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Innovation Development in South American SMEs: Examining University Cooperation and Innovation Efforts through PLS-SEM

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Abstract*– Small and medium-sized enterprises (SMEs) play a key role in national economies, particularly for emerging markets (EM), where potential economic growth is needed and consumer preferences dynamically shift. Innovation has been reported as an important mechanism for EM SMEs to enhance firm performance, competitiveness, and market expansion. However, SMEs encounter barriers to innovation, emphasizing the importance of cooperative partnerships. Among these, university-firm cooperation emerges as a significant driver of innovation. Despite these insights, limited research contrasts the effectiveness of university cooperation in the results of innovation efforts. Therefore, this study investigates the moderating effect of university cooperation on the relationship between innovation efforts and innovation outputs across manufacturing SMEs from Colombia, Ecuador and Peru. Our findings suggest that innovation efforts positively impact innovation development regardless of the cooperative relationship with universities.

Keywords*– SMEs, Emerging markets, innovation, University-firm cooperation.

I. Introduction

Innovation is essential for small and medium-sized enterprises (SMEs) operating in emerging markets (EM). These markets are characterized by potential economic growth [1] and rapid changes in consumer preferences based on the heterogeneity of their sociocultural characteristics [2]. This makes it essential for SMEs to innovate and, in turn, improve firms' performance [3], competitiveness, and market expansion [4], regardless of companies' tech level [5].

However, limitations in internal capabilities, just as economic factors, are some of the EM SMEs' obstacles to innovation development [6]. Other SMEs' features, such as inflexible internal procedures, structures, lack of strategic fit, and knowledge issues, also hamper innovation efforts [7]. These barriers highlight SMEs' challenges in performing innovation efforts and emphasize the need for supportive partnerships. According to the literature review, cooperation and partnerships can provide SMEs with the necessary resources for survival and innovation driving [8], [9]. However, the volatility of emerging markets could challenge traditional theories primarily studied in developed markets [10].

Academic is one of the most studied cooperative relationships beneficial for firms' goals. University-firm cooperation has demonstrated a positive impact on firms' innovation performance [11]–[13], market growth [9], and technological resource accessibility [14]. Nonetheless, there is evidence that larger companies make more benefit from this kind of cooperation [12], [13], mainly due to SMEs' limitations on internal absorptive capacity, lack of knowledge of university programs [9], and, in general, fewer abilities and resources to exploit cooperative relationships [15]. For SMEs, forming cooperative relationships with universities occurs mainly through personal (or informal) relations [9]. Also, when referring to EM SMEs, heterogeneity in the quality of universities or research institutes affects the relationship between academic cooperation and innovation performance [16].

Despite the evidence of cooperation and knowledge acquisition effectiveness on innovation performance, no studies contrast the results of innovation efforts when university cooperation is applied in SMEs in EM, where innovation efforts work differently compared to developed markets [3]. Thus, this study aims to analyze the moderating effect of university cooperation on the relationship between innovation efforts and innovation outputs, using PLS-SEM in 2 775 manufacturing SMEs from Colombia, Ecuador and Peru, three Latin American emerging markets that share geographical boundaries and that have not been studied together in the innovation context to the extent of our literature review.

The research is theoretically framed in the resource-based view (RBV). It analyzes innovation as a driver for productivity increase and new product or service adoption [17], which is boosted when collaborative relationships are formed [18].

II. Theoretical Background

A. *Innovation in SMEs from emerging markets*

Innovation in EM should be analyzed differently from developed economies since the social and economic structures are less uniform and organized [19]. In this context, developing non-technological innovation (NTI; marketing or organizational innovation) in manufacturing EM SMEs is a precursor of technological innovation (TI; product or process innovation) development and, in turn, of innovation sales [3].

However, it has been found that NTI is less common among SMEs in EM, and TI is still moderately performed [20].

This research analyzed the innovation behavior of manufacturing SMEs in Colombia, Ecuador, and Peru. These countries produced fewer innovation outputs in comparison to their level of innovation investment in the last years [21]. Colombia performed best at business sophistication but had a weakness in human capital and research. Ecuador was strong in infrastructure innovation, but it was weak institutionally. Peru performed best at market sophistication but worst at knowledge and technology outputs [21]. During the analysis period, their Global Innovation Index rankings were 67, 71, and 119 for Colombia, Peru, and Ecuador, respectively. Also, Colombia and Peru had increased their performance in Infrastructure and Market sophistication, mainly as an output of consistent policies to improve these areas [21].

