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EXTERNAL COLLABORATION OF OPEN INNOVATION AND FINANCIAL PERFORMANCE OF SMES IN TAMAULIPAS, MEXICO

Colaboración externa de la innovación abierta y desempeño financiero de las PYMES en Tamaulipas, México

Colaboração externa da inovação aberta e desempenho financeiro das PMEs no Tamaulipas, México

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ABSTRACT

Open innovation is a collaborative paradigm that improves business performance. However, the majority of investigations approach large and multinational companies with developed economies, so this work analyzed the relationship of external collaboration of open innovation with financial performance in small and medium-sized companies in an emerging economy. For this, a questionnaire was applied to owners and managers of 145 companies located in Tamaulipas, Mexico. The results processed through structural equations in SPSS and AMOS indicate the absence of a positive and significant relationship between the vertical collaboration of open innovation (customers, users and suppliers) and financial performance. In contrast, a positive and significant relationship was found between the horizontal collaboration of open innovation (educational institutions, government and competitors) with financial performance, with elements such as co-development of products, inputs of knowledge and ideas, acquisition of machinery, equipment, software and supplies.

Keywords: Open innovation, horizontal collaboration, vertical collaboration, financial performance, emerging economy.

RESUMEN

La innovación abierta es un paradigma colaborativo que mejora el desempeño empresarial. Sin embargo, la mayoría de las investigaciones abordan empresas grandes y multinacionales de economías desarrolladas, por lo que este trabajo analizó la relación de la colaboración externa de la innovación abierta con el desempeño financiero en pequeñas y medianas empresas en una economía emergente. Para ello, se aplicó un cuestionario a propietarios y directivos de 145 empresas localizadas en Tamaulipas, México. Los resultados procesados mediante ecuaciones estructurales en SPSS y AMOS indican ausencia de relación positiva y significativa entre la colaboración vertical de la innovación abierta (clientes, usuarios y proveedores) con el desempeño financiero. En contraste, se comprobó una relación positiva y significativa entre la colaboración horizontal de la innovación abierta (instituciones de educación, gobierno y competidores) con el desempeño financiero, con elementos como el codesarrollo de productos, entradas de conocimiento e ideas, adquisición de maquinaria, equipo, software e insumos.

Palabras Clave: *Innovación abierta, colaboración horizontal, colaboración vertical, desempeño financiero, economía emergente.*

RESUMO

A inovação aberta é um paradigma colaborativo que melhora o desempenho dos negócios. No entanto, a maioria das investigações aborda empresas grandes e multinacionais com economias desenvolvidas. Este trabalho analisou a relação da colaboração externa da inovação aberta com o desempenho financeiro em pequenas e médias empresas em uma economia emergente. Para isso, foi aplicado um questionário a proprietários e gerentes de 145 empresas localizadas em Tamaulipas, no México. Os resultados processados por meio de equações estruturais no SPSS e AMOS indicam a ausência de uma relação positiva e significativa entre a colaboração vertical da inovação aberta (clientes, usuários e fornecedores) e o desempenho financeiro. Em contraste, uma relação positiva e significativa foi encontrada entre a colaboração horizontal da inovação aberta (instituições educacionais, governo e concorrentes) com o desempenho financeiro, com elementos como o codesenvolvimento de produtos, insumos de conhecimento e ideias, aquisição de máquinas, equipamentos, softwares e suprimentos.

Palavras-Chave: *Inovação aberta, colaboração horizontal, colaboração vertical, desempenho financeiro, economia emergente.*

INTRODUCTION

Currently, traditional or closed innovation is insufficient, however, open innovation arises as an alternative for research and development (R&D) to obtain knowledge and resources that improve financial performance through external collaboration, thus obtaining competitive advantages (Alvarez-Aros & Álvarez-Herrera, 2018; Chesbrough, 2003; Chesbrough, Vanhaverbeke, & West, 2006; Enkel, Gassmann, & Chesbrough, 2009; García-Vidales, Maldonado-Guzmán, & Pinzón-Castro, 2019).

This shows an open innovation complementary to internal R&D, characterized by experience and work capacity. On the other hand, open innovation collaborates externally, outside the organizational limits, obtaining ideas and knowledge to enrich innovative processes and financial performance (Chesbrough, 2006; Greco, Grimaldi, & Cricelli, 2015; Schroll & Mild, 2011).

However, although open innovation is more accepted in academia, the business world continues to explore the collaborative approach, as it has not made a strong contribution to the financial performance of any kind of companies and sectors (Chesbrough, 2003, 2015; Dahlander & Gann, 2010).

Most of the studies on open innovation focus on large and multinational companies in the technology and software sector. Consequently, the study in small and medium-sized enterprises (SMEs) and other sectors have not amply demonstrated the benefits generated (Calderón, 2010; Krause & Schuttle, 2015; Raposo, Ferreira, & Fernandes, 2014; Stanisławski, 2020; Yoon, Shin, & Lee, 2016).

