**0.757**			
Technological acquisition	0.094	0.473	**0.785**		
Product innovation	0.091	0.377	0.297	**0.796**	
Process innovation	0.097	0.368	0.324	0.332	**0.749**

Notes: Fornell-Larcker Criterion: the diagonal values (bold) are the square root of the shared variance between the constructs and their measurements (AVE). For discriminant validity, the square root of the AVE (bold) is greater than the correlations between the other latent variables.

Source: AMOS software.

3.2. Structural model

After verifying the measurement models, the structural model was estimated. Table 3 presents the coefficients and p-values of the research model.

Table 3. Results of the structural model

Hypothesis	Relation	Path coefficient	p-value
H1	CN -> ACAP	0.721***	0.001
H2	ACAP -> ProdI	0.461***	0.001
H3	ACAP -> ProcI	0.251***	0.001
H4	TECH -> ProdI	0.201 *	0.060
H5	TECH ->ProcI	0.251***	0.001
H6	ProcI ->ProdI	0.695***	0.001

CN=Collaboration networks; ACAP=Absorptive capacity; TECH=Technological acquisition; ProdI= Product innovation; ProcI=Process innovation.
Note: n.s. = insignificant; * p ≤ 0.1; ** p ≤ 0.05, *** p ≤ 0.01, **** p ≤ 0.001.
Source: AMOS software.

The control variables are shown in Tables 4 and 5.
Las variables de control se muestran en las Tables 4 y 5.

Table 4. Control variables for product innovation

	Coef.	p-val
Firm size	-0.137	0.006
Firm age	0.050	0.258

Source: AMOS software.

Table 5. Control variables for process innovation

	Coef.	p-val
Firm size	-0.085	0.030
Firm age	-0.045	0.194

Source: AMOS software.

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It can be observed that there is a small, negative, statistically significant relationship between firm size and innovation. In other words, small firms are more likely to innovate. These results coincide with Lin et al. (2019), who point out that small firms are better able to develop innovations because they are more flexible and independent.

The model also complies with the goodness of fit index, according to the following indicators: CMIN / df, GFI, TLI, CFI, and RMSEA. The values obtained show the adequate fit of the research model. See Table 6 (Singla et al., 2018).

Table 6. Model fit summary

Indicators	Structural Model
CMIN/DF	1.967
CFI	0.962
NFI	0.927
RFI	0.903
TLI	0.950
IFI	0.963
RMSEA	0.030

Source: AMOS software.

3.3. Analysis of the mediation

When absorptive capacity was analyzed, certain steps were taken to confirm if it was a mediating variable and what type of effect it had. Hair et al. (2014) demonstrate that mediation is present when a mediating variable is able to somewhat absorb whatever effects an exogenous construct (in the case of independent variables) or endogenous construct (in the case of dependent variables) might have. The variance accounted for (VAF) determines to what degree the process of mediation explains the variance of the dependent variable. If the VAF is under 20 %, it can be concluded that there is no mediation, and a VAF that is greater than 20 % and less than 80 % would indicate partial mediation (Hair, Hult, Ringle, & Sarstedt, 2016). A VAF of over 80 % indicates complete mediation. The VAF is the relationship between the indirect effect (0.191) and the total effect (0.306) for the absorptive capacity between collaboration networks and product innovation and the relationship between the indirect effect (0.119) and the total effect (0.296) for the absorptive capacity between collaboration networks and process innovation, obtaining 62 % and 40 %, respectively. Therefore, the partial mediation of absorptive capacity is present for both relationships.

Table 7. Mediation test

Hypothesis	Influence	Direct Effect	Efecto indirecto (valor p)	Efecto total	VC (%)	Interpretación
H7a	**CN>ACAP> ProdI**	0.115** (0.014)	0.191** (0.014)	0.306** (0.014)	62 %	Mediación parcial
H7b	**CN>ACAP> ProcI**	VAF (%)	Interpretation	0.296*** (0.001)	40 %	Mediación parcial

Note: VAF = Variance Accounted For; n.s. = insignificant; * p ≤ 0.1; ** p ≤ 0.05, *** p ≤ 0.01, **** p ≤ 0.001 significant. VAF > 80% indicates total mediation, 20% ≤ VAF ≤ 80% indicates partial mediation, and VAF < 20% indicates that there is no mediation.
Source: SMART PLS software, the authors' calculations.

