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Analyzing the Medium-Low and Low-Technology Firms' Innovative Behavior in an Emerging Economy

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ABSTRACT **Objective.** Design a model that shows what factors favor the development of technological innovation in manufacturing companies of medium-low and low technological intensity. **Methodology.** A sample of 1106 manufacturing companies that participated in the innovation surveys in 2012 and 2015 was used, applying the partial structural equations approach and estimating the invariance between the two groups. **Results.** The results of this study from the structural model, which allow obtaining the positive and statistically significant coefficients, which allow empirically validating the hypotheses. **Conclusions.** It was evidenced that non-technological innovation, absorption capacity and technological acquisition favor technological innovation in companies with low technological intensity. This article confirms that manufacturing companies should guide efforts to improve their capacity for innovation.

KEY WORDS Innovation behavior, industry, technological change, Peru.

Análisis del comportamiento innovador de las empresas de tecnología media-baja y baja en una economía emergente

RESUMEN **Objetivo.** Diseñar un modelo que muestre qué factores favorecen el desarrollo de la innovación tecnológica en las empresas manufactureras de media-baja y baja intensidad tecnológica. **Metodología.** Se utilizó una muestra de 1106 empresas manufactureras que participaron en las encuestas de innovación en 2012 y 2015, aplicando el enfoque de ecuaciones estructurales parciales y estimando la invariancia entre los dos grupos. **Resultados.** Con los resultados del modelo estructural del estudio se obtienen los coeficientes positivos y estadísticamente significativos, lo que permite validar empíricamente las hipótesis. **Conclusiones.** Se evidenció que la innovación no tecnológica, la capacidad de absorción y la adquisición tecnológica favorecen la innovación tecnológica en las empresas con baja intensidad tecnológica. Este artículo confirma que las empresas manufactureras deben orientar sus esfuerzos a mejorar su capacidad de innovación.

PALABRAS CLAVE comportamiento de la innovación, industria, cambio tecnológico, Perú.

Análise do comportamento inovador de empresas de média-baixa e baixa tecnologia em uma economia emergente

RESUMO **Objetivo.** Desenhar um modelo que mostre quais são os fatores que favorecem o desenvolvimento da inovação tecnológica em empresas manufatureiras de média-baixa e baixa intensidade tecnológica. **Metodologia.** Foi utilizada uma amostra de 1106 empresas de manufatura que participaram das pesquisas sobre inovação em 2012 e 2015, aplicando a abordagem de equações estruturais parciais e estimando a invariância entre os dois grupos. **Resultados.** Com os resultados do modelo estrutural do estudo, obtêm-se os coeficientes positivos e estatisticamente significativos, o que permite validar empiricamente as hipóteses. **Conclusões.** Constatou-se que a inovação não tecnológica, a capacidade de absorção e a aquisição tecnológica favorecem a inovação tecnológica em empresas com baixa intensidade tecnológica. Este artigo confirma que as empresas de manufatura devem focar seus esforços na melhoria de sua capacidade de inovação.

PALAVRAS CHAVE comportamento da inovação, indústria, mudança tecnológica, Peru.

Introduction

Innovation has caught the attention of academia, governments and business managers alike. Academics would like to know what motivates companies to innovate. Governments seek to foment innovation because, according to Ahlstrom (2010), innovative firms generate economic growth and employment. Business managers are interested in innovation because it allows them to generate competitive advantages (Urbancova, 2013) and improve the performance of their companies (Jansen, Van Den Bosch and Volberda, 2006).

In the literature on innovation, most of the studies draw their data from developed countries and research high-intensity technology firms (Hervas-Oliver, Garrigos and Gil-Pechuan, 2011). The relationships between absorptive capacity and both technological innovation (Ali and Park, 2016) and organizational innovation (Chen and Chang, 2012) have also been analyzed. How organizational innovation mediates the relationship between absorptive capacity and technological innovation (Camisón and Villar-López, 2014) and how the acquisition of machinery, hardware and software improves innovation capability (Santamaría, Nieto and Barge-Gil, 2009) have been studied as well.

The first contribution of this study is that it analyzes the innovative behavior of manufacturing firms in Peru, an emerging Latin American economy. As Latin American economies face the double challenge of needing to keep growing while at the same time reducing levels of poverty, understanding and evaluating the way that Latin American firms develop innovation capacities is critical (Olavarrieta and Villena, 2014). A second contribution is that this study focuses its attention on the relationship between non-technological and technological innovation. Most studies have analyzed how organizational innovation is related to technological innovation (Camisón and Villar-López, 2014), but these tend not to take into account marketing innovation, which is one of the key elements of non-technological innovation.