B. Innovation efforts in SMEs from EM

Innovation efforts (IE) could be understood as how firms foster the investment of internal and external resources to obtain innovation results [22]. IEs include knowledge acquisition as a dimension since organizational innovation could significantly benefit from the synergistic effects of properly integrating and applying externally acquired knowledge [23]. Knowledge refers to information understanding and its use for different purposes. This is based on cognitive effort. Therefore, it is complex to transfer new knowledge as it requires the receiver's learning. Information like knowledge is obtained or created inside or outside and transferred between organizations [24].

Also, investing in innovation activities (IA) is part of IE that companies use to innovate. IAs are defined as the development of financial and commercial activities by a firm aiming to obtain an innovation [25]. Investment in IA, such as R&D, is a relevant predictor for IE besides knowledge acquisition (KA) [22]. Studies conclude that EMs, particularly in Latin America, face different contexts from those found in developed countries [3], such as low levels of innovation and R&D [26], informal economy and labor market rigidity [27], and diversity in social, economic structures and the educational system [1].

Given that R&D investment is not necessarily a driver for firm performance among SMEs from Latin America, NTI has become an important driver in economic, production, and market performance among innovators from this type of market [3], [28]. The innovation developments of EM companies demonstrate that NTI cannot be dissociated from TI since performing NTI promotes the TI, which, in turn, affects innovation performance [3]. Therefore, the analysis of the effects on firm performance must consider the dynamics between the different types of innovation [29]. Thus, we propose the following hypotheses:

- H1. IEs have a positive effect on performing NTI.
- H2. IEs have a positive effect on performing TI.

C. Innovation and the cooperative relationship between University - SMEs

SMEs differ from large companies in terms of organizational agility [30], the flexibility of interaction in the business environment and their vicinity to customers and suppliers [31], limited resources [32], poor connectivity [9], and difficulty in dealing with rapid technological change and product innovation [9]. Therefore, forming cooperative networks is essential to access resources [32]. The term cooperation refers to the working relationship between two institutions, SMEs and universities, in our study. In this sense, the parties have mutually dependent objectives common to both or at least compatible, sharing and exchanging resources and performing joint activities [9], [33]. Cooperation is a route that allows SMEs to access knowledge and innovation resources.

Therefore, cooperation with universities may be beneficial, as universities are known to be agents of influence in the knowledge-intensive economy [34]. SMEs need to establish cooperation to promote innovation and enhance production, commercialization, quality and access to complementary resources, among others, and here universities could become ideal partners [9], [35]. However, it is important to understand where academic cooperation impacts innovation development. Therefore, the following hypotheses are put forward:

- H3. Cooperating with universities has a positive effect on performing NTI.
- H4. Cooperating with universities has a positive effect on performing TI.

D. University cooperation and innovation efforts

Through cooperative relations to innovate, SMEs learn, transfer, and acquire knowledge to increase their operational capacity and competitive advantage to enter new markets [36]. Also, it is known that cooperation and information sources release product and marketing innovation. Generally, manufacturing firms, using R&D resources in cooperation and consulting information sources, have developed product, process, and marketing innovations [37].

In the context of SMEs, cooperation allows the firm to benefit from strategic resources that can attract new customers and business partners in long-lasting relationships [32]. These relationships can help attract partnerships capable of adding long-term value for the firm [38] in innovation and R&D activities that can influence its performance [9], [30].

Nonetheless, in the context of SMEs, cooperative relations with universities predominantly manifest as informal relationships, highlighting the need to establish interpersonal connections between universities and SMEs as a prerequisite to formal cooperation [11], [39]. Also, it is generally difficult for EM SMEs to connect with universities since they tend to perceive this relationship as a cost-based, bureaucratic contract [9], [40]. But, trust could overcome these barriers [41]. This lack of information makes it difficult to understand the impact of university cooperation on innovation efforts, as

literature has only analyzed the impact on innovation results. Thus, we proposed the following hypotheses:

- H5. Cooperating with universities moderates the relationship between IE efforts and NTI fulfillment, such that increasing cooperation with universities strengthens the relationship between IE and NTI fulfillment.
- H6. Cooperating with universities moderates the relationship between IE and TI fulfillment, such that increasing cooperation with universities strengthens the relationship between IE and TI fulfillment.