As an example, Colombian and Venezuelan SMEs highlight the importance of external collaboration but carry out a traditionalist innovation with minor openings to suppliers and customers. In other words, companies work on internal, instead of collaborating externally and looking for other sources of knowledge and resources (Bernal-Torres & Frost-González, 2015; Rodríguez, Terán, & Bucci, 2011).

In an emerging economy like Mexico, innovation and its practices represent a key element for business performance and sustainability (Armenteros, Elizondo, Medina, Ballesteros, & Molina, 2012; Maldonado-Guzmán, Madrid-Guijarro, Martínez-Serna, & Aguilera-Enríquez, 2009; Souza, Torres, & Miyake, 2018). However, as far as open innovation is concerned, there is little research that supports external collaborations with organizational performance.

In business size, SMEs contribute mostly to the local economy and job creation, having more small economic units where they face greater challenges than multinationals (Andersen, 1999; Armenteros et al., 2012; Fred, 2017; Marín-Idárraga & Cuartas-Marín, 2019; Sánchez, Zerón & Mendoza, 2015; Ugarte-Cataldo, 2013; Vieira, 2014).

In Mexico, the National Institute of Statistics and Geography (Inegi) in 2016, registered 4.2 million economic units, 99.8% were SMEs and generated 52% of the gross domestic product (GDP) and 78% of the employment rate (Inegi, 2016). According to annual data from 1989, 1994, 1999, 2004, 2009 and 2014, the average survival of new businesses in Mexico is 7.8 years, but in Tamaulipas it is 6.4 years, ranking among the last states.

Tamaulipas contributes 3% of GDP, according to the National Statistical Directory of Economic Units (Denue) and is a relevant region due to its geographical location with respect to the United States of America (Denue, & Inegi, 2019). In this way, it highlights the importance of SMEs in the economy and jobs, and their survival and performance should be improved.

Therefore, the purpose of this research was to analyze the relationship of external collaboration of open innovation with the financial performance of SMEs in the northern border of Mexico, providing novelty and originality. To do this, methodologically, a questionnaire and structural equation modeling (SEM) was applied with SPSS and AMOS software. This research presents the theoretical foundation, the method, the results, and the conclusions.

EXTERNAL COLLABORATION AND FINANCIAL PERFORMANCE

External collaboration

From open innovation, external collaborations represent a strategy to complement R&D activities, and facilitate technological exploration, the generation of ideas and knowledge, and the acquisition of resources that improve organizational performance (Faems, Visser, Andries, & Looy, 2010; Greco et al., 2015; Mazzola, Bruccoleri, & Perrone, 2012; Rogo, Cricelli, & Grimaldi, 2014; Sisodiya, Johnson, & Grégoire, 2013).

The collaboration is dimensioned in vertical and horizontal external collaborations, in order to obtain ideas, knowledge, technology and opportunities (Parida, Westerberg, & Frishammar, 2012; Vrande, Jong, Vanhaverbeke, & Rochemont, 2009; Wang, Chang, & Shen, 2015). Collaboration with users, customers and suppliers is called vertical external collaboration (Bueno & Balestrin, 2012; Chatenier, Verstegen, Biemans, Mulder, & Omta, 2010; Chesbrough et al., 2006; Gassmann, Sandmeier, & Wecht, 2006; Henkel, 2006). Collaboration with educational institutions, government and competitors is called horizontal external collaboration (Cancino & Cárdenas, 2018; Lee, Park, Yoon, & Park, 2010).

Vertical external collaborations cooperate with exogenous agents, such as users, clients and suppliers, and take advantage of resources such as knowledge. In this way, it influences the company to the extent that it can connect with external agents in the innovation process, and exchange experiences and solutions, through knowledge transfer (Gassmann et al., 2006; Hippel, 2005; Schweisfurth & Raasch, 2015).

In addition, users reduce costs in generating innovative ideas, mutually benefiting. Companies encourage users to co-develop products through strategies such as open-source, where technology is made available to the public to collaborate without guarantees (Bueno & Balestrin, 2012; Henkel, 2006; Hienerth, 2006).

On the other hand, resources are accessed through interaction with customers that provide more detailed external knowledge of business needs, such as innovation processes where several business areas intervene that efficiently capture ideas to meet customer needs and create new or improved products and services (Hippel, 2005; Khanagha, Volberda, & Oshri, 2016; Schweisfurth & Raasch, 2015).

Within the vertical external collaborations are the suppliers, who provide great benefits in the innovation processes, either due to a lack of external inputs that companies do not have in their learning processes, or also working on joint solutions of matters premiums, delivery times, guarantees (Chatenier et al., 2010; Romijn & Albaladejo, 2002).