The third contribution is methodological: since most of the aforementioned studies are cross-sectional studies; for this research, a repeated cross-sectional design was applied using the database of two national surveys of innovation in Peruvian industry corresponding to the years 2012 and 2015. Therefore, it was possible to measure invariance, thus providing an opportunity to verify that the averages and compound variances were equal in the two groups. The groups were then compared to identify the change in the innovative behavior of medium-low- and low-technology firms (Mathews, 2017). This approach enabled a response to the research question: How did Peruvian manufacturing companies change their innovative behavior between 2012 and 2015?

Based on this question, the approach aims to explain five relationships, namely: (i) absorptive capacity and technological innovation; (ii) absorptive capacity and non-technological innovation; (iii) non-technological innovation and technological innovation; (iv) the acquisition of machinery, hardware and software and technological innovation; and (v) how non-technological innovation mediates the relationship between absorptive capacity and technological innovation.

It is worth noting that the context of this research is the Peruvian economy, which has shown sustained growth (Scott and Chaston, 2012) making it one of the fastest-growing economies in the region before the commodities crisis in 2014 (Brenes et al., 2016), which forced companies to face a reality with the following characteristics: (i) a government that promotes open innovation (Ramírez and García-Peñalvo, 2018) and exports (Salas and Deng, 2017); (ii) companies that invest very little in research and development and prefer to innovate by buying machinery, hardware and software (Tello, 2017); (iii) companies that face informal competition (Heredia et al., 2017) and have problems obtaining financial resources to promote innovation (Pérez et al., 2018).

The unit of analysis is Peruvian manufacturing companies that participated in the national innovation surveys of the manufacturing industry in the years 2012 and 2015 and that presented a medium-low and low-technological intensity.

The structure of the present study is as follows: first, the theoretical framework and the hypotheses are presented; second, the methodology is shown; third, the results are given; and finally, the

discussion, conclusions, limitations and suggestions for future research are presented.

Theoretical Background

This theoretical background begins by defining the key characteristics of medium-low and low-technology firms, absorptive capacity, and acquisition by medium-low and low-technology firms and proceeds to generate the study's hypotheses for the five relationships outlined above.

As shown by the fourth European Community Innovation Survey (CIS4), which analyzes medium-low and low-technology firms, these two firm types tend to be characterized by innovations in processes, organization or marketing and have a high dependence on an external supply of technologies in the form of machinery, hardware and software (Heidenreich, 2009). In these firms, the role of formal and informal knowledge is important, as it has been discovered that they innovate beyond activities directly related to research and development (Sciascia et al., 2014; Santamaría, Nieto and Barge-Gil, 2009).

Absorptive capacity (AC) is the firm's ability to recognize the value of new, external information in order to assimilate it and apply it for commercial purposes (Cohen and Levinthal, 1990). AC has had a major impact on organizational research and has attracted the attention of a large number of researchers, as it is the capability that most influences the development of competitive advantages and firm performance (Volberda, Foss and Lyles, 2010).

Arbussa and Coenders (2007) contend that the acquisition of machinery, equipment and hardware is one of the activities carried out by firms to improve their innovation capability. Moreover, Frank et al. (2016) researched innovation in Brazil and pointed out that the purchase of machinery and equipment had a positive effect on the innovation capabilities of those firms.

Absorptive capacity and technological innovation

The influence of AC on innovation has been the subject of several studies. Cohen and Levinthal (1990) argued that AC is very important in the firm's innovation process, since it increases in speed and frequency as more innovations occur.

Innovations are based on the firm's knowledge (Kim and Kogut, 1996), and Caloghirou, Kastelli and Tsakanikas (2004) investigated the extent to which firms' existing internal capabilities and their interaction with external information sources affect their level of innovation. In addition, Wang and Han (2011) conducted a study of small and medium-sized enterprises in China that validated the hypothesis that knowledge properties and AC are two inseparable determinants of innovation performance; they also indicated that AC moderates the relationship between knowledge properties and innovation performance. Finally, Ali and Park (2016) developed a study of 195 Korean firms of various sizes and sectors, in which they confirmed that AC is crucial to the organization's innovation and performance.