III. Methodology

A. Dataset

This research used an exploratory and quantitative approach. We used secondary data from the National Innovation Surveys taken from the Colombian [42], Peruvian [43] and Ecuadorian [44] Statistical Institutes in charge of the surveys, respectively, following the methodology of ref. [3], [27], [37], [45]. The surveys were taken from 2012 to 2014 and contained the most current information on at least one of the three countries. According to those institutes, the surveys were based on the methodological framework proposed by the Oslo Manual [25].

We merged the three datasets by limiting variables to matched questions. The datasets contain only SMEs in the manufacturing industry. We classified firms based on the reported number of employees; small firms had less than 50 employees, and medium companies had less than 250 [25]. After omitting missing, inconsistent and invalid responses, the sample consisted of 2 775 questionnaires (1 242 Colombian, 745 Ecuadorian and 788 Peruvian firms).

B. Model

Based on the hypotheses stated, we explored a model described in Fig. 1 where the relationship between IE and the development of innovation (NTI or TI) was analyzed for EM SMEs in Latin America, just as the impact of university cooperation. We analyzed the path through the Partial Least Square Structural Equation Model (PLS-SEM) since it is better preferred in exploratory contexts and it is more robust when secondary data is used, unlike its equivalent method based on covariance (CB-SEM), which tends to have very restrictive assumptions [46]–[48].

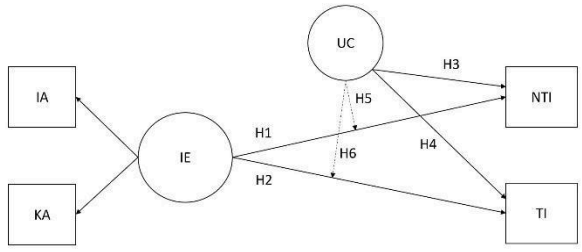

Fig. 1 Path model of the relationship between innovation efforts and its results moderated by university cooperation. For abbreviations reference, consider IA: Innovation activities; KA: Knowledge acquisition; IE: Innovation efforts; UC: University cooperation; NTI: Non-technological innovation; TI: Technological innovation.

The model considered the independent variable, IE, as a second-order construct (HOC) dependent on two first-order constructs (LOC). The dependent variables, TI and NTI, and the moderator, UC were also LOCs. HOCs help to achieve model parsimony by overcoming the bandwidth-fidelity dilemma and summarizing the relationships of main interest in the path [49]. All indicators and constructs are reflective since we hypothesized that their respective construct causes all of them. However, this was confirmed visually through GH-biplot for exploring the variance-covariance among the variables [50]. The validity, composite reliability, and indicator's loading values were analyzed as suggested in the PLS-SEM literature [46], [47], [49], i.e., indicators with loading values less than 0.4 were removed, and those with greater values were retained under the conditions suggested in the literature review. Also, we used the heterotrait-monotrait ratio (HTMT) criterion as indicated in the literature, where values up to 0.9 are recommended to establish discriminant validity in conceptually similar constructs [46], [47], [49]. Alternatively, when trespassing the HTMT threshold, we also analyzed the correlation between constructs and the cross-loadings of the conflict indicators [51].

The model paths were specified using the disjoint two-stage approach, where LOCs were analyzed first, then their scores were used as indicators of the respective HOCs [49]. The structure of the model was analyzed considering the statistical significance of the path coefficients (α=0.05) resulting from the bootstrapping method (1000 subsamples) [47]. The SEM has been analyzed using the *seminr* package in R software.

C. Variables

The dependent variables of the model were the development of the two types of innovation, TI and NTI, that comprise the development of innovation (e.g., organizational, marketing, product or process innovation) and the share of innovative products from the total sales, based on [3]. The independent variable was IE, modeled as a HOC of efforts in IA and KA, based on [45]. IA comprised investment in innovation activities (e.g., total investment in internal R&D, machinery and equipment acquisition, and others, divided by firm revenue). KA synthesizes the external information sources (e.g., use of customers, suppliers and competitors as information sources, etc.). The moderator variable was a construct that measured the cooperation with universities using reflective indicators of the cooperation purposes (e.g., use of university cooperation for R&D, training, etc.).

