Analyzing technological innovation in low and medium-low tech peruvian manufacturing companies

Análisis de la innovación tecnológica en las empresas peruanas de manufactura de baja y media baja intensidad tecnológica

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Abstract

Greater attention should be given to low- and medium-low- tech companies in emerging countries because they contribute a significant share of GDP and employment in their economies. However, innovation practices of these companies have not taken yet the attention of innovation scholars. This article proposes a model to study how absorptive capacity, perceived impact of information sources and expenditure in acquisition of technology are associated with technological innovation practices in Peruvian low- and medium-low-tech manufacturing companies. A sample of 856 manufacturing companies of low- and medium-low- tech was obtained from the first National Survey of Innovation in the Manufacturing Industry carried out in 2012. A SEM model is proposed and has been analyzed using a partial least squares approach. Our study reveals that absorptive capacity is associated to improve technological innovation, that perceived impact of information sources are important for absorptive capacity and that greater importance should be given to the acquisition of technology: machinery, hardware and software.

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Resumen

Debe prestarse mayor atención a las empresas de baja y media baja intensidad tecnológica en los países emergentes porque contribuyen con una parte importante del PBI y el empleo en sus economías. Sin embargo, las prácticas de innovación de estas empresas no han llamado la atención de los investigadores en innovación. Este artículo propone un modelo para estudiar cómo la capacidad de absorción, el impacto percibido de las fuentes de información y los gastos en la adquisición de tecnología están asociados con las prácticas de innovación tecnológica en las empresas manufactureras peruanas de baja y media baja intensidad tecnológica. Una muestra de 856 empresas manufactureras de baja y mediana-baja tecnología se obtuvo de la primera encuesta nacional de innovación en la industria manufacturera realizada en 2012. Se propone un modelo SEM que ha sido analizado utilizando un enfoque de mínimos cuadrados parciales. Nuestro estudio revela que la capacidad de absorción está asociada a la mejora de la innovación tecnológica, que el impacto percibido de las fuentes de información es importante para la capacidad de absorción y que se debe dar mayor importancia a la adquisición de tecnología: maquinaria, hardware y software.

Código JEL: O30, O32, O55.
Palabras clave: capacidad de absorción; fuentes de información; adquisición de tecnología; innovación tecnológica; intensidad tecnológica Perú.

Introduction

The extant literature tends to focus on high tech manufacturing firms to understand the relationship between R&D practices and innovation outcomes (Santamaría, Nieto, & Barge-Gil, 2009). However, it is equally important to analyze the behavior of low- and medium-low- tech enterprises, because of their contribution to economic growth, the number of jobs they provide and the innovations they introduce to the market (Heidenreich, 2008). Therefore, low-tech companies are also fundamental for economic development. When measured in terms of results or invested capital, low- and medium-low- tech companies dominate the economies of highly developed and developing countries, and provide more than ninety percent of the gross product of the European Union, the United States, and Japan (Robertson, Smith & Von Tunzelmann, 2009). In addition, Krammer (2016) points out that "some of these mature industries still exhibit significant sales of technology among leading firms, but more importantly, they form the backbone of all economies in the world" (p.529) and provides important lessons for developed and developing country policymakers for both, where a significant share of GDP and employment is provided by mature industries.

The industries of low- and medium-low- tech are characterized by innovation and incremental adoption, that is to say, a constant improvement of their products according to the market demand; often focusing on production efficiency, product differentiation and marketing (Von Tunzelmann & Acha, 2005). According to the OECD (2011), the manufacturing companies can be classified into low and medium-low technological intensity, we found these companies in economic activities, such as food and beverages, textiles, leather and footwear, printing and publishing, chemicals excluding pharmaceuticals, electrical machinery and apparatus, among others.

Here we focus on the Peruvian manufacturing companies of low- and medium-low- tech (LML). In this way, we contribute the literature by recognizing that for the LML companies, the traditional approach cannot explain the product and process innovations (Trott and Simms, 2017). A further contribution is by adding to innovation studies in Latin American countries (Zuniga & Crespi, 2013) and in context of emerging economies (Geldes, Felzensztein, & Palacios-Fenech, 2017).

Fifteen years ago the Peruvian economy showed sustained growth (Scott & Chaston, 2012), which made it one of the fastest growing economies in the region. Then came the crisis of commodities (Brenes, Camacho, Ciravegna & Pichardo, 2016), forcing companies to face a change of reality, where the government encouraged more open innovation (Ramírez & García-Peñalvo 2018) and exports (Salas & Deng, 2017). However, Peruvian companies tend to invest very little in research and development, preferring to innovate by buying machinery, hardware and software (Tello, 2017). In Peru, many companies also face informal competition (Heredia, Flores, Geldes & Heredia, 2017) and have problems getting financial resources to promote innovation (Pérez, Geldes, Kunc, & Flores, 2018).

The study proposes to show how the absorptive capacity of low- and medium-low- tech companies are related to the technological innovation, and study how the perceived impact of information sources is associated with the technological innovation, also, the mediator role of absorptive capacity in the relationship between the information sources and technological innovation. Besides, it is analyzed how the expenditure in acquisition of machinery, hardware and software are related to technological innovation.

The article therefore proceeds as follows. Firstly, we provide the study's key concepts and the variables. Next, the hypotheses of the study are presented in more detail. Third, we identify the data used for the study and the methods of analysis. Fourth, we show the results of the study that confirms the acceptance of the hypotheses. Finally, we present the discussion of the results, conclusion and relevance of these to promote the valuation of certain points in the technological innovation of companies classified as low- and medium-low- tech.

Theoretical framework

Firm classification with respect to technology have been categorized in a number of ways. Kirner, Kinkel & Jaeger (2009) classified firms according to a measure calculated by dividing research and development expenses among internal sales during a given year. Their analysis established three categories: (1) high technological intensity, which were those companies with an indicator higher than 7%; (2) average technological intensity, which were those companies whose indicator is between 2.5% and 7%; and (3) low-tech companies that are those with an indicator below 2.5%. Heidenreich (2009) offers an alternative view, based on the fourth Community Innovation Survey (CIS4) whereby companies belonging to the low and medium intensity technology industries tend to be characterized by process, organizational or commercialization innovations, and they have a high dependence on the external supply of technologies in the form of machinery, hardware and software. It has also been determined that the role of formal and informal knowledge among enterprises is important for low or medium technology industries, as it has been discovered that these industries learn beyond activities directly related to research and development (Sciascia, D'Oria, Bruni and Larrañeta, 2014; Santamaría et al., 2009).