In this sense, the following hypothesis is proposed:

Hypothesis 1: Absorptive capacity is related to technological innovation in medium-low and low-technology firms.

Absorptive capacity and non-technological innovation

Arguably, firms facing competitive environments should consider knowledge to be one of their most valuable resources (Liao and Wu, 2010). The consolidation of acquired knowledge is determined by AC development (Sun and Anderson, 2010).

Firms with higher AC have been more likely to carry out product, process, organizational and marketing innovations (Schmidt and Rammer, 2006). Along the same line, Calero-Medina and Noyons (2008) found that the relationship between AC and organizational innovation has not been given much attention. In addition, Chen and Chang (2012) found that the greater the firm's AC, the greater the degree of organizational innovation.

On the basis of the above, the following hypothesis is proposed:

Hypothesis 2: Absorptive capacity is related to non-technological innovation in medium-low and low-technology firms.

Technological and non-technological innovation

The relationship between technological and non-technological innovation has caught the attention of academics. Schmidt and Rammer (2007) argue that innovation studies have focused on product and process innovations, i.e., technological innovation, yet firms also engage in other activities that lead them to develop organizational and marketing innovations. When analyzing Turkish manufacturing firms, Gunday et al. (2011) found that higher levels of organizational innovations favor the development of product and process innovations and that higher levels of marketing innovation favor the development of product innovations.

Likewise, Mothe and Uyen (2012) point out that marketing and organizational innovations significantly increase the propensity to develop technological innovations. Along these lines, Camisón and Villar-López (2014) have shown that organizational innovation favors the development of firms' technological innovation capabilities.

More recently, Geldes, Felzensztein and Palacios-Fenech (2017) have focused on deepening the knowledge of the interactions between non-technological and technological innovation and on how both types of innovation favor firm performance.

On the basis of the above, the following hypothesis is proposed:

Hypothesis 3: Technological innovation is related to non-technological innovation in medium-low and low-technology firms.

Technological acquisition and technological innovation

Ahuja and Katila (2001) have argued that it is important to clarify that, in order to increase innovation, it is not enough only to acquire technology but also to evaluate whether its impact will be favorable or not for the development of future innovations. The benefits that can be received will depend on the type of knowledge that will be offered to the acquiring firm.

Calantone, Cavusgil and Zhao (2002) determined that "innovative capacity is one of the most important determinants of the firm's performance" (p. 516). The acquisition of machinery, hardware and software enhances a firm's ability to innovate, and, in turn, this ability will improve the firm's performance. Potters (2009) stated that the purchase of machinery and equipment favors the implementation of new or improved products or processes.

In addition, Santamaría, Nieto and Barge-Gil (2009) pointed out that not only are research and development (R&D) activities sources of innovation for the firm but other activities, such as the knowledge and experience acquired through the use of advanced machinery and tools constitute a source of innovation in medium-low and low-technology firms.

In addition, Zuniga and Crespi (2013) indicated that innovation strategies consist of investment in R&D, the acquisition of technology already on the market through R&D contracting, technology and licensing knowledge, contracting technical and engineering services and acquiring machinery and equipment.

The following hypothesis is therefore proposed:

Hypothesis 4: The acquisition of machinery, hardware and software is related to technological innovation in medium-low and low-technology firms.

The mediation of non-technological innovation in the relationship between absorptive capacity and technological innovation

The extant literature indicates that non-technological innovations and technological innovations have been studied both independently and in the way they relate to each other. Schmidt and Rammer (2007) analyzed the effects of non-

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technological innovations (organizational and marketing innovations) and compared them with the effects of technological innovations. Their results show that technological and non-technological innovations are closely related; thus, it can be said that marketing innovations can coincide with product innovations or that organizational innovations often introduce new technological innovations into processes.

In addition, Battisti and Stoneman (2010) noted that innovations can be placed into two broad, complementary categories: organizational and technological, which cannot act as substitutes one for the other. Also, Camisón and Villar-López (2014) conducted research on innovation and confirmed that organizational innovation favors the development of technological innovations and that both types help the firm to improve its performance.

Moreover, it should also be noted that Min, Ling and Piew (2015) analyzed how organizational innovation mediated the relationship between AC and technological innovation. Recently, Del Carpio and Miralles (2018) found that non-technological innovation mediated the relationship between AC and technological innovation.