IV. Results

When analyzing the descriptive statistics of the variables of interest for each country, we observed that most Peruvian SMEs used KA from the different information sources evaluated in the survey. Similarly, most Ecuadorian firms used customers, competitors, suppliers, internet and conferences as information sources, unlike Colombia, where less than 50% of the companies in the sample used information sources.

Also, universities were barely used for cooperative relations across all the countries. Cooperation was primarily focused on R&D in Colombia and other unspecified purposes in Ecuador and Peru. Regarding innovation, the distribution of innovation accomplishment was similar across countries, although a prominent group among the Ecuadorian SMEs reported carrying out process innovation. The study found that in Peru, over 50% of companies engaged in NTI, and interestingly, the percentage of new product sales was higher (about 24%) than the neighbors. However, a direct relationship between NTI and innovation sales was also observed in the other countries, where NTI was less common. Across all countries, the highest investment in AI was in industrial machinery and equipment, followed by the percentage of staff dedicated to R&D.

We analyzed the variance-covariance distribution of the variables before they were interpreted as constructs through GH-biplot. We observed a high correlation between KA and IA, suggesting that these constructs were related. KA's indicators displayed consistently high variance and covariance. However, sources such as universities and consultants showed less interrelation with the other information sources, especially for Colombia and Ecuador, suggesting low item reliability from these indicators. Regarding IA, some indicators displayed low variance. In the case of Colombia, the investment in internal R&D and the percentage of staff dedicated to it exhibited the highest variance among the IA indicators. On the other hand, the investment in internal R&D and industrial design and engineering displayed the highest variance in Ecuador and Peru. These results suggested a clear definition of the two constructs forming IE.

Regarding innovation constructs, NTI had a high intra-correlation, and all its indicators had a consistently high variance across the countries. As for TI, the correlation between product innovation and its sales was higher in Colombia and Ecuador and lower in Peru. On the other hand, the process innovation displayed a lower correlation with the other two indicators across the countries in the sample, namely Ecuador and Colombia. In the Peruvian sample, the three indicators of TI showed a moderate intra-correlation. These results support building at least two constructs, TI and NTI.

As for cooperation with universities, most indicators displayed high variance and moderate-to-high intra-correlation, with some exceptions. This suggested a possible exclusion of some indicators from the UC construct in the PLS-SEM so that the corresponding country could have a clearly defined construct.

A. Measurement model

When analyzing the model hypotheses, PLS-SEM reference [46], [47], and the conclusions from the GH-biplot variance-covariance distribution analyzed previously, we built the path in two stages [49]. Table I summarizes the output of indicators retained for the LOCs and HOC. It displays that most indicators of information sources had a high variance extracted by the KA construct, confirming the results in the GH biplot. Information sources such as consultants and universities were left out since their loadings were less than the suggested reference [47] across the countries. For the overall analysis of the KA construct, virtually all the indicators were retained.

For the university cooperation construct, cooperating for training showed the lowest extracted variance. Thus, it was removed from the Colombian and Peruvian samples. Regarding these samples, cooperation for R&D and technical assistance showed a higher explained variance in the UC construct, and industrial design and engineering displayed a high variance only for the Peruvian sample. For the Ecuadorian firms, cooperation for training and other purposes displayed the highest variance extracted values.

Regarding TI, process innovation was removed since it was irrelevant to the construct in Colombia and Ecuador, as the GH-biplot results suggested. On the other hand, both indicators of NTI were relevant to the construct across the countries.

Regarding the IA construct, all the countries had low loading values for investment in information technology, technological transfer, equipment and machinery, training, and marketing activities in common. Conversely, only investment in internal R&D showed one of the highest extracted variances across all the countries. In addition, dedicating staff to R&D activities was relevant for the construct in Colombia and Peru, while investing in industrial design and engineering for Ecuador.

As for IE, Colombian and Ecuadorian SMEs explained the variance of KA better, unlike Peru, where the construct explained the variance of IA and KA similarly well. As for the overall sample, the indicators retained are like those in the individual models.