The ability of an organization to gain knowledge or its absorptive capacity has had a great impact on organizational research and it has called the attention of a great number of researchers. Absorptive capacity influences in the development of competitiveness advantages and company performance (Volberda, Foss & Lyles, 2010). Thus Cohen & Levinthal (1990) point out that absorptive capacity is the ability of the company to recognize the value of new and external information, to assimilate it and to apply it for commercial purposes and its innovative critical capabilities. Zahra & George (2002) proposed that the absorptive capacity of the company is a multidimensional construct comprising of four dimensions; that (i) acquisition, (ii) assimilation, (iii) transformation, and (iv) exploitation. Though Todorova & Durisin (2007) criticized Zahra & George (2002) dimensional view, noting that the development of the absorptive capacity is a path dependent process and that it is the increase of the knowledge in the area of the experience that leads to the future capability development.

Organizations gain knowledge through the interaction of internal and external information sources (Laursen & Salter, 2006). This external knowledge comes from a range of suppliers (Li & Vanhaverbeke, 2009): clients (Grimpe & Sofka, 2009), competitors (Lim, Chesbrough & Ruan, 2010) or universities (Fabrizio, 2009). While firms using external and internal sources improve their innovation performance, the combined effect of these sources of knowledge is often unclear (Frenz & Ietto-Gillies, 2009).

According to Arbussa & Coenders (2007), companies improve their innovation capacity by acquiring machinery, equipment and hardware. In this way, Frank, Cortimiglia, Ribeiro

& De Oliveira (2016) assert that, for Brazilian firms the purchase of machinery and equipment improved the results of innovation and processes. Gronum, Verreynne and Kastelle (2012) considered that technological innovation can be measured combining responses from companies that have introduced a new or improved product or service or a new or improved process over the last three years.

Henceforth, we propose four hypotheses. However, before presenting them, it is convenient to mention the concepts and the research which is related to each.

The first hypothesis is related to the concept of absorptive capacity, which has been found to influence on innovation. Cohen & Levinthal (1990) argued that the absorptive capacity is very important for company innovation process, since it increases the speed and frequency of innovation, where innovations are based mainly on the company knowledge base (Kim & Kogut, 1996). Similarly, Zahra & George (2002) found a significant positive relationship between absorptive capacity and innovation, as these factors work together to establish the organization competitive advantage. This also suggests that absorptive capacity is an important factor in the prediction of the organization innovation capacity (Knudsen & Roman, 2004).

Caloghirou, Kastelli & Tsakanikas (2004) investigated the extent to which the existing internal capabilities of firms and their interaction with external sources of knowledge affect their level of innovation. Ttheir findings show that some capacities result from a protracted process of investment and knowledge accumulation within companies and linked to the company's absorptive capacity. In addition, the results show that both internal capabilities and openness to knowledge sharing are important for improving innovation performance. Wang & Han (2011) carried out a study on SMEs in China that validated the knowledge properties and absorptive capacity as two inseparable determinants of innovation performance, while indicating that absorptive capacity moderates the relationship between knowledge properties and innovation performance. Ali & Park (2016) developed a study of 195 Korean companies of various sizes and sectors, in which they validated that absorptive capacity is crucial for innovation and organizational performance. It is also important to mention that Ince, Imamoglu, & Turkcan (2016) developed a theoretical model that holds that absorptive capacity has a positive impact on technological innovation capabilities. Based on this evidence our first hypothesis is:

Hypothesis 1. Absorptive capacity is associated with technological innovation in companies.

The second hypothesis is related to the perceived impact of information sources and are separated in hypothesis 2a and 2b. It is clear that firms can improve their ability to innovate by carefully managing information that comes from relationships with suppliers, customers, and other resource providers, such as universities or government agencies (Kauffman,

McAndrews & Wang, 2000). Yli-Renko, Autio and Sapienza (2001) consider that this customer knowledge acquisition shows a positive influence on product innovation.

In this sense, both customers and suppliers can play an important role in the innovation process as they contribute to providing key information on technologies, markets and user needs (Pérez & Díaz, 2007). Although some innovative firms may devote little financial resources to formal R&D activities, they achieve successful innovations due to the use of knowledge and the application of experience from a wide range of external information sources (Laursen & Salter, 2006). Also, Wu, Lin, & Hsu (2007) found a positive relationship between customers, suppliers and product innovation, as they seem to complement each other as companies acquire and apply external knowledge and skills. From the point of view of open innovation, the knowledge from the information sources that a company can get from clients and suppliers is related to the technological innovation.

Furthermore, absorptive capacity allows companies to identify more flows of perceived impact of information sources. Todorova & Durisin (2007) and Zahra & George (2002), state that companies depend more and more on suppliers, customers, competitors, universities, other research institutions, specialized magazines, conferences and meetings. In other words, a company is not capable of identifying, assimilating and applying new information sources without absorptive capacity as a mediating role.

Thus, we propose the following hypothesis:

Hypothesis 2a: Perceived impact of information sources is associated with the technological innovation of companies.

Hypothesis 2b: Perceived impact of information sources is associated with the absorptive capacity (mediator) to affect technological innovation.

Lastly, the third hypothesis is related to the acquisition of technology. Calvo (2000) argues that in 1998, Spain's innovative companies not only invested on R&D, but also in the acquisition of machinery, the purchase of intangible technology, training and marketing. Therefore, we can say that they diversified their expenses across several activities. In addition, for Ahuja & Katila (2001), it is important to clarify that it is not enough just to acquire technology to increase innovation, but also to evaluate its impact, favorable or not, on the innovation performance. For this reason, Calantone, Cavusgil and Zhao (2002) asserted that "innovation capability is one of the most important determinants of company performance" (p.518).

In this sense, it could be assumed that if the acquisition of machinery, hardware and software improves the company innovation capacity, the company's performance will improve. It can be assumed that the purchase of technological assets is also a contribution to the improved company

performance. Potter (2009) states that in order to implement new or improved products or processes, that is to say, innovation activities, the purchase of machinery and equipment is required. Among advanced machinery, we have, for example, computer hardware, which is generally considered to be necessary for the process and product improvement. This technology can be directly used as in many cases it is built into the equipment and machinery. As Santamaría et al. (2009) point out not only are R&D activities an innovation source for the company but other types of activities, including the knowledge and experience gained through the use of advanced machinery and tools, which are an important innovation source for low- and medium-low- tech companies.