In view of the above, the following hypothesis is proposed:

Hypothesis 5: Non-technological innovation mediates in the relationship between absorptive capacity and technological innovation in medium-low and low-technology firms.

Methodology

The present study is based on data obtained from two different waves of a national innovation survey of the Peruvian manufacturing industry carried out in 2012 and again in 2015. The Instituto Nacional de Estadísticas e Informática —INEI— collected the data. INEI surveyed Peruvian manufacturing firms using a questionnaire developed according to the Bogotá Manual, which is based on the Oslo Manual.

INEI conducted the first Peruvian innovation survey in 2012, collecting information for the period

2009-2011 from a representative sample of 1220 large, medium and small firms from different Peruvian regions. From this database, 856 medium-low and low-technology firms were selected for the present research. Meanwhile, from the 2015 innovation survey, the information gathered belongs to the period 2012-2014 and consisted of a representative sample of 1452 large, medium and small firms from different regions. From this database, 1106 medium-low and low-technology firms were considered for this study.

Figure 1 shows the conceptual model of the relationship between the four constructs: technological innovation, non-technological innovation, absorptive capacity and technological acquisition.
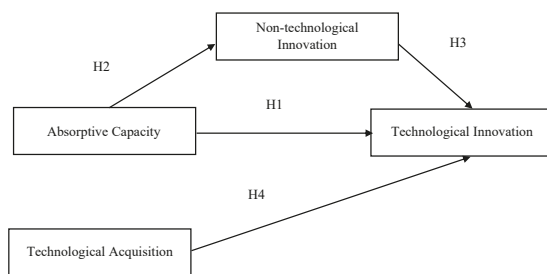

Figure 1. Proposed model. Source: author's own elaboration.

In this research, the dependent variable is technological innovation, which is composed of two dimensions: product innovation and process innovation (Gronum, Verreynne and Kastelle, 2012). Product innovation is the result of the sum of the dichotomous answers to the question of whether or not the firm managed to introduce to the market to: a new product, a new service, a significantly improved product or a significantly improved service. Process innovation is the result of the sum of the dichotomous answers to the question of whether or not the following were introduced: new processes or significantly improved processes.

For this study, three independent variables have been considered. Firstly, non-technological innovation is used. Following the Gronum, Verreynne and Kastelle (2012) approach, non-technological innovation has two dimensions: organizational innovation and marketing innovation. Organizational innovation is measured as the sum of the dichotomous answers to three

questions related to the activities carried out by the firm: new business practices, new methods of organizing work and new methods of organizing external relations with other firms or public institutions. Marketing innovation is measured as the sum of the dichotomous answers to four questions that are related to the following items: significant changes in the design or packaging of the good or service, new means or techniques of product promotion, new methods for product positioning in the market or sales channels and new methods of pricing goods or services.

Secondly, AC is calculated on the basis of three variables: expenditure on research, training for innovation and the R&D department. The first two variables were transformed by applying logarithm base 10, and the last one is a dichotomous variable. Thirdly, technological acquisition is made up of the following variables: machinery investment, hardware investment and software investment, all transformed by applying logarithm base 10.

The firm size and firm age can influence technological innovation. The firm size (expressed as a logarithm) is measured by the number of employees (Schoenmakers and Duysters, 2006; Laursen and Salter, 2006), and the firm age is measured by the number of years (expressed as a logarithm) from its foundation to the year in which the firm data were recorded (Thornhill, 2006).

SMARTPLS 3 software, which applies the partial structural equation estimation model in two steps, according to Chin, Marcolin and Newsted (2003), was used. First, the measurement model is estimated when determining the relationship between the indicators and the latent construct. Second, the structural model, in which the relationships between the constructs are obtained through the coefficients and the level of significance, is estimated. Hair et al. (2019) stated that SMARTPLS should be applied when the data is secondary and when the data demonstrate a lack of normality; the data for this study met both of these criteria.

Table 2 shows the outer loadings of the constructs for the years 2012 and 2015, respectively.

Results

The results that were obtained using descriptive statistics, the measurement model, the structural model, mediation analysis, control variables, invariance measurement and multi-group analysis are shown below.

Table 1 shows firm participation for the years 2012 and 2015, respectively, according to their size (the number of employees), their age as measured from the start of operations (before 1975, old; between 1975 and 1992, mature; and from 1992 onwards, young) and their technological intensity.