TABLE I
INDICATOR LOADINGS RETAINED OF THE CONSTRUCTS IN THE MODEL

LOC/ HOC	Variable	Colombia	Ecuador	Peru	Overall
KA	Customers	-	0.7	0.74	0.74
	Competitors	-	-	0.75	0.74
	Suppliers	-	-	-	0.75
	Internet	0.82	0.71	0.75	0.77
	Conferences	0.77	0.76	0.74	0.74
	Publications	0.82	0.78	0.72	0.75
	Other	0.77	0.72	-	-

UC	R&D	0.72	-	0.8	0.77
	Technical Assistance	0.88	-	0.59	0.68
	Training	-	0.68	-	-
	Industrial Design & Engineering	-	-	0.86	0.81
	Other	-	0.88	0.75	-
TI	Product	0.94	0.92	0.94	0.86
	Process	-	-	0.66	-
	% New Sales	0.76	0.85	0.82	0.89
NTI	Marketing	0.53	0.67	0.78	0.79
	Organization	0.92	0.88	0.83	0.82
IA	Internal R&D	0.7	0.76	0.86	0.42
	Industrial Design & Engineering	-	0.95	0.65	-
	R&D Staff	0.9	-	0.58	0.97
IE	*IA*	*0.59*	*0.39*	*0.77*	*0.53*
	KA	*0.89*	*0.95*	*0.7*	*0.92*

Note(s): The values highlighted in italics correspond to the indicators of the higher-order construct. For reference to abbreviations, consider UC: University cooperation, NTI: Non-technological innovation, TI: Technological innovation, IA: Innovation activities, KA: Knowledge acquisition, IE: Innovation efforts.

Table II shows the convergent validity indicators, suggesting that all LOCs yielded satisfactory levels of convergent validity in terms of average variance extracted (AVE) and ρ_C composite reliability (CR). Nonetheless, Cronbach's alpha coefficients (CA) were lower than the reference for most of the constructs across all the countries. Still, this coefficient is less precise in measuring reliability than CR and tends to yield lower values [46]. In terms of AVE, the model in the Ecuadorian and Colombian samples displayed better results. The overall model also reached convergent validity.

TABLE II
RELIABILITY AND VALIDITY STATISTICS OF THE CONSTRUCTS IN THE MODEL

Country	LOC/HOC	CA	CR	AVE
Colombia	IA	0.49	0.79	0.65
	KA	0.81	0.87	0.63
	UC	0.47	0.78	0.65
	NTI	0.27	0.71	0.56
	TI	0.64	0.84	0.72
	*IE**	*0.27*	*0.72*	*0.57*
Ecuador	IA	0.68	0.85	0.74
	KA	0.79	0.85	0.54
	UC	0.4	0.76	0.62
	NTI	0.39	0.76	0.61
	TI	0.74	0.88	0.79
	*IE**	*0.06*	*0.56*	*0.5*
Peru	IA	0.49	0.74	0.5
	KA	0.79	0.86	0.55
	UC	0.76	0.84	0.58
	NTI	0.45	0.78	0.65
	TI	0.73	0.85	0.66
	*IE**	*0.15*	*0.7*	*0.54*
Overall	IA	0.3	0.69	0.56
	KA	0.84	0.88	0.56
	UC	0.62	0.8	0.57
	NTI	0.45	0.78	0.64
	TI	0.69	0.87	0.76
	*IE**	*0.28*	*0.71*	*0.57*
Reference		≥ 0.7	≥ 0.7	≥ 0.5

Note(s): The values highlighted in italics correspond to the higher-order construct. For abbreviations reference, consider CA: Cronbach's alpha, CR: Composite reliability, AVE: Average variance extracted, UC: University cooperation, NTI: Non-technological innovation, TI: Technological innovation, IA: Innovation activities, KA: Knowledge acquisition, IE: Innovation efforts.

Table III displays the HTMT ratios, which suggest that discriminant validity was established in the model across the countries. However, we can observe that the IE construct in Ecuador was not empirically distinct from the structure of the TI construct, according to the HTMT criterion (> 0.90). But, when computing the average cross-loadings of each pair between the IE and NTI indicators in the Ecuadorian sample (0.1), and also the correlation between the two constructs (0.23), just as the HTMT(NTI, IA) and HTMT(NTI, KA) values less than 0.4, as criteria, we concluded non-relevant issues on discriminant validity, in general. However, the low loading value of IA (less than 0.4) as an indicator of IE in Ecuador (see Table I) could hinder the establishment of discriminant validity between IE and NTI.