On the other hand, in horizontal external collaborations, innovation efforts are made jointly to create and maintain superior performance, in addition, external knowledge is acquired that provides a diversity of ideas and technological capabilities (Cancino & Cárdenas, 2018; Hagedoorn, Roijakkers, & Kranenburg, 2006; Lee et al., 2010; Tether, 2003).

In horizontal external collaborations, academic research has been fundamental to accelerate the results of innovation and business performance (George, Zahra, & Wood, 2002; Vrande et al., 2009). Companies acquire knowledge from universities, taking into account the technological life cycle, to make decisions regarding the number of people involved, the resources assigned, the positioning within or outside the limits of the company, the degree of specialization and the degree of formalization among others (Buganza & Verganti, 2009).

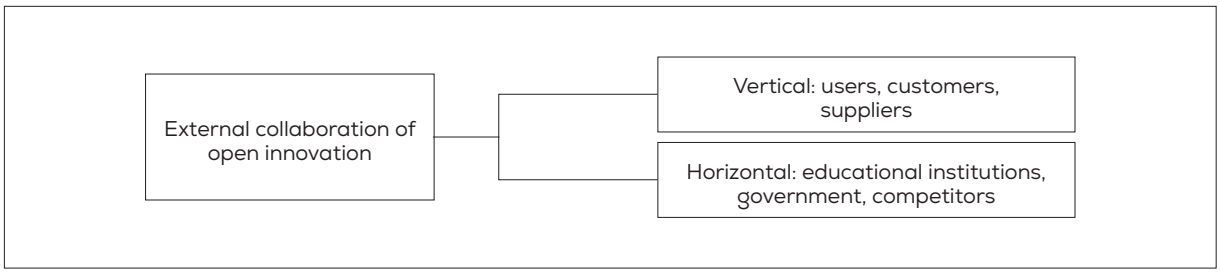
The horizontal external collaborations with the government promote policies, economic support, business advice to improve products and services, new markets, joint ventures, associations, alliances and R&D consortia to manage organizational knowledge, without ruling out informal networks to create and manage knowledge (Feller, Finnegan, Hayes, & O'Reilly, 2009; Lee, Hwang, & Choi, 2012; Pipkin, 2018).

Horizontal external collaboration with competitors is increasingly used because technologies, customers and markets are shared, not only technology and knowledge are acquired, but other global knowledge sources are accessed where the purpose is the integral development of technologies, the creation of new markets, the discovery of new business opportunities, increased profits in the search for innovation and better organizational performance (Lee et al., 2010; Parida et al., 2012).

Therefore, collaborative companies develop specific characteristics that increase their efficiency through the acquisition of technology and complementary knowledge, addition, collaboration strategies increase the use of human capital and resources, so it is necessary to set limits that prevent the scarcity of resources and meeting contracted needs and their interactions (Alvarez-Aros & Bernal-Torres, 2017; Mention & Asikainen, 2012; Quintana-García & Benavides-Velasco, 2004).

In summary, collaborations with horizontal and vertical external agents represent new advantages and opportunities in areas such as open innovation, representing an invitation to organizational openness outside of business boundaries, as shown in Figure 1:

Figure 1. External collaboration of open innovation



Source: Prepared from Parida et al. (2012); Vrande et al. (2009); Wang et al. (2015).

From Figure 1, it can be seen that collaboration is classified according to whether it is supported by each external agent, however, it depends on the strategy of each organization to determine which collaborations improve innovation and financial performance, an issue addressed in the next section.

Financial performance

Good performance is sustained by financial viability, effectiveness, efficiency, and organizational productivity. In this regard, the measurement of organizational performance has undergone changes over time, however, the financial perspective remains in force on issues such as open innovation (Fry, Mention, Temel, & Torkkeli, 2016; Hung & Chou, 2013). As an example, Mazzola, Bruccoleri and Perrone (2016) studied biopharmaceutical companies and their mix in open innovation practices to extend R&D processes beyond business boundaries and improve financial results.

Other examples of the benefit of external collaborations are P&G, IBM, Intel, Safer, Philips, Unilever and Whirpool, where economic achievements are highlighted, acquisition, application and protection of ideas, new scientific and technological knowledge, the interaction of the channels of network communication with external agents and organizational flexibility to face adversities (Chesbrough, 2015; Muller & Hutchins, 2012; Ollila & Yström, 2015).

In this sense, greater business flexibility with the ability to respond and adapt to the environment provides greater financial returns, both to the company and to its collaborators in open innovation, as argued by empirical studies that highlight the effect of spillovers from the network of knowledge, as they are key resources that improve relational capacity with external connections (Ollila & Yström, 2015; Sisodiya et al., 2013).