Table 1. Description of manufacturing enterprises 2012 and 2015

	2012	2015
Firm size		
Small (≤50 employees)	478	390
Medium (>50 and ≤250 employees)	190	452
Large (>250 employees)	188	264
Total	856	1106
Firm Age		
Old (over 36 years old)	209	173
Moderate (19 and 36 years old)	203	324
Young (under 19 years old)	444	609
Total	856	1106
Technological intensity		
Low	505	706
Medium-low	351	400
Total	856	1106

Source: author's own elaboration.

As can be seen, all loads are greater than 0.5, so the constructs must remain in the model.

Table 2. Outer loading on the constructs (models 2012 and 2015)

Variables	Technological acquisition	Absorptive capacity	Technological innovation	Non-technological innovation
2012				
ACAP1		0.839		
ACAP2		0.807		
ACAP3		0.693		
INNO_COM				0.899
INNO_ORG				0.915
INNO_PROC			0.884	
INNO_PROD			0.878	
TECH1	0.790			
TECH2	0.812			
TECH3	0.761			
2015				
ACAP1		0.876		
ACAP2		0.779		
ACAP3		0.622		
INNO_COM				0.870
INNO_ORG				0.873
INNO_PROC			0.847	
INNO_PROD			0.876	
TECH1	0.825			
TECH2	0.772			
TECH3	0.708			

Source: author's own elaboration.

Table 3 shows the reliability and validity indicators for both years (2012 and 2015). It can be seen that for the Cronbach alpha (CA), the constructs have a value above 0.5. With respect to composite reliability (CR), all constructs have values greater than 0.7; the average variance extracted (AVE) is above 0.5. In addition, it can be seen that, with regard to multicollinearity, the variance inflation factor (VIF) is controlled for values of less than 5. The coefficient of determination (R^2) for the relationship between absorptive capacity and non-technological innovation is 0.556 (for 2012) and 0.409 (for 2015), and for the relationship between the following independent variables: AC, non-technological innovation and technological acquisition; and the dependent variable: technological innovation, the coefficient of determination is 0.253 (for 2012) and 0.187 (for 2015). According to Hair Jr et al. (2019), coefficient of determination values of 0.50 and 0.25 are considered moderate and weak, respectively. Based on the results of the indicators, it is possible to carry out the structural model.

Table 3. Reliability and validity indicators for 2012 and 2015

Latent variable	2012			2015		
	CA	CR	AVE	CA	CR	AVE
Technological innovation	0.713	0.874	0.777	0.654	0.852	0.742
Non-technological innovation	0.785	0.903	0.823	0.683	0.863	0.759
Absorptive capacity	0.688	0.825	0.612	0.651	0.807	0.588
Technological acquisition	0.7	0.831	0.621	0.671	0.813	0.593
Reference values	**›0.7**	**›0.7**	**›0.5**	›0.7	›0.7	›0.5

Source: author's own elaboration.

Table 4 shows that all variables achieve discriminant validity following the criteria of Fornell and Larcker (1981).

Table 4. Discriminant validity of 2012 and 2015

Variables	Absorptive capacity	Non-technological innovation	Technological innovation	Technological acquisition
2012				
Absorptive capacity	**0.783**			
Non-technological innovation	0.501	**0.907**		
Technological innovation	0.584	0.638	**0.881**	
Technological acquisition	0.564	0.542	0.617	**0.789**
2015				
Absorptive capacity	**0.767**			
Non-technological innovation	0.432	**0.871**		
Technological innovation	0.497	0.558	**0.861**	
Technological acquisition	0.48	0.361	0.403	**0.771**

Note: Fornell-Larcker criterion: Diagonal elements (in bold) are the square root of the variance shared between constructs and their measures (AVE). For discriminant validity, the square root AVE (in bold) is greater than the correlations between the other latent variables.

Source: author's own elaboration.

After evaluating the measurement models, the structural model was estimated.

Table 5 shows the coefficients and t-value for each model's construct for the years 2012 and 2015. To generate statistical significance in the hypotheses, according to Hair Jr et al. (2014), the bootstrapping technique was used, with 4000 samples.

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Table 5. Results of the structural model 2012 and 2015

	2012		2015	
Paths	β	t-value	B	t-value
ACAP->IT	0.257**	7.502	0.277**	8.652
ACAP->INT	0.501**	18.09	0.433**	14.833
INT->IT	0.356**	10.919	0.393**	12.453
TECH->IT	0.312**	8.837	0.148**	5.155

Note: n=856; Bootstrapping 4000 samples; β= Standardized Coefficients; **p<0.05.