TABLE III
DISCRIMINANT VALIDITY OF THE CONSTRUCTS IN THE MODEL, MEASURED THROUGH HETEROTRAIT-MONOTRAIT RATIO (HTMT)

Country	LOC	*IE*	UC	NTI	TI	IA
Colombia	UC	*0.66*				
	NTI	*0.54*	0.13			
	TI	*0.53*	0.23	0.1		
	IA		0.3	0.14	0.27	
	KA		0.31	0.37	0.25	0.23
Ecuador	UC	*0.87*				
	NTI	*1.2*	0.29			
	TI	*0.96*	0.06	0.31		
	IA		0.11	0.07	0.04	
	KA		0.24	0.39	0.35	0.08
Peru	UC	*0.56*				
	NTI	*0.69*	0.14			
	TI	*0.67*	0.17	0.73		
	IA		0.29	0.2	0.32	
	KA		0.12	0.27	0.17	0.15
Overall	UC	*0.38*				
	NTI	*0.83*	0.14			
	TI	*0.74*	0.16	0.53		
	IA		0.24	0.26	0.33	
	KA		0.18	0.52	0.42	0.27

Note(s): The values highlighted in italics correspond to the higher-order construct. For reference to abbreviations, consider UC: University cooperation, NTI: Non-technological innovation, TI: Technological innovation, IA: Innovation activities, KA: Knowledge acquisition, IE: Innovation efforts.

B. Structural model

In the second stage, we estimated the structural model [49], where the interaction term was added to the path. Table IV shows the coefficients, their 95% confidence interval, and the significance of the hypothesized model for each country.

We observed that IE had a significantly positive effect on NTI and TI across the countries. However, the average effects were more significant in the overall analysis, followed by the Ecuadorian sample, while Colombian and Peruvian firms yielded similar results. For all countries, the coefficient of IE was greater over TI than NTI. These outputs confirmed H1 and H2.

In addition, UC had a significant but irrelevant positive effect on TI across all countries except Ecuador. It was also greater in the Colombian sample, allowing us to reject H3 and accept H4 for all countries except Ecuador. Finally, the moderator effect of UC in the relationship between IE and the development of any innovation (NTI or TI) was not significant, leading us to reject H5 and H6.

TABLE IV
PATH COEFFICIENTS ESTIMATE AND 95% CONFIDENCE INTERVAL FOR EACH COUNTRY

Hypothesis	Colombia	Ecuador	Peru	Overall
H1: IE→NTI	0.17*** (0.11, 0.23)	0.22*** (0.15, 0.30)	0.17*** (0.11, 0.26)	0.31*** (0.28, 0.35)
H2: IE→TI	0.21*** (0.16, 0.26)	0.27*** (0.21, 0.36)	0.21*** (0.17, 0.28)	0.33*** (0.30, 0.36)
H3: UC→NTI	0.01 (-0.07, 0.11)	0.05 (-0.11, 0.19)	0.08* (-0.001, 0.16)	0.03 (-0.01, 0.09)
H4: UC→TI	0.11** (0.01, 0.21)	0.07 (-0.06, 0.16)	0.08* (0.01, 0.16)	0.05* (0.01, 0.10)
H5: IE:UC→NTI	-0.02 (-0.08, 0.05)	0.05 (-0.07, 0.25)	-0.03 (-0.10, 0.02)	-0.01 (-0.5, 0.04)
H6: IE:UC→TI	-0.02 (-0.08, 0.06)	-0.11 (-0.23, 0.01)	-0.01 (-0.05, 0.04)	0 (-0.05, 0.04)

Note(s): The significance of coefficients and confidence intervals (in parentheses) were estimated through bootstrapping. Significance codes: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$. For reference to abbreviations, consider UC: University cooperation, NTI: Non-technological innovation, TI: Technological innovation, IA: Innovation activities, KA: Knowledge acquisition, IE: Innovation efforts.