Therefore, despite the fact that organizational performance has been measured differently in its evolution, the financial dimension was chosen for the study because it represents a great interest for SMEs and open innovation (Akhisar, Tunay, & Tunay, 2015; Laursen & Salter, 2006). In this regard, the indicators that measure financial performance are based on return on investment (ROI), return on assets (ROA), growth in sales, profits, earnings per share, market value and book value (Akhisar et al., 2015; Kalkan, Bozkurt, & Arman, 2014; Sánchez et al., 2015).

External collaboration and financial performance

Financial performance and its relationship with external collaborations suggests that a company improves its results through interaction with vertical and horizontal external agents (Hung & Chiang, 2010; Laursen & Salter, 2006; Mazzola et al., 2016). In this way, vertical external collaboration with clients and suppliers is beneficial for company innovation due to the combination of complementary technological capabilities and common objectives with external agents (Hwang & Lee, 2010; Tsai, 2009).

In addition, horizontal external collaboration with research centers and universities positively impacts the innovative performance of products (Hung & Chiang, 2010; Tsai, 2009); since these agents have mechanisms to access new knowledge. On the other hand, other investigations confirmed that the external acquisition of knowledge has a negative effect on organizational results and innovation (Inauen & Schenker-Wicki, 2011).

Also, the opening to universities in R&D processes has a positive impact on the percentage of sales of innovative products, therefore, it represents a positive effect on financial performance (Inauen & Schenker-Wicki, 2011). However, researchers such as Belderbos, Faems, Leten and Looy (2010) suggest the possibility of a negative effect of these practices on financial performance, if the organizational limits are not maintained.

In fact, although collaborative R&D activities could reduce technical risks and costs associated with uncertainty, external collaboration could introduce relational risks and increase coordination costs (Das & Teng, 1998). To mitigate such risks, companies require contractual negotiations that could be time-consuming to design and implement, as well as to formulate generally costly monitoring mechanisms.

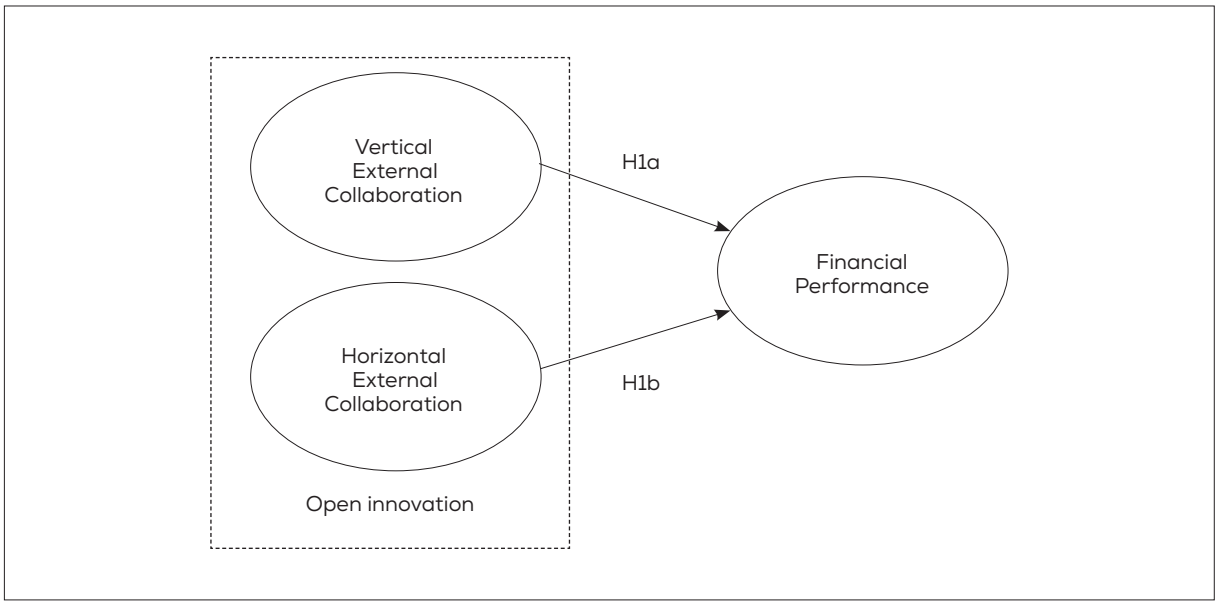
From the above, there are multifaceted reasons for this negative relationship, including inadequate or insufficient absorption capacity (Cohen & Levinthal, 1990; Martínez-Senra, Quintás, & Caballero, 2014) to absorb knowledge and technologies from other industries, or the fading of resources that the acquisition of external knowledge creates. In addition to impacting innovative performance (Aschhoff & Schmidt, 2008), some empirical works described show that collaboration with external agents tends to be beneficial, not only in innovation, but also in financial performance. Therefore, as a result of the schism of the previous considerations, the following hypotheses are raised:

H1a: The vertical external collaboration of open innovation positively and significantly influences the financial performance of SMEs.

H1b: The horizontal external collaboration of open innovation positively and significantly influences the financial performance of SMEs.