Source: author's own elaboration.

The goodness of fit index (GoF index) was used to verify the model fit (Tenenhaus et al., 2005). The GoF index ranges between the values of 0 and 1. Although there is no minimum threshold, a value greater than 0.31 is recommended (Camisón and Villar-López, 2014). For the 2012 model, the GoF index shows a value of 0.53 and, for 2015 model, 0.45. In both cases the indices are higher than the minimum recommended to guarantee the model fit.

The analysis of the coefficients of the structural models for the years 2012 and 2015, shown in Table 5, allows for the empirical verification of the following hypotheses: for hypothesis 1 ("There is a positive and statistically significant relationship between AC and technological innovation"), it can be stated that the results coincide with those obtained in the studies carried out by Rangus and Slavec (2017) and Ali and Park (2017), which indicate that firms showing a higher level of AC at the same time show higher levels of product and process innovation capability.

With regard to hypothesis 2 ("There is a positive and statistically significant relationship between AC and non-technological innovation"), it can be specified that the results are in line with the study by Chen and Chang (2012).

Regarding hypothesis 3 ("There is a positive and statistically significant relationship between non-technological innovation and technological innovation"), it should be pointed out that, unlike the study by Camisón and Villar-López (2014), in which it was concluded that organizational innovation develops firm technological innovation

capability, this study considers non-technological innovation, which includes not only organizational but also marketing innovation.

With respect to hypothesis 4 ("There is a positive and statistically significant relationship between the acquisition of machinery, hardware and software and technological innovation"), it can be concluded that it corroborates what was pointed out by Tello (2017), who argued that Peruvian manufacturing firms prefer to innovate by buying machinery, hardware and software.

When analyzing non-technological innovation, certain steps are evaluated to confirm whether or not it is a mediating variable and, if so, whether total or partial mediation is present. According to Hair Jr et al. (2014), mediation refers to a situation in which a mediating variable in some form absorbs the effect of an exogenous construct (with independent variables) in an endogenous construct (with a dependent variable) in the PLS path model.

Table 6 shows the explained variance assessment (VAF) and determines to what extent the mediation process explains the variance of the dependent variable. The rule is that, if the VAF is less than 20 %, one must conclude that there is no mediation; a situation where the VAF is greater than 20 % and less than 80 % could be characterized as a typical partial mediation (Hair Jr et al., 2016), while a VAF above 80 % indicates complete mediation.

As noted, Table 6 shows that non-technological innovation mediates the relationship between AC and technological innovation. The analysis of the

variance indicator for the 2012 model is 40.97 %, and, for 2015, the indicator is 38 %. Therefore, in both cases, non-technological innovation partially mediates the relationship between AC and technological innovation.

This result is in line with the findings of Min, Ling and Tan (2016), who found that organizational

innovation partially mediates the relationship between AC and technological innovation. The present model shows that not only to organizational innovation but also to marketing innovation as a component of non-technological innovation partially mediates this relationship.

Table 6. Mediation outcome for 2012 and 2015

	2012				2015			
Relation	Indirect effect	Direct effect	Total effect	VAF (%)	Indirect effect	Direct effect	Total effect	VAF (%)
ACAP›INT›IT	0.178	0.257	0.435	40.97 %	0.170	0.277	0.447	38 %
	(‹0.001)	(‹0.001)	(‹0.001)		(‹0.001)	(‹0.001)	(‹0.001)	

Source: author's own elaboration.

Table 7 shows the coefficients, standard deviations and p-values of the control variables for the years 2012 and 2015, respectively.

Table 7. Mediation outcome for 2012 and 2015

	2012			2015		
Control Variables	Coefficient	Standard dev.	P-value	Coefficient	Standard dev.	P-value
Firm size	-0.07	0.029	0.014	-0.065	0.024	0.007
Firm age	0.022	0.026	0.389	-0.001	0.023	0.98

Source: author's own elaboration.

From Table 7, it can be seen that the firm size has a small, negative and statistically significant coefficient. The literature points to a positive relationship between firm size and innovation (Zuniga and Crespi, 2013). However, Benavente (2006) argues that, in some cases, factors other than size, such as demand pressure, encourage firms to innovate.