Besides, Pavitt (1984) indicates that industrial sectors that are dominated by suppliers, such as textiles, leather and footwear manufacturers, which are also typical examples of low technology industries, which tend to focus on their innovation capacity development efforts through the purchase of machinery and advanced equipment. In addition, Zuniga and Crespi (2013) indicate innovation strategies are those that allow the technological innovation. These strategies may consist of: investment in research and development (R&D); the acquisition of technology in the market through the recruitment of R&D, licensing technology and know-how; contracting technical and engineering services; and the acquisition of machinery and equipment that favor innovation. Besides, the acquisition of machinery, hardware, and software favors the development of innovations in products and processes; this is a characteristic of the Peruvian industry as pointed out by Pérez et al. (2018). Therefore, we propose following hypothesis:

Hypothesis 3: Expenditure in acquisition of machinery, hardware and software is associated with the technological innovation of companies.

Methodology

For this empirical study, we use the data collected in the National Survey of Innovation in the Manufacturing Industry 2012 (INEI Survey, 2012), a survey applied to companies in the Peruvian manufacturing sector to obtain information about their innovation processes, determinants and specific characteristics. The survey was conducted during the reference period 2009-2012. The sample consisted of 1 220 companies, large, medium and small, from different regions of the country; places where more than 90% of the production value of manufacturing activity is generated nationwide. For the study, 856 companies of low and medium low technology intensity were identified. The design of this survey was developed on the basis of the methodological framework of the "Bogotá Manual", which in turn will allow the development of indicators comparable to the results of other countries in the Latin American region. In the table 1, we present information about firm size (according to the number of employees), the firm age and the number of companies according to its technological intensity.

Table 1
Descriptive statistics for manufacture industries

Firm size	Count	Percentage
Small (50 employees)	478	55.8%
Medium (51 to 250 employees)	190	22.3%
Large (251 or more employees)	188	21.9%
Total	856	
Firm age		
<10 years	79	9.2%
10 to 19 years	365	42.6%
20 to 29 years	203	23.7%
30 or more	209	24.4
Total	856	
Technological intensity		
Low	505	58.9%
Medium-low	351	41.1%
Total	856	

Source: Own elaboration.

Figure 1 shows the conceptual model that relates the three constructs: absorptive capacity, perceived impact of information sources and technology acquisition with technological innovation.
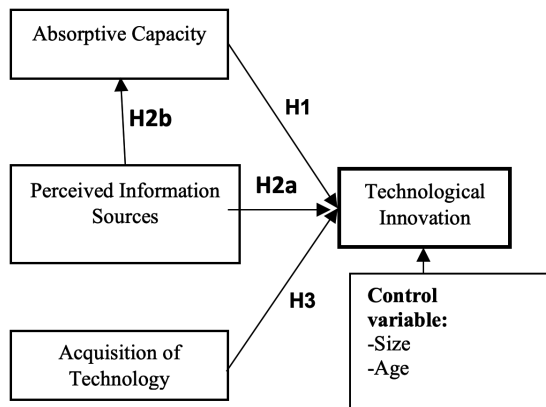

Figure 1. Conceptual model.
Source: own illustration.

A description of how each of the constructs has been measured is shown, see table 2 and 3.

Table 2

Description of dependent variables

Dependent variables	Description	Metric	Source
Technological Innovation			
Product	Amount of process innovations that managed to introduce to the market	From 0 to 4	Gronum et al. (2012)
Process	Amount of process innovations that managed to introduce the market	From 0 to 2	

Source: Own elaboration.

Table 3

Description of independent variables

Independent variables	Description	Metric	Source
Absorptive Capacity			
Research expenditure	Logarithm of expenditures in research and development activities (R&D) internal	Continuous	Escribano, Fosfuri & Tribó (2009).
Training innovation	Logarithm of the expenditures in training activities for activities of innovation		
R&D departament	If the company has a department of R&D	1: Yes 0: No	
Perceived Information Sources			
Supplier		Degree of importance:	Escribano, Fosfuri & Tribó (2009).
Consultant			Laursen & Salter (2006).
Conference	Sources of information	1: None	
		2: Low	
Magazine		3: Medium	
		4: High	
Association			
Acquisition of Technology			
Machinery			Arbussa & Coenders (2007)
Hardware	Logarithm of the expenditures	Continuous	Escribano, Fosfuri & Tribó (2009).
Software			

Source: Own elaboration.

Finally, let's review the control variables, see table 4.

Table 4

Description of control variables

Control variables	Description	Metric	Source
Employee	Logarithm of the total of employees		Schoenmaker & Duysters (2006)
Investigator	Ratio of the personnel in investigation and development among the total of employees	Continuous	Rothwell & Dodgson (1991)
Organizational innovation	Amount of innovations in organization that managed to incorporate	From 0 to 3	Schmidt & Rammer (2007) Damanpour and Aravind (2012)

Source: Own elaboration.

The evaluation of the hypotheses was carried out with the model of structural equations (SEM). Specifically, the technique used was PLS (Partial Least Squares), which is used with formative and reflective constructs and with small samples. The software is SmartPLS 3, developed by Ringle, Wende & Will (2005). SmartPLS 3 estimates the process of the estimation model and SEM analysis in two steps (Chin, Marcolin & Newsted 2003). First, the measurement model is estimated, where the relationship between the indicators and the latent construct is determined. Second, the structural model is estimated, in which the relationships between the constructs are obtained by means of the path coefficients and the level of significance.

Finally, when analyzing absorptive capacity, certain steps are evaluated to confirm if it is a mediating variable and the type of effect. According to Hair, Sarstedt, Hopkins, & Kuppelwieser (2014), mediation represents a situation in which a mediating variable to some extent absorbs the effect of an exogenous construct (with independent variables) in an endogenous construct (with the dependent variable) in the PLS path model. The evaluation of variance accounted for (VAF) determines to what extent the mediation process explains the variance of the dependent variable. The rule is, if the VAF is less than 20 percent, one must conclude that there is no mediation; a situation in which the VAF is greater than 20 percent and less than 80 percent could be characterized as a typical partial mediation (Hair Jr, Hult, Ringle, & Sarstedt, 2016); and a VAF above 80 percent indicates full mediation. The VAF is the ratio between the indirect effect and the total effect.