The hypotheses and the representation of the model are seen in Figure 2.

Figure 2. Conceptual model and hypothesis



METHODOLOGICAL DESIGN

Method

In order to verify the hypotheses raised, an investigation with a quantitative approach, of causal scope, cross-sectional, was designed through the collection of data with primary sources by means of a questionnaire. Before applying the definitive questionnaire, a pilot test was carried out with 30 companies from Tamaulipas to identify possible interpretation problems, guarantee the correct use of the scale and achieve the validity of the instrument. The data collection was through a 5-point Likert scale survey, consisting of 14 items related to the measurement of both vertical and horizontal external collaboration and seven items to measure financial performance

The questionnaire was made up of two sections. The first compiled general information, such as position, education, gender, business sector and business size. The second collected data on external collaboration and financial performance.

In vertical external collaboration, 7 items related to business involvement were used to research, develop or innovate with: current clients; potential customers; current users; potential users; current providers; potential suppliers; and if the involvement is carried out through a web service or digital platforms to facilitate collaborations with users, clients, and suppliers. The design was based on Afcha (2011), Obea (2009), y Vrande et al. (2009).

In horizontal external collaboration, the 7 items used were related to business involvement with: educational institutions; government; competitors; joint work of activities such as the

co-development of products or services with educational institutions, or government or competitors; use of networks for the exchange of experiences with educational institutions, or the government or competitors; obtaining inputs of knowledge and ideas with educational institutions, or government or competitors; entries of equipment, machinery, software, and supplies with educational institutions, or government or competitors. The items were based on Afcha (2011), Obea (2009), Vrande et al. (2009) y Wang et al. (2015).

For the items of vertical and horizontal external collaboration, the scale options were: one "never", two "rarely", three "sometimes", four "most of the time" and five "always".

To evaluate financial performance, the items used were related to profitability; collection from clients; payment to suppliers; inventory turnover; return on assets; return on sales; and return on investment. For these items, were taken into account the works of Martínez, Charterina and Araujo (2010), Park and Lee (2011), Rogo et al. (2014) and Sisodiya et al. (2013). The options on the scale were: one "lousy", two "bad", three "fair", four "good" and five "superior".

The questionnaire was applied to a non-probabilistic sample for convenience (without statistical inference) and was sent by email to 250 executives, that is, owners, general and financial managers of SMEs in the industrial, commercial and services sector in Tamaulipas, Mexico. Prior to shipment, chambers and associations provided the contacts were contacted and provided the e-mails. 170 surveys were received, but 25 were discarded due to multivariate normality problems, according to the Mahalanobis test (McLachlan, 1999), leaving a final sample of 145 questionnaires.

Data processing

Statistical processing was performed with SPSS 24 and AMOS, with the multivariate structural equation modeling technique (SEM), because it analyzes multiple relationships between variables. This technique involves estimating the measurement and structural model. The first verifies the suitability of the items used to evaluate each construct (vertical and horizontal external collaboration and its relationship with financial performance). The second verifies the relationships between the latent variables created (Weston & Gore, 2006), that is, vertical and horizontal external collaboration.

Subjects

The subjects analyzed were 145 owners and managers of SMEs (small 75% and medium 25%) of the industrial (23.45%), commercial (48.28%) and services (28.27%) sectors, in Tamaulipas, on the northern border of Mexico. The data collected was from complete questionnaires, sent digitally to 250 companies in mid-2019, selected under the criteria of having five years or more of economic activity.

This is because there is consensus that the evaluation of innovation requires a period of business activity. The characteristics of the owners and managers were: 73% men and 27% women; 48% owners and 52% managers; Regarding academic training, 1% said they had no training; 8%, upper secondary level; 77%, undergraduate and 14%, specialty or postgraduate.

RESULTS AND DISCUSSION

Measurement model

Confirmatory factor analysis was used to check the reliability and validity of the scales. First, the standardized factor loadings (SFL) were analyzed for each item of the vertical (VEC), horizontal (HEC) and financial performance (FP) external collaboration constructs, eliminating those with loads below the minimum acceptable value of 0.700. (Hair, Black, Babin, & Anderson, 2014).

Three items were eliminated from the vertical external collaboration construct (Vec3, Vec4, Vec7), of horizontal external collaboration, three items were excluded (Hec9, Hec12 y Hec14), and four items were eliminated from financial performance (FP1, FP2, FP3 y FP4. Next, the reliability of the measurement scales was assessed through Cronbach's alpha (α) and the composite reliability index (CRI), which obtained values higher than the required minimum of 0.700 (Nunnally, 1978). Subsequently, the convergent validity was reviewed, which shows an adequate correlation between items that make up a construct, measured with the average variance extracted (AVE), with values above the acceptable threshold of 0.50 (Fornell & Larcker, 1981).