V. DISCUSSION

This study analyzed the potential moderator effect of university cooperation over the relationship between innovation efforts and innovation development among small and medium-sized manufacturers from emerging markets. Our results revealed that innovation efforts, measured through the performance of innovation activities and knowledge acquisition, positively affected the achievement of both types of innovation, similarly in Colombian, Ecuadorian and Peruvian manufacturing SMEs. The effect was slightly greater in the achievement of technological innovation [21].

However, our results showed that innovation efforts explained most of the variability of knowledge acquisition in Colombia and Ecuador, i.e., innovation efforts were higher when knowledge acquired was higher. These results support the importance of connections with knowledge centers as sources of knowledge acquisition since they are one of the predictors of innovation efforts [22]. In this sense, knowledge acquisition is one of the measurement dimensions of innovation efforts [23]. SMEs generally face limitations of knowledge and other resources [7], [32], especially in emerging economies, so it is not surprising that the innovative efforts of the companies studied placed greater emphasis on knowledge acquisition.

In this context, our results also revealed that the preferred knowledge acquisition came mainly from sources that involved low social interaction, such as Internet, conferences, trade fairs and publications. In this regard, external information sources were little appreciated by SMEs [20]. These results would reflect the lack of openness of Colombian and Ecuadorian SMEs regarding innovative efforts, limiting knowledge acquisition to information sources with low social interaction. This could restrict the firm's ability to make direct connections or reinforce others, such as with customers, competitors, and suppliers, which ends up hindering beneficial cooperative relationships [39], [52] and the firm's ability to perform continuous innovation [53], [54].

On the other hand, innovation efforts explained most of the variability of the innovation activities carried out by Peruvian SMEs, i.e., there was greater innovation effort when increasing investment in innovation activities, mainly in internal R&D, followed by industrial design engineering and R&D staff. It is important to note that, in general terms, the companies studied reported higher investment in equipment and machinery as an innovation activity [21]. However, this makes no difference in innovative efforts since R&D investment is one of the most important predictors of innovation efforts in SMEs [22] and one of the main characteristics of innovative firms, regardless of location [55].

Regarding the type of innovation developed by the companies studied, our results showed that more than 50% of Peruvian SMEs carried out non-technological innovations, unlike Colombia and Ecuador. This confirms the tendency of manufacturing companies in Peru towards this type of innovation [27], [37]. Notably, in this research, Peruvian SMEs also had the highest percentage of sales of new products, approximately 24%, significantly surpassing the results of Ecuador and Colombia. However, this direct relationship between the development of non-technological innovation and innovation sales could also be observed in Ecuador and Colombia, where organizational and marketing innovation was less common. Non-technological innovation facilitates technological innovation development and subsequently improves innovative performance based on revenue in the context of manufacturing SMEs in emerging markets [3].

In this sense, manufacturing SMEs in emerging markets prefer to maintain methods of management, marketing, operations and daily activities as they have traditionally done,

resulting in low development of non-technological innovation, as in our research [20]. However, the absence of non-technological innovation does not mean counteracting the development of new or significantly improved products, services, or processes. Instead, non-technological innovation can enhance such developments, either in the scope of innovation (e.g., new products/services for the market or the world) or in performance (e.g., higher percentage of sales, better market positioning, among others).

Our study found that university cooperation had a positive effect, although not relevant, on technological innovation development (process or product innovation) among Colombian and Peruvian companies, which led to a significant effect on the overall analysis of this type of innovation. However, there was no significant effect on performing organizational or marketing innovation in the countries studied. Since technological innovation mainly accounted for product innovation and product sales in our sample, these results for Colombia and Peru could point out cooperation with universities as an enhancer factor of product innovation performance [9], [20]. However, compared to results from other studies in similar contexts, the effect of university linkage on developing technological innovation has been less intense [56] in this study, highlighting the challenges that Latin American markets can pose for management theories in smaller businesses [10].

Notably, R&D and technical assistance accounted for most of the university cooperation among Colombian and Peruvian firms [57]. These results confirm the SMEs' characteristics regarding the lack of culture and resources to invest in R&D [9] and the need to supply these resources through beneficial cooperation to achieve innovation. However, the frequency of companies that reported cooperation with universities was low, regardless of the purpose of the relationship. In this context, cooperative relationships with universities are marked mainly by informal relationships for SMEs, implying that an interpersonal relationship must be established between universities and SMEs before formal cooperation [11], [39]. This would be a barrier for the companies studied in this research, whose profile prefers low social interaction concerning information acquisition. This feature seems common among SMEs concerning cooperative relationships, where the perception of cooperation barriers and benefits depends on the firm's trust in its counterpart [39].