4. Discussion and conclusions

This study contributes to the literature on innovation that establishes that firms that are linked to collaboration networks obtain knowledge through them by applying the inbound open innovation approach; this knowledge, processed through the firm's absorptive capacity, will improve its innovation capacity. The results show that collaboration networks are related to absorptive capacity in low-tech and medium-low tech firms; the results obtained coincide with those of Tsai (2001) and Hurmelinna-Laukkanen et al. (2012).

The literature recognizes that absorptive capacity is one of the determinants of product innovation. The identification of external information and its assimilation process achieved through absorptive capacity allow the firm to be better able to introduce new products to the market, adapting to the demands of its customers. This result coincides with the findings of Murovec and Prodan (2008) and Martinez-Senra et al. (2015), who found that firms with higher levels of absorptive capacity are more able to develop product innovations.

Many studies find that firms develop innovations in process through the acquisition of machinery and equipment, but it is also necessary to mention that the development of absorptive capacity will allow the firm to assimilate external knowledge that comes from suppliers, consultants, universities, and research centers, which will make the firm develop its innovation capacity, and, therefore, process innovations. These results agree with those obtained by Murovec and Prodan (2008) and Del Carpio and Miralles (2018), who found that firms that develop absorptive capacity are more able to implement process innovations.

Low or medium-low tech manufacturing firms that make investments in machinery, hardware, and software are more able to carry out product innovations, even though to a great extent these technological acquisitions lead firms to carry out process innovations and even though the implementation of process innovation favors product innovations. The results obtained coincide with those of Vaona and Pianta (2008), Goedhuys and Veugelers (2012), and Pellegrino et al. (2012). In other words, there is a positive relationship between the acquisition of machinery, hardware, and software and product and process innovations.

Likewise, low and medium-low technological intensity firms make product innovations in order to maintain or increase their position in the market or have more satisfied customers, while they make process innovations to reduce their operating costs or be more efficient, which allows these firms be better able to develop product innovations. These results agree with those obtained by Gunday et al. (2011) and Roldan and Bastos (2019).

Regarding the mediating role of absorptive capacity on the relationship between collaboration networks and technological innovation, in the present study, absorptive capacity partially mediates product innovation; however, this partial mediation is at high levels close to total mediation, which coincides with the findings of Tsai (2001) and Kostopoulos et al. (2011). The exception is that in these studies, the dependent variable is innovation capability. Meanwhile, in the case of process innovation, the mediating role of absorptive capacity is only partial.

As for the control variables, the size of the firm has a negative, statistically significant relationship with product innovation. This result seems to contradict Tsai (2001), who found that large firms have more resources to carry out more innovations, but, on the other hand, agrees with Laforet (2008), who indicates that small, lower-tech firms are more creative when introducing new products onto the market.

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It has been empirically verified that low-tech manufacturing firms that participated in the innovation survey in 2015 and connected with market networks were more likely to develop product and process innovations. As firms connected with institutional networks, they were more likely to develop process innovations.

This research has contributed to the literature on technological innovation carried out by low-tech and medium-low tech firms in an emerging economy—in this case, Peru—by analyzing how these firms connect with market and institutional networks to be able to develop technological innovations.

The results of the present study allow for the identification of some practical implications. The managers of low-tech firms should strengthen connections with customers, suppliers, and competitors and, at the same time, with universities and research institutes with the intention of developing a greater number of technological innovations.

The present study is not exempt from limitations, which are as follows.

The first limitation refers to how this study has used the database that was obtained from the national innovation survey of the manufacturing industry in Peru from the year 2015. As a cross-sectional study, it faces two problems: the bias generated by the fact that a single person at the firm responded to the questionnaires and the fact that this type of study does not allow a causal relationship to be established between constructs (Rindfleisch et al., 2008). It is suggested that longitudinal studies be carried out. Another option would be comparative studies using the innovation surveys carried out in other Latin American countries.

The second limitation has to do with how the constructs of market and institutional networks have been measured; these constructs reflect connections to customers, suppliers, or competitors and public or private research institutes. It is suggested that studies be carried out that identify specific connections, for example, connections with customers, suppliers, or universities, and how these relationships individually favor the development of product or process innovations.

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