In summary, there are three results to be highlighted in Table 1. First, financial performance is determined by the return on assets, the return on sales and the return on investment, the most relevant aspects considered in financial activity. (Akhisar et al., 2015; Kalkan et al., 2014; Sánchez et al., 2015).

Second, vertical external collaboration is done with current and potential suppliers and customers, which is consistent with other empirical results. (Bueno & Balestrin, 2012; Chatenier et al., 2010; Chesbrough et al., 2006), although without highlighting the current and potential users of the products or services.

Third, horizontal external collaboration manifests itself through interaction with educational institutions, government, and competitors. (Cancino & Cárdenas, 2018; Lee et al., 2010), in the co-development of products or services, obtaining knowledge and ideas from the environment, the acquisition of equipment, machinery, software and supplies, and the use of networks for the exchange of experiences with educational institutions, government and competitors, in accordance with other studies (Feller et al., 2009; Lee et al., 2012).

(Continua)

Table 1. Validation of the measurement scales

Variable	Indicator	SFL	α	CRI	AVE
Financial performance	FP5. Return on assets	0.842	0.895	0.896	0.743
	FP6. Return on sales	0.880			
	FP7. Return on investment	0.863			
Vertical external collaboration	Vec1. Potential customers	0.913	0.861	0.869	0.626
	Vec2. Current customers	0.666			
	Vec5. Current providers	0.818			
	Vec6. Potential Suppliers	0.748			
Horizontal external collaboration	Hec8. Co-development of products or services with educational, government or rival institutions	0.683	0.800	0.804	0.509
	Hec10. Obtaining knowledge and ideas with educational institutions, government or rivals	0.697			
	Hec11. Acquisition of equipment, machinery, software and supplies with educational institutions, government or rivals	0.834			
	Hec13. Networks for the exchange of experiences with academic institutions, government and competitors	0.624			

Source: Own elaboration based on the results results from AMOS.

Regarding the discriminant validity, it allows demonstrating the difference of one construct from the rest in the model, and it was analyzed by comparing the AVE and the squared correlations of each construct, the AVE being higher than the recommended correlations (Fornell & Larcker, 1981), observed in Table 2.

Table 2. Discriminant validity

Constructs	Financial performance	Vertical external collaboration	Horizontal external collaboration
Financial performance	0.743		
Vertical external collaboration	0.052	0.626	
Horizontal external collaboration	0.166	0.271	0.509

Source: Results from AMOS.

Structural model

Table 3 lists the indicators of goodness of fit appropriate to Hair et al., (2014), obtaining a reliable incremental adjustment of CFI=0.964, TLI=0.951, NFI= 0.918, greater than 0.900 recommended. On the other hand, a good absolute fit was achieved, with an RMSEA = 0.070,

lower than the recommended 0.0800. (Browne & Cudeck, 1992). Finally, the parsimony adjustment determined by chi-square / gl was adequate with a value of 1,700, being a value less than 2,000.

Table 3. Model fit

Statistical	Value	Abbreviation	Criterion
Absolute adjustment			
Chi squared	69.713 (0.003)	X2	Significance >0,050
The root of the mean square residual of approx.	0.070	RMSEA	< 0,080
Incremental adjustment			
Comparative goodness-of-fit index	0.964	CFI	> 0,900
Index of Tucker-Lewis	0.951	TLI	> 0,900
Normalized fit index	0.918	NFI	> 0,900
Parsimony			
Chi-square / gl ratio	1.700	(CMIN/DF)	Smaller than 3.000

Source: Results from AMOS.

The data in Table 4 show that vertical external collaboration has a low positive and non-significant effect on the financial performance of SMEs (H1a), with a P value of 0.831 (the hypotheses are accepted with P values <0.05), Therefore, the claim that vertical external collaboration of open innovation positively and significantly influences the financial performance of SMEs is rejected, being a different finding from previous research (Hippel, 2005; Khanagha et al., 2016; Schweisfurth & Raasch, 2015).

From the previous finding, this could be due to the fact that the collaboration relationship with clients and suppliers is limited to informal dialogues on basic activities (types of products or services, specifications, prices, volumes, etc.), and not to formal and complex activities that involve changes in products or services, inputs, supply chains, etc. The foregoing shows that this type of collaboration is not always relevant for companies, or that it requires an appropriate configuration, human resources, and qualified external agents, as other empirical studies assert (Huang, Krull, & Ziedonis, 2020; Raposo, Ferreira, & Fernandes, 2014).

While horizontal external collaboration has a positive and very significant effect on financial performance, with a P value of 0.001 (H1b). Therefore, the hypothesis that the horizontal external collaboration of open innovation positively and significantly influences the financial performance of SMEs is confirmed. The above is consistent with work done by Afcha (2011), Cancino and Cárdenas (2018) and Wang et al. (2015), in which it is stated that getting involved for the co-development of products or services with educational institutions (Vrande et al., 2009), government (Lee et al., 2012) and competitors (Parida et al., 2012) generates financial value in these companies.