Results

Through of the factorial analysis of principal components with varimax rotation, we verify the significance of the correlation matrix with Bartlett's contrast. In this case, the correlations taken as a whole are significant at a significance level of 0.05 (Bartlett's sphericity test = 2535.687, gl = 55, p <.005). On the other hand, the sample adequacy measure of Kaiser-Meyer-Olkin also falls within the acceptance range (0.807). After four iterations, the factorial solution converges in three factors that explain 59.3% of the variance. Although the Kaiser criterion yielded a two-factor solution, the observation of the sedimentation graph and the slope change in the eigenvalues clearly showed a three-factor structure. The configuration matrix, table 5, offers the saturations of the variables in the factors of the rotated solution. These saturations represent the net contribution of each variable in each factor.

Table 5

Matrix of configuration of the rotated factors

Name of factor	Description of ítem	Factor 1	Factor 2	Factor 3
Absorptive Capacity (ACAP)	Expenditure on research and technological development.	0.727		
	Training costs for innovation activities.	0.502		
	Department of research and technological development.	0.839		
Perceived Information Sources (SOI)	Equipment and software suppliers.		0.628	
	Private consultants and institutes.		0.599	
	Conferences and exhibitions.		0.793	
	Scientific magazines.		0.806	
	Professional associations.		0.753	
Acquisition of Technology (TECH)	Acquisition of capital machinery.			0.651
	Acquisition of hardware.			0.828
	Acquisition of software.			0.786

Source: SPSS software, own elaboration.

It is observed in the measurement model in all constructs that the composite reliability index exceeds the minimum requirement of 0.7, which does not occur with the Cronbach's alpha of absorptive capacity, which does not exceed the reference value of 0.7, while multicollinearity is controlled with values lower than 5. When analyzing convergent validity using AVE, it must

be greater than 0.5; in all constructs is satisfactory. In addition, when discriminant validity is analyzed, in all cases, the square root of the AVE is greater than the correlations. Therefore, the measurement models can be accepted. Table 6 presents the indicators of validity, reliability, coefficient of determination and multicollinearity, while table 7 provides discriminant validity data.

Table 6
Indicators of validity, reliability, coefficient of determination and multicollinearity

Latent variable	Description of item	Item Loadings	Cronbach´s alpha	Composite Reliability (CR)	AVE	VIF	R^2
Absorptive Capacity (ACAP)	Expenditure on research and technological development.	0.827	0.688	0.825	0.613	1.769	0.337
	Training costs for innovation activities.	0.814					
	Department of research and technological development.	0.701					
Perceived Information Sources (SOI)	Equipment and software suppliers	0.685	0.775	0.846	0.525	1.105	
	Private consultants and institutes	0.680					
	Conferences and exhibitions	0.769					
	Scientific magazines	0.786					
	Professional associations	0.694					
Acquisition of Technology (TECH)	Acquisition of capital machinery.	0.774	0.701	0.833	0.624	1.971	
	Acquisition of hardware.	0.816					
	Acquisition of software.	0.779					
Reference value			>0.7	>0.7	>0.5	<5	

Source: Application to SMART PLS software, own calculations.

Table 7
Discriminant validity (AVE square root comparison and correlations)

	ACAP	Technological Innovation	SOI	TECH
ACAP	0.783			
Technological Innovation	0.565	0.881		
SOI	0.254	0.205	0.724	
TECH	0.565	0.614	0.214	0.790

Source: Application to SMART PLS software, own calculations.

After evaluating the measurement models, we proceed to estimate the structural model. See annex 1.1.

First, we examine collinearity using the Variance Inflation Factor (VIF), which must be found below 5. Looking at table 6, collinearity is not a problem among the constructs of the structural model. Second, the non-parametric bootstrap procedure with 2 000 subsamples was used to generate the path coefficients and 90% confidence intervals (Chin, 1998). Table 8 shows the results. Third, the indirect effect has to be significant, since it is an indispensable requirement to evaluate the importance of the mediating effect (Hair Jr et al. 2014; Preacher & Hayes, 2008). In the study, the direct relationship between perceived impact of information sources and technological innovation is not significant, but its indirect effect through absorptive capacity is significant (b = 0.039 ****, t = 4.470) considering indirect mediation. The results are presented in table 9. In order to complement, we present the Variance Accountant For (VAF), which determines the indirect effect in relation to the total effect; 78% of the VAF is obtained through the absorptive capacity, which explains the perceived impact of information sources and technological innovation.

Table 8
Shows the coefficients of the variables and the coefficient of determination

Hipótesis	Variable endógena	Path coefficient	90% confidence interval	p-Value
	INNOVATION (R²= 0.520)			
H1	ACAP -> INNOVATION	0.283****	(0.21;0.347)	0.001
H2a	SOI -> INNOVATION	0.011 n.s	(-0.035;0.058)	0.659
H3	TECH -> INNOVATION	0.331****	(0.261;0.402)	0.001
	CONTROL			
	Organization size	-0.075***	(-0.127; -0.016)	0.009
	Trained persons	0.025 n.s	(0;0.099)	0.384
	Organizational innovation	0.286****	(0.219;0.351)	0.001

Note: n.s. = not significant; *** p = 0.01, **** p = 0.001.
Source: Application to SMART PLS software, own calculations.

Table 9
Mediation test using the bootstrapping method

Hypothesis	Effect of	Direct effect (tvalue)	Indirect effect (tvalue)	Total effect	VAF (%)	Interpretation
H2b	SOI>ACAP> INNOVATION	0.011 n.s (0.441)	0.039**** (4.470)	0.050	78%	Partial mediation

Note: VAF = Variance Accounted For; n.s = not significant; ** │t│ >=1.96 at p=0.05 level; **** │t│ >= 3.29 at p = 0.001 level. The VAF > 80% indicates full mediation, 20% <= VAF <= 80% shows partial mediation while VAF < 20% assumes no mediation. Source: Application to SMART PLS software, own calculations.