In the case of the firm age, the coefficients are neither significant nor contradictory. The literature shows mixed results. Nieto, Santamaría and Fernández (2015) point out that mature firms should be more prone to innovate because of the experience they have acquired, but Cucculelli (2018) states that a negative relationship is questionable,

indicating that young firms tend to be innovative and assume greater risks.

The invariance of the composite models should be measured before comparing the groups used in the 2012 and 2015 models. As SMARTPLS software was used, Henseler, Ringle and Sarstedt (2015) recommend using the MICOM ("measurement invariance of composite models") procedure.

The MICOM procedure requires three steps to be carried out. The three steps are as follows: (i) configurable variance, (ii) compositional variance and equality of mean values and (iii) composite variances. Step (i) does not require statistical testing, only the verification that the data have been treated identically for both groups. Step (ii) involves

performing the permutation test. If the permutation test reveals that the correlation c (the average of the correlation obtained by permutation) is not significantly different from (i), then compositional invariance is established. In this study, 5000 permutations were carried out. Step (iii) assesses the equality of the mean values and composite variances. If the statistical test determines that the mean values and composite variances are not significantly different, then the equality of the mean values and composite variances is established.

As shown in Table 8, in both cases, the null hypothesis is rejected, so that the averages and variances of the 2012 firms showed significant differences from those of the 2015 firms.

Table 8. MICOM model results

Constructo (Step 2)	c-value (=1)	95 % confidence interval	Compositional invariance?
ACAP	0.999	[0.997; 1.000]	Yes
TECH	0.999	[0.995; 1.000]	Yes
INT	1.000	[0.999; 1.000]	Yes
IT	1.000	[0.999; 1.000]	Yes
Constructo (Step 3a)	Difference of the mean value of the construct (=0)	95 % confidence interval	Equal average value?
ACAP	0	[-0.092; 0.091]	Yes
TECH	-0.001	[-0.089; 0.090]	Yes
INT	-0.001	[-0.090; 0.089]	Yes
IT	-0.001	[-0.092; 0.089]	Yes
Constructo (Step 3b)	Logarithm of the variance ratio of the construct (=0)	95 % confidence interval	Equal variance?
ACAP	-0.001	[-0.176; 0.170]	Yes
TECH	-0.002	[-0.174; 0.171]	Yes
INT	-0.002	[-0.128; 0.124]	Yes
IT	-0.001	[-0.131; 0.140]	Yes

Source: author's own elaboration.

In conclusion, the results obtained, after applying the procedure for measuring invariance, conclude that the invariance is complete and, therefore, it is possible to proceed with the analysis of the two groups.

Multi-group analysis was conducted to determine the heterogeneity of the firms' innovative behavior in 2012 and 2015. A total of 2000 permutations were used for greater robustness of the results. As shown in Table 9 and according to Chin and Dibbern (2010), two t-tests are carried out. The first t-test assumes that the variances are equal and the t-parametric (EV) indicator is obtained. The second t-test assumes that the variances are different and the t-parametric indicator (NEV) is obtained. After applying the tests, it can be seen that the results are similar.

Table 9. Multi-group comparison test results

Relation	Path (2012)	Path (2015)	Diff (2012-2015)	t-parametric (EV)	t-parametric (NEV)	Permutation P-val	Significance
ACAP->IT	0.257	0.277	0.020	0.422	0.424	0.040	No
ACAP->INT	0.501	0.433	0.068	1.713*	1.754*	0.664	Yes
INT->IT	0.356	0.393	0.037	0.793	0.803	0.789	No
TECH->IT	0.312	0.148	0.164	3.719***	3.694***	0.001	Yes

Note: *significant at 0.1 (t distribution of 2 tails); **significant at 0.05 (t distribution of 2 tails); ***significant at 0.01 (t distribution of 2 tails).

Source: author's own elaboration.

As shown in Table 9, when comparing the coefficients of the models corresponding to the years 2012 and 2015, the relationships between AC and technological innovation and between non-technological innovation and technological innovation remained constant. This situation was not evident for the relationship between AC and non-technological innovation or for the relationship between the acquisition of machinery, hardware and software and technological innovation. In the latter two cases, the firms that participated in the 2012 survey made greater efforts to develop higher levels of AC and invested more resources acquiring machinery, hardware and software, and, in this way, improved their innovation capability.