Likewise, the importance of obtaining knowledge and diversity of technical and scientific ideas through involvement with educational institutions, government and competitors is also highlighted, since the time to acquire the necessary knowledge to face new challenges is reduced, and knowledge is accessed development, accelerating learning curves and ensuring better use of technological capabilities, R&D results, and financial performance (Hagedoorn et al., 2006; Tether, 2003).

Activities involving the acquisition of equipment, machinery, software and supplies also stand out, as they have a considerable impact on financial results. This positive relationship could be due to the fact that acquiring machinery and equipment, software and supplies, as well as carrying out projects outside the value chain, receives more business interest due to its direct implications on financial indicators; For example, collaboration with rivals minimizes risks in project development and allows sharing of resources, improving times, costs and financial indicators (Alvarez-Aros & Bernal-Torres, 2017; Lee et al., 2010; Mazzola et al., 2016).

In addition to the above, a final element to consider is participation in networks for the exchange of experiences with academic institutions, government and competitors, since it allows improving the formalization of communication with external agents and, in turn, establishing organizational limits that guarantee a collaboration oriented towards joint R&DI+D and innovation achievements, impacting on better financial performance (Chesbrough, 2015; Muller & Hutchins, 2012; Ollila & Yström, 2015).

Table 4. Estimated results

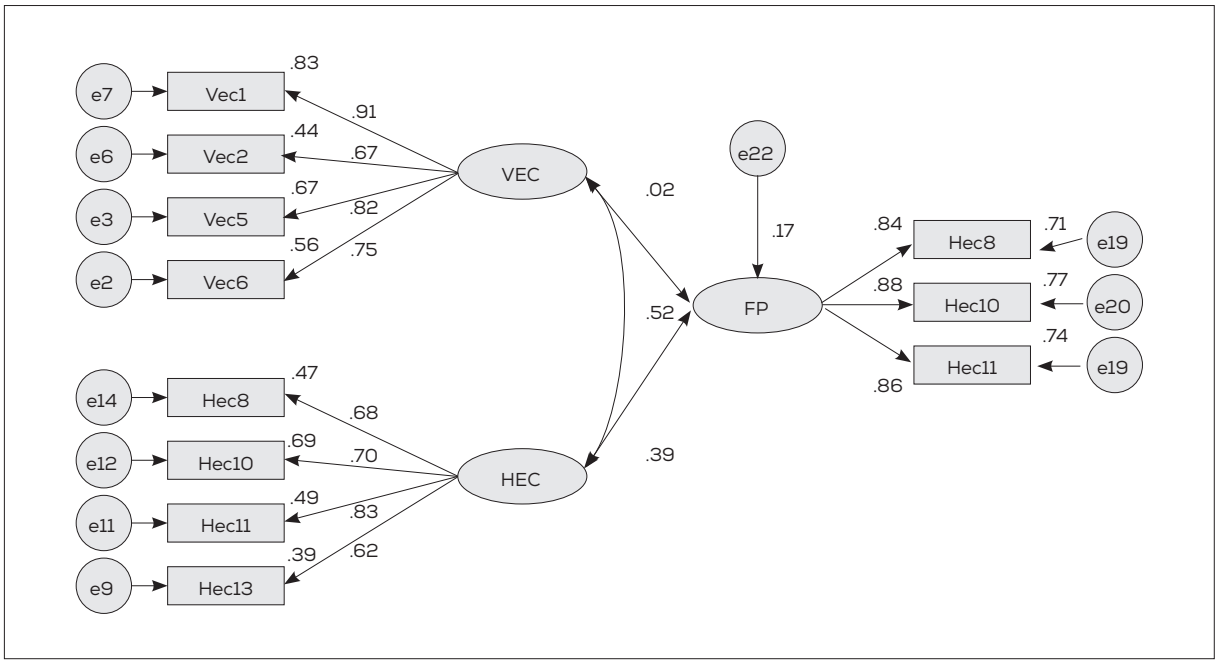
Hypothesis	Endogenous variables relationship			Standardized estimates	S.E.	C.R.	P value
H1a	Financial performance	<--	VEC	0.022	0.102	0.214	0.831
H1b	Financial performance	<--	HEC	0.452	0.139	3.241	0.001

Source: Own elaboration based on the results from AMOS.

Complementary to Table 4, Figure 3 shows the standardized results of the structural model, of the relationships between the items of the vertical and horizontal external collaborations of SMEs with different exogenous agents, and the relationship of these collaborations with financial performance. The determination coefficient (R^2) of the model is observed with a value of 0.17, which represents those external collaborations explain 17% of financial performance. This coefficient is classified as weak according to Chin (1998), being less than 0.19, therefore, the predictive value of the model is low and represents a limitation of the work.