And finally, the analysis of the results using the coefficient of determination (Henseler, Ringle & Sinkovics, 2009), where the values of 0.19 reflects a weak relationship, a value of 0.33, reflects a moderate relationship, and a value of 0.67, a relationship substantial. It can be inferred that a moderate relation is observed. The model also complies with the goodness-of-fit index, the GoF index (Tenenhaus, Esposito Vinzi, Chatelin and Lauro, 2005) is calculated by taking the square root of the average product of the AVE for the latent variables (the reflective indices) and the average R^2 for the endogenous variables. This index varies between the values of 0 and 1. Although there is no minimum threshold, a value greater than 0.31 is recommended. The GoF index reaches a value of 0.50, which is higher than the recommended minimum to guarantee the quality of the adjustment of the model under study.

Discussion

This research has been carried out in a sample of manufacturing companies based on information obtained in the technological innovation survey carried out in 2012 by INEI and the Ministry of Production of Peru.

We found that absorptive capacity is associated with technological innovation in companies. Hypothesis 1 was verified that the absorptive capacity has an influence on the company performance. This finding is supported by Volberda et al. (2010), who also observed that absorptive capacity is associated to technological innovation. Our results show that in low and medium-low technological companies, research and development expenses, training expenses for innovation activities and having a research and development department aid to improve the company's innovation performance.

Hypothesis 2a, was rejected. However, the perceived impact of information sources was found to be associated with technological innovation through the mediating effect of absorptive capacity, thus accepting hypothesis 2b. This confirms what Todorova & Durisin (2007) stated in that "a company is not capable of identifying, assimilating and applying new information sources without the role of absorptive capacity". This infers that companies cannot benefit

from information sources simply by being exposed to them (Cohen & Levinthal, 1989; Cohen & Levinthal, 1990). However, absorptive capacity in a mediating role allows companies to improve their technological innovation performance. It is, therefore, necessary that the members of the companies assimilate and use knowledge for innovative purposes. The sources of this knowledge may lie with suppliers of equipment and software, consultants and private institutes, through attending conferences and exhibitions and from scientific magazines or professional associations.

The third and last hypothesis 3, where the association between the expenditure in acquisition of machinery, hardware and software and the technological innovation of the companies, was also confirmed. This finding should further firm to acquire technologies, through means such as the purchasing of embedded technology that improves the innovative diversity of the company (Huang, Arundel & Hollanders, 2011) and thus contributes to improving the company performance. These results are in accordance with the research of Santamaría et al. (2009) and also by Heidenreich, (2009), whofound that low and medium-low technological companies develop better innovations through the acquisition of machinery, equipment and software

Regarding the study's control variables, it is concluded that organizational innovation is positively associated with technological innovation (product and process) (Mazzanti, Pini, Tortia, 2006, Mol and Birkinshaw, 2009). For organization size, we found that when the company is bigger, the impact on technological innovation is lower. As Mothe & Uyen (2010) also note this stating it "could be due to the fact that small innovative companies have a smaller product portfolio: therefore, when small companies participate in product innovation activities, the innovation part will be greater in global turnover than in the big companies" (p.324). Qualified personnel were found to not directly influence technological innovation. This likely to be due to formal qualifications being more highly regarded that experience in developing economies , whereas higher education and experience in Research and Development (R&D) activities would be the criteria in a developed economy context(Li, Wang & Liu, 2013).

Our results also have implication for managers by using the results to develop their own innovation capacity. They may apply the three variables used here. In terms of the development of absorptive capacity, managers can consider, to increase a company's capacity, increase training costs to improve skills and knowledge of the workforce to identify or propose innovations in processes and products. Managers should be considering also spend time and resources strengthening research and technological development activities as well as considering the company´s absorptive capacity to get more benefits from external and internal information sources. Finally, managers should encourage machinery and equipment acquisitions if they wish to improve the company's technological innovation.

Conclusions

In this article we aimed to analyze the technological innovations of the LMT Peruvian manufacturing companies. Through this analysis we provide a threefold contribution. Firstly, we examine a different group from the extant literature as most of the studies focus on the companies that have a high intensity technology (Dominguez & Brenes, 1997; Contractor, Kumar, & Kundu, 2007; Luo & Tung, 2007; Lopez, Kundu, & Ciravegna, 2009; Nicholls-Nixon, Castilla, Garcia, & Pesquera, 2011; Vassolo, De Castro, & Gomez-Mejia, 2011; Ciravegna, Lopez, and Kundu, 2014).Secondly, we identify the factors that influence technological innovation in LMT Peruvian manufacturing companies, through the constructs of absorptive capacity, perceived impact of information sources and expenditure in technology acquisition (Zahra & George, 2002, Laursen & Salter, 2006, Potters, 2009) further contributing to innovation knowledge of Latin America. Thirdly, by situating ourselves in the context of an emerging economy, we are able to compare and contrast the manufacturing sector of developed countries with those of an emerging economy, finding similarities in the application of technological innovation through the absorptive capacity, perceived impact of information sources and expenditure in acquisition of technology (Lee, Özsomer & Zhou, 2015).

Our results verify that absorptive capacity favors the development of technological innovation, leading us to conclude that for an emerging economy like Peru that invests very little in research and development, it would be advisable for these LMT firms to consider implementing an office to develop R & D activities, and to begin to invest more in the training of personnel and activities that encourage the development of innovation.

Interestingly, we found a divergence for previous published work, where in this case the perception of the importance of information sources is not associated with technological innovation. We were also able to verify the partial (very close to total) mediating effect of absorption capacity on the relationship between the perceived impact of information sources and technological innovation. These empirical results suggest that Peruvian manufacturing companies should improve their absorptive capacity, and pay more attention to sources of information that come from professional associations, scientific journals, fairs and conferences, as well as knowledge held by their suppliers. This should provide even more avenues to investigate innovation and firm development. Moreover, future research should begin to examine how non-technological innovation is related to technological innovation.

In an economy dominated by low tech and low medium tech companies, the most common form in innovation activities carried out by Peruvian manufacturing industry tends to be the acquisition of machinery, hardware, and software. The results shows how the technology acquisition favors the technological innovation.

For this study, only the information corresponding to the year 2011 has been analyzed. To improve the analysis and the coherence of the hypotheses, it would be convenient to analyze the information corresponding to future periods. Although the data is considered robust, they are limited. As such, it is suggested that additional research be conducted to gather more characteristics of companies that undertake innovations or to specify and contrast industrial sectors. Likewise, it may be possible to identify which of the innovation activities has the greatest impact on the development of products, processes and non-technological innovation.