This would reveal a limitation, beyond resources, to form cooperative relations with universities among SMEs, such as a lack of understanding about the benefits to be obtained from the relationship or a cost-based perception of the formalization of the relationship [39], as well as unknowing on how to access to the academia resources [9], [40]. In this sense, trust and, therefore, informal relationships seem to be an agent of change over these barriers [41]. Similarly, from the universities' point of view, relational governance, which is based on interpersonal relationships and trust, leads to a more contractual style that positively affects SME innovation as a cooperation output [58].

According to our results, cooperation with universities had no significant moderating effect on the relationship between innovation efforts and development. That is, the relationship between these dimensions was independent of cooperative relationships with universities among the companies studied. Although there are no studies that analyze university cooperation as a moderator between innovative efforts and their results, we could affirm in light of the literature that innovation results not only depend on external resources acquired by the company but also on the firms' capacity to make the most of them and transform them into valuable resources for innovation development, this is known as absorptive capacity [59]. There is a vast amount of literature that emphasizes the importance of this capacity among firms for boosting innovation performance and cooperative relationships [11], [59], especially for SMEs in emerging markets [56]. However, lack of absorptive capacity is more frequent in emerging markets, as their conditions reinforce barriers to developing absorptive capacity [60].

Finally, our results could reveal country-specific variations in the governance of companies and the quality of academic institutions. In this sense, within-region institutional variation among universities from emerging countries can promote differences in the outcome of university-SMEs cooperation [16].

VI. Theoretical and practical implications

Small-and-medium-sized manufacturers' efforts to achieve innovation may vary across countries in emerging markets, hindering the possibility of building a regional system [61]. Some SMEs focus on acquiring knowledge from external sources with low social interaction. On the other hand, others risk investing in research and development activities, proving to be more successful in developing innovation. Regarding innovative behavior, non-technological innovation has demonstrated to enhance technological innovation performance in emerging markets.

On the other hand, SMEs' limited resources and knowledge emphasize the need for academic cooperation. This relationship can benefit the firms and universities that can materialize what they have learned in classrooms by applying their knowledge to solve local problems in different segments. However, manufacturing SMEs in emerging markets are sensitive to relationships with academia, as they rely on interpersonal or informal relationships with a key player in universities to achieve this, resulting in a low number of manufacturers deciding to form this cooperative relationship. Barriers to forming relationships can be mitigated by relaxing procedures for creating relationships and socializing the

benefits of cooperation and willingness from companies to cooperate.

VII. Limitations and future research

This research presented limitations that could potentially reveal new results, such as the lack of a standard structure and organization in the innovation surveys conducted by the countries studied that belong to the same region. It is key that countries from the same region develop a standard questionnaire and agree on the collection time, allowing researchers to construct a standardized dataset that gathers the most information from all the countries and their realities in comparable and current periods.

Although this study's results revealed important relationships in companies' innovative behavior, longitudinal monitoring of this behavior could reveal complete scenarios. Likewise, this study could encourage future research on exploring the impact of academia in different instances of the innovation process in SMEs in emerging markets.

VIII. Conclusions

Our research explored empirically the relationship between innovation efforts and their innovation results, just as the potential moderator effect in this relationship, among small and medium-sized manufacturing firms in Colombia, Ecuador, and Peru. The results showed that innovation efforts had a positive impact on innovation development. For Ecuador and Colombia, knowledge acquisition was their main source of effort, namely low social interaction sources of knowledge, which could limit their ability to establish beneficial cooperative relationships. In contrast, Peruvian companies focused their innovation efforts on innovation activities, especially R&D investment. Additionally, it was observed that Peruvian companies had a greater propensity to undertake non-technological innovations and achieved higher sales of new products.

On the other hand, cooperation with universities was uncommon among the studied SMEs, and its effect was weak and limited to technological innovation development. Also, cooperation with universities did not moderate the relationship between innovation efforts and innovation outcomes. These findings evoke a discussion about the importance of the strength of the universities-SMEs relationship, firms' absorptive capacity and institutional differences in university cooperation in emerging market contexts.

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