However, it should be noted that financial performance is a complex construct that is explained by different variables related to the operation of each organization and the same environment that surrounds the companies, and that have been addressed in the organizational literature. Therefore, this research only tries to determine the part of the variance of financial performance explained by external collaboration. In this regard, Hair et al., (2014) point out that in a model with only two independent variables and with a sample size less than 250, a coefficient of determination (R^2) of 13% is considered statistically significant.

Figure 3. Standardized structural model



Source: Own elaboration based on the results from AMOS.

CONCLUSIONS

This study contributes to a better understanding of open innovation activities, specifically vertical and horizontal external collaboration, and their relationship with financial performance. Regarding H1a, little positive and non-significant relationship was found between vertical external collaboration with customers, suppliers and users, with financial results (Belderbos et al., 2010; Inauen & Schenker-Wicki, 2011).

This probably stems from the fact that the majority of the sample of companies in the northern border are not industrial companies with a technological profile, since they belong mainly to the commercial sector, where they are limited to a collaborative configuration of basic deals with users, clients and suppliers; and more informal business deals that do not stand out from the operational routine and become irrelevant for that sector (Huang, Krull, & Ziedonis, 2020; Pipkin, 2018; Raposo et al., 2014).

The other hand, from the H1b, as a novel result, a positive and significant relationship was confirmed from the approach of horizontal external collaboration of open innovation (education institutions, government and competitors) in relation to financial performance indicators. This shows the main contribution of the study, due to the importance of involvement activities with these external agents, from the perspective of the theory of the reduction of transactional costs, such as the co-development activities of products and services, the obtaining of knowledge and ideas from the environment to improve R&D and innovation.

Also noteworthy are the acquisition of machinery, equipment, software and supplies, as well as the networks for the exchange of experiences regarding the financial results of SMEs (Buganza & Verganti, 2009; Lee et al., 2010, 2012).

Therefore, this research contributes to the reflection on the awareness of the owners and managers of SMEs in collaborative work with agents inside and outside the environment in open innovation. This represents a strategy to be promoted for the configuration of the competitive capacity of businesses and in the role of the limited market, where SMEs usually operate that seem not to be forced to carry out collaborative activities with external actors. Said strategy to be promoted would undoubtedly improve the contextual role where SMEs carry out their activity, especially in an emerging economy, where the culture of collaborative work is still incipient.

This is in contrast to the broad markets where large companies in developed economies operate, where collaborative work is constantly required to innovate and enhance competitive capacity (García-Vidales et al., 2019; Stanisławskiy, 2020). This indicates that collaborative work in SMEs in emerging economies is determined by managers' awareness of the role of the environment, the size of the market and the context where the market is developing.

These results are added to other investigations that emphasize the need to investigate more in this regard, especially in emerging economies such as Mexico or undeveloped economies, as is mostly the case in Latin America (Scott & Chaston, 2013). Therefore, the findings so far are inconclusive regarding the use of horizontal and vertical external collaborations to improve financial performance in SMEs.

From the above, it is important to highlight that the search and acquisition of inputs, the use of exogenous sources and external collaboration are incoming open innovation strategies, so these activities could be within the reach of any sector, be it commercial, industrial or of services. This is because the practices of incoming open innovation are more oriented to obtain intangible resources from the exogenous environment (Alvarez-Aros & Álvarez-Herrera, 2018).

Evidence is also provided for business decision-making, the directors of government entities responsible for stimulating these companies and academics interested in the subject, since a joint effort is required to continue exploring the different interactions between external agents, taking into account elements such as the breadth and depth necessary in said collaborations, which allow a mutual benefit between company and society.

Regarding the limitations of the study, it is important to mention that the results obtained and the proposals are valid only for the analyzed sample, and cannot be generalized. In addition, this work leaves aside activities such as information disclosure, intellectual property, licensing, and joint projects, which are activities typical of outgoing or mixed open innovation strategies, if they are complemented with the incoming strategy, and represent a future agenda as established by other works (Alvarez-Aros & Bernal-Torres, 2017).

Finally, other future lines of research are to continue studying the issue of external open innovation collaborations in border cities of emerging or undeveloped economies of multiple business sectors, with longitudinal studies and also considering other external agents such as banking institutions, private research centers, among others.

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AUTHORS' CONTRIBUTIONS

Erick Leobardo Alvarez-Aros, César Augusto Bernal-Torres, and Yesenia Sánchez Tovar worked on the conceptualization and theoretical-methodological approach. The theoretical review was carried out by Erick Leobardo Alvarez-Aros, and César Augusto Bernal-Torres. Erick Leobardo Alvarez-Aros coordinated the data collection and the first methodological analysis. The second data and methodological analysis was reworked Yesenia Sánchez Tovar. All the authors worked together in the writing results and conclusions, and final revision of the manuscript.