Referencias

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. Strategic management journal, 22(3), 197-220. http://dx.doi.org/10.1002/smj.157

Ali, M., & Park, K. (2016). The mediating role of an innovative culture in the relationship between absorptive capacity and technical and non-technical innovation. Journal of Business Research, 69(5), 1669-1675. https://dx.doi.org/10.1016/j.jbusres.2015.10.036

Arbussa, A., & Coenders, G. (2007). Innovation activities, use of appropriation instruments and absorptive capacity: Evidence from Spanish firms. Research Policy, 36(10), 1545-1558.https://dx.doi.org/10.1016/j.respol.2007.04.013

Brenes, E. R., Camacho, A. R., Ciravegna, L., & Pichardo, C. A. (2016). Strategy and innovation in emerging economies after the end of the commodity boom—Insights from Latin America. Journal of Business Research, 69(10), 4363-4367. https://dx.doi.org/10.1016/j.jbusres.2016.03.059

Calantone, R. J., Cavusgil, S. T., & Zhao, Y. (2002). Learning orientation, firm innovation capability, and firm performance. Industrial marketing management, 31(6), 515-524. https://dx.doi.org/10.1016/S0019-8501(01)00203-6

Caloghirou, Y., Kastelli, I., & Tsakanikas, A. (2004). Internal capabilities and external knowledge sources: complements or substitutes for innovative performance? Technovation, 24(1), 29-39. https://dx.doi.org/10.1016/S0166-4972(02)00051-2

Calvo, J. L. (2000). Una caracterización de la innovación tecnológica en los sectores manufactureros españoles: Algunos datos. Economía Industrial, 331, 139-150.

Chin, W., Marcolin, B., & Newsted, P. (2003). A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic-mail Emotion/Adoption Study. Information Systems Research, 189-217. https://dx.doi.org/10.1287/isre.14.2.189.16018

Chin W.W. (1998). The partial least squares approach for structural equation modeling. G.A. Marcoulides (Ed.), Modern methods for business research, Lawrence. Erlbaum Associates, Mahwah, NJ.

Ciravegna, L., Lopez, L., & Kundu, S. (2014). Country of origin and network effects on internationalization: A comparative study of SMEs from an emerging and developed economy. Journal of Business Research, 67(5), 916-923. https://dx.doi.org/10.1016/j.jbusres.2013.07.011

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R & D. The economic journal, 99(397), 569-596. https://dx.doi.org/10.2307/2233763

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. Administrative science quarterly, 128-152. https://dx.doi.org/10.2307/2393553

Contractor, F. J., Kumar, V., & Kundu, S. K. (2007). Nature of the relationship between international expansion and performance: The case of emerging market firms. Journal of World Business, 42(4), 401-417. https://dx.doi.org/10.1016/j.jwb.2007.06.003

Damanpour, F., & Aravind, D. (2012). Managerial innovation: Conceptions, processes, and antecedents. Management and Organization Review, 8(2), 423-454. https://dx.doi.org/10.1111/j.1740-8784.2011.00233.x

Pérez, P. D. S., & Díaz, N. D. (2007). Incidencia de los Recursos Humanos de I+ D internos y contratados en la innovación. Cuadernos de Economía y Dirección de la Empresa, 10(33), 7-30. https://dx.doi.org/10.1016/S1138-5758(07)70096-8

Dominguez, L. V., & Brenes, E. R. (1997). The internationalization of Latin American enterprises and market liberalization in the Americas: A vital linkage. Journal of Business Research, 38(1), 3-16. https://dx.doi.org/10.1016/S0148-2963(96)00113-0

Escribano, A., Fosfuri, A., & Tribó, J. A. (2009). Managing external knowledge flows: The moderating role of absorptive capacity. Research policy, 38(1), 96-105. https://dx.doi.org/10.1016/j.respol.2008.10.022

Fabrizio, K. R. (2009). Absorptive capacity and the search for innovation. Research Policy, 38(2), 255-267. https://dx.doi.org/10.1016/j.respol.2008.10.023

Frank, A. G., Cortimiglia, M. N., Ribeiro, J. L., & De Oliveira, L. S. (2016). The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. Research Policy, 45(3), 577-592. https://dx.doi.org/10.1016/j.respol.2015.11.011

Frenz, M., & Ietto-Gillies, G. (2009). The impact on innovation performance of different sources of knowledge: Evidence from the UK Community Innovation Survey. Research Policy, 38(7), 1125-1135. https://dx.doi.org/10.1016/j.respol.2009.05.002

Geldes, C., Felzensztein, C., & Palacios-Fenech, J. (2017). Technological and non-technological innovations, performance and propensity to innovate across industries: The case of an emerging economy. Industrial Marketing Management, 61, 55-66. https://dx.doi.org/10.1016/j.indmarman.2016.10.010

Grimpe, C., & Sofka, W. (2009). Search patterns and absorptive capacity: Low-and high-technology sectors in European countries. Research Policy, 38(3), 495-506. https://dx.doi.org/10.1016/j.respol.2008.10.006

Gronum, S., Verreynne, M. L., & Kastelle, T. (2012). The role of networks in small and medium- sized enterprise innovation and firm performance. Journal of Small Business Management, 50(2), 257-282. https://dx.doi.org/10.1111/j.1540-627X.2012.00353.x

Hair Jr. J.F., Hult, G.T.M., Ringle, C. & Sarstedt, M. (2016). A primer on partial least squares structural equation modeling (PLS-SEM). SAGE Publications, Inc

Hair Jr, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM) An emerging tool in business research. European Business Review, 106-121. https://dx.doi.org/10.1108/EBR-10-2013-0128

Heidenreich, M. (2009). Innovation patterns and location of European low-and medium-technology industries. Research Policy, 38(3), 483-494. https://dx.doi.org/10.1016/j.respol.2008.10.005

Heidenreich, M. (2008). Low-tech Industries between Trade and Untraded Interdependencies: a dynamic concept of industrial complementarities. Innovation in Low-Tech Firms and Industries, Industrial Dynamics, Entrepreneurship and Innovation Series, Edward Elgar, Cheltenham, 221-244. https://doi.org/10.4337/9781848445055.00022

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. New challenges to international marketing, 277-319. https://dx.doi.org/10.1108/S1474-7979%282009%290000020014

Heredia, J., Flores, A., Geldes, C., & Heredia, W. (2017). Effects of informal competition on innovation performance: the case of pacific alliance. Journal of Technology Management & Innovation, 12(4), 22-28. https://dx.doi.org/10.4067/S0718-27242017000400003

Huang, C., Arundel, A., & Hollanders, H. (2011). How firms innovate. In DIME Final Conference. Maastricht.