Conclusions

This research work focuses on understanding the changes between the differences in innovative behavior of Peruvian manufacturing medium-low and low-technology firms between 2012 and 2015. Initially, the firms that participated in the 2012 innovation survey developed higher levels of absorptive capacity and increased expenditure of resources for the acquisition of machinery, hardware and software compared to those firms in the sample of 2015. Although this initial perspective could seem contradictory to the main assumptions of the model, an overall study of the results exhibits new perspectives on the evolution of innovative behavior in medium-low and low-technology firms.

The main point in this discussion starts from the evidence that the mediation effect of non-technological innovation in the relationship between absorptive capacity and technological innovation appears in the two samples. In both samples, the effect is very similar (Table 6) and shows that it is necessary to develop non-technological innovation to favor technological innovation. This work results show that this effect has not changed in two different periods. Although firms increased considerably their efforts on digital transformation this mediation effect has not reduced its importance. This behavior could suggest that the effect of non-technological innovation in technological innovation is something permanent and that opportunities in technological innovation either could come from or can be favored by non-technological innovation efforts.

Deepening the analysis of the models for each sample, two path present significant differences between the sample of 2012 and the sample of 2015. On the one side the influence of absorptive capacity on technological innovation is lower in the sample of 2015 (0.433) than in sample of 2012 (0.501). This result means that technological innovation depends less on a firms' absorptive capacity for medium-low and low-technology firms in 2015 than for firms in 2012. Interestingly, this result can suggest that low-technological intensity firms have internalized some practices that are less dependent of firms' absorptive capacity and proposes to explore for new factors that can influence technological innovation.

On the other hand, the path from technological acquisition to technological innovation is lower in the sample of 2015 (0.148) than in the sample of 2012 (0.312). Taking into account the increasing effort of digital transformation of all firms, the reduction on the effect of technological acquisition into technological innovation suggests a delay on the effect of new equipment and hardware on technological innovation. Also, taking into consideration the persistence of the mediating effect of non-technological innovation between absorptive capacity and technological innovation, this result suggests that acquisition of new equipment and hardware has to be accompanied of organizational and marketing changes that could mediate in the effects on technological innovation; which has been related to the commoditization of information technologies (Carr, 2003).

This research work intended to contribute to a better understanding of innovation efforts in manufacturing medium-low and low-technology firms, with focused attention on Peruvian firms. In this vein, this research work aims to contribute to this understanding by shedding some new light to the relationship of absorptive capacity, non-technological innovation and technological acquisition on technological innovation. The study's outcomes suggest taking into consideration the persistence of the mediating effect of non-technological innovation between absorptive capacity and technological innovation, to be aware of new factors that could complement absorptive capacity, and the commoditization of the digitalization efforts of firms.

From an academic perspective, this research proposes new challenges regarding those factors or variables that can help to understand how technological or non-technological innovation can be developed in medium-low and low-technology firms. This adds to recent perspectives where organization learning has been used to understand how ERP implementation affects organizational performance in a context of digital transformation and where the impact of technology is found to have many different facets when it is adopted by small firms (Riverola and Miralles, 2016).

The development of this study makes it possible to identify some practical implications. Thus, the managers of medium-low and low-technology firms should encourage an increase in absorptive capacity and other factors with the intention of developing more technological innovations, i.e. product or process innovation. Also medium-low and low-technology firms should allocate resources for the acquisition of machinery, hardware and software, and include those organizational changes that can accompany the implementation of new equipment to participate in developing technological innovations. Overall, decision-makers in low-technological intensity firms should consider investment efforts in new technology as an organizational change challenge and take into consideration all impacts that can affect the overall organization.

The present study is not without limitations. First is that all samples were obtained from a single source, namely the databases of the national innovation surveys of the manufacturing industry in Peru. It is suggested that future research be carried out in other Latin American economies in order to make comparisons and generalizations of the relationships that can be established between the constructs.

Second is the use of samples that include all industrial sectors with lower technological intensity. It would be very valuable to develop research in specific industries, such as the food industry, the garment industry or basic chemical products, to identify what activities firms implement to develop technological innovation in each industry.

Third is how absorptive capacity was measured. Here the criteria considered by Escribano, Fosfuri and Tribó (2009) were used and adapted to the database of the INEI of Peru. Rather, it has been suggested that questionnaires be developed to better measure the absorptive capacity construct (Fernhaber and Patel, 2012; Tortoriello, 2015).

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