Ince, H., Imamoglu, S. Z., & Turkcan, H. (2016). The Effect of Technological Innovation Capabilities and Absorptive Capacity on Firm Innovativeness: A Conceptual Framework. Procedia-Social and Behavioral Sciences, 235, 764-770. https://dx.doi.org/10.1016/j.sbspro.2016.11.078

INEI Survey (2012). Peru: National Survey of Innovation in Manufacturing Industry, 2012- Main Results. Retrieved from Questionnaire 79-90. Available in: http://innovacion.enlacesred.org/pdf/peru/Peru_Manufacturera.pdf Consulted: 16/08/19

Kauffman, R. J., McAndrews, J., & Wang, Y. M. (2000). Opening the "black box" of network externalities in network adoption. Information Systems Research, 11(1), 61-82. https://dx.doi.org/10.1287/isre.11.1.61.11783

Kim, D. J., & Kogut, B. (1996). Technological platforms and diversification. Organization Science, 7(3), 283-301. https://dx.doi.org/10.1287/orsc.7.3.283

Kirner, E., Kinkel, S., & Jaeger, A. (2009). Innovation paths and the innovation performance of low-technology firms—An empirical analysis of German industry. Research Policy, 38(3), 447-458. https://dx.doi.org/10.1016/j.respol.2008.10.011

Knudsen, H. K., & Roman, P. M. (2004). Modeling the use of innovations in private treatment organizations: The role of absorptive capacity. Journal of substance abuse treatment, 26(1), 51-59. https://dx.doi.org/10.1016/S0740-5472(03)00158-2

Krammer, S. M. (2016). The role of diversification profiles and dyadic characteristics in the formation of technological alliances: Differences between exploitation and exploration in a low-tech industry. Research Policy, 45(2), 517-532. https://dx.doi.org/10.1016/j.respol.2015.10.014

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. Strategic management journal, 27(2), 131-150. https://dx.doi.org/10.1002/smj.507

Lee, R., Özsomer, A., Zhou K. (2015). Introduction to the special issue on "innovation in and from emerging economies". Industrial Marketing Management, 50 (2015), pp. 16-17. https://dx.doi.org/10.1016/j.indmarman.2015.07.005

Li, Y., & Vanhaverbeke, W. (2009). The effects of inter-industry and country difference in supplier relationships on pioneering innovations. Technovation, 29(12), 843-858. https://dx.doi.org/10.1016/j.technovation.2009.08.001

Li, X., Wang, J., & Liu, X. (2013). Can locally-recruited R&D personnel significantly contribute to multinational subsidiary innovation in an emerging economy?. International Business Review, 22(4), 639-651. https://dx.doi.org/10.1016/j.ibusrev.2012.12.002

Lim, K., Chesbrough, H., & Ruan, Y. (2010). Open innovation and patterns of R&D competition. International Journal of Technology Management, 52(3/4), 295-321. https://dx.doi.org/10.1504/IJTM.2010.035978

Lopez, L. E., Kundu, S. K., & Ciravegna, L. (2009). Born global or born regional? Evidence from an exploratory study in the Costa Rican software industry. Journal of International Business Studies, 40(7), 1228-1238. https://dx.doi.org/10.1057/jibs.2008.69

Luo, Y., & Tung, R. L. (2007). International expansion of emerging market enterprises: A springboard perspective. Journal of international business studies, 38(4), 481-498. https://dx.doi.org/10.1057/palgrave.jibs.8400275

Mazzanti M., Pini P. & Tortia E. (2006). Organizational innovations, human resources and firm performance. The Emilia–Romagna food sector. The Journal of Socio-Economics, 35, pp. 123-141 https://dx.doi.org/10.1016/j.socec.2005.12.007

Mol M.J. & Birkinshaw J.. (2009). The sources of management innovation: When firms introduce new management practices. Journal of Business Research, 62, pp. 1269-1280. https://dx.doi.org/10.1016/j.jbusres.2009.01.001

Mothe, C., & Uyen Nguyen Thi, T. (2010). The link between non-technological innovations and technological innovation. European Journal of Innovation Management, 13(3), 313-332. https://dx.doi.org/10.1108/14601061011060148

Nicholls-Nixon, C. L., Davila Castilla, J. A., Sanchez Garcia, J., & Rivera Pesquera, M. (2011). Latin America management research: Review, synthesis, and extension. Journal of Management, 37(4), 1178-1227. https://dx.doi.org/10.1177/0149206311403151

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. Research policy, 13(6), 343-373. https://dx.doi.org/10.1016/0048-7333(84)90018-0

Pérez, J. A. H., Geldes, C., Kunc, M. H., & Flores, A. (2018). New approach to the innovation process in emerging economies: The manufacturing sector case in Chile and Peru. Technovation. https://dx.doi.org/10.1016/j.technovation.2018.02.012

Potters, L. (2009). Innovation input and output: differences among sectors. Communities, (10), 38. IPTS WORKING PAPER ON CORPORATE R&D AND INNOVATION - No. 10/2009. Available in: http://iri.jrc.es/ Consulted: 16/08/19

Preacher, K. J. & Hayes A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behavior Research Methods, 40 (3), pp. 879-89. https://dx.doi.org/10.3758/BRM.40.3.879

OECD (2011). OECD Science, Technology and Industry Scoreboard 2011, OECD Publishing, Paris. http://dx.doi.org/10.1787/sti_scoreboard-2011-en

Ramírez, M. S., & García-Peñalvo, F. J. (2018). Co-creation and open innovation: Systematic literature review. Comunicar, 26(54), 9-18. https://dx.doi.org/10.3916/C54-2018-01

Ringle, C., Wende, S., & Will, S. (2005). SmartPLS 2.0 (M3) Beta, Hamburg 2005. Available in: http://www.smartpls.de Consulted: 16/08/19

Robertson, P., Smith, K. & Von Tunzelmann, N. (2009). Innovation in low-and medium-technology industries. Research Policy, 38(3), 441-446. https://dx.doi.org/10.1016/j.respol.2008.10.019

Rothwell, R., & Dodgson, M. (1991). External linkages and innovation in small and medium□sized enterprises. R&d Management, 21(2), 125-138. https://dx.doi.org/10.1111/j.1467-9310.1991.tb00742.x

Salas, W. G. V., & Deng, Z. (2017). High ownership concentration and exporting of emerging market firms: evidence from Peru. Frontiers of Business Research in China, 11(1), 17. https://dx.doi.org/10.1186/s11782-017-0018-2

Santamaría, L., Nieto, M. J., & Barge-Gil, A. (2009). Beyond formal R&D: Taking advantage of other sources of innovation in low-and medium-technology industries. Research Policy, 38(3), 507-517. https://dx.doi.org/10.1016/j.respol.2008.10.004

Schmidt, T., & Rammer, C. (2007). Non-technological and technological innovation: strange bedfellows?. Available in: http://193.196.11.222/pub/zew-docs/dp/dp07052.pdf Consulted: 16/08/19

Schoenmakers, W., & Duysters, G. (2006). Learning in strategic technology alliances. Technology analysis & strategic management, 18(2), 245-264. https://dx.doi.org/10.1080/09537320600624162

Sciascia, S., D'Oria, L., Bruni, M., & Larrañeta, B. (2014). Entrepreneurial Orientation in low-and medium-tech industries: The need for Absorptive Capacity to increase performance. European management journal, 32(5), 761-769. https://dx.doi.org/10.1016/j.emj.2013.12.007

Scott, G. J., & Chaston, I. (2012). Culture and innovation in Peru from a management perspective. Journal of Global Initiatives, 7(2), 131-145. https://doi.org/10.7835/ccwp-2012-09-0010

Tello, M. D. (2017). Innovation and productivity in services and manufacturing firms: the case of Peru. CEPAL Review. https://dx.doi.org/11362/42010

Tenenhaus, M., Vinzi, V. E., Chatelin, Y. M., & Lauro, C. (2005). PLS path modeling. Computational statistics & data analysis, 48(1), 159-205. https://dx.doi.org/10.1016/j.csda.2004.03.005

Todorova, G., & Durisin, B. (2007). Absorptive capacity: Valuing a reconceptualization. Academy of management review, 32(3), 774-786. https://dx.doi.org/10.5465/AMR.2007.25275513

Trott, P., & Simms, C. (2017). An examination of product innovation in low-and medium-technology industries: Cases from the UK packaged food sector. Research Policy, 46(3), 605-623. https://dx.doi.org/10.1016/j.respol.2017.01.007

Vassolo, R. S., De Castro, J. O., & Gomez-Mejia, L. R. (2011). Managing in Latin America: Common issues and a research agenda. The Academy of Management Perspectives, 25(4), 22-36. https://dx.doi.org/10.5465/amp.2011.0129

Volberda, H. W., Foss, N. J., & Lyles, M. A. (2010). Perspective-absorbing the concept of absorptive capacity: how to realize its potential in the organization field. Organization science, 21(4), 931-951. https://dx.doi.org/10.1287/orsc.1090.0503

Von Tunzelmann, N. & V. Acha (2005), "Innovation in "Low Tech' Industries", Chapter 15 in J. Fagerberg, D. Mowery and R.R. Nelson (eds), The Oxford Handbook of Innovation, Oxford University Press, Oxford. https://dx.doi.org/10.1093/oxfordhb/9780199286805.003.0015

Wang, C., & Han, Y. (2011). Linking properties of knowledge with innovation performance: the moderate role of absorptive capacity. Journal of Knowledge Management, 15(5), 802-819. https://dx.doi.org/10.1108/13673271111174339

Wu, S.H., Lin, L.Y., & Hsu, M.Y. (2007). Intellectual capital, dynamic capabilities and innovative performance of organisations. International Journal of Technology Management, 279-296. https://dx.doi.org/10.1504/ijtm.2007.013496

Yli- Renko, H., Autio, E., & Sapienza, H. J. (2001). Social capital, knowledge acquisition, and knowledge exploitation in young technology- based firms. Strategic management journal, 22(6- 7), 587-613. https://dx.doi.org/10.1002/smj.183

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. Academy of management review, 27(2), 185-203. https://dx.doi.org/10.5465/AMR.2002.6587995

Zuniga, P., & Crespi, G. (2013). Innovation strategies and employment in Latin American firms. Structural Change and Economic Dynamics, 24, 1-17. https://dx.doi.org/10.1016/j.strueco.2012.11.001
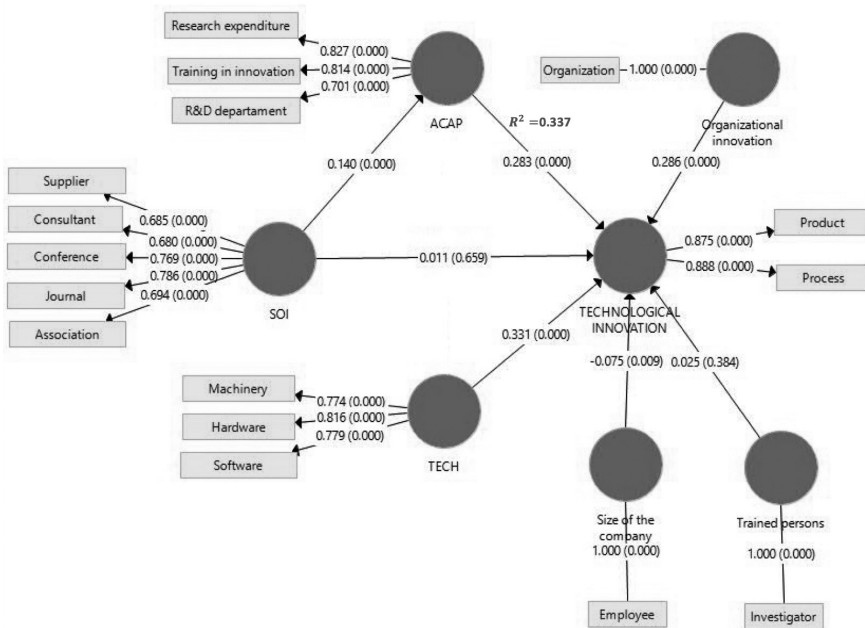
Annex

Structural model

Figure 2. Graphical representation of the PATH diagram for the measurement
model of companies with low- and medium-low- tech.
Source: PATH diagram applied to SMART PLS software.