STUDYING THE RELATIONSHIPS AMONG HUMAN CAPITAL, TECHNOLOGICAL CAPABILITIES, AND INNOVATION IN SPANISH MANUFACTURING FIRMS

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Abstract: This paper focuses on the relationships among human capital, technological capabilities and innovation. In particular, following the resource-based view and the dynamic capabilities approach, this research proposes that both technological capabilities and human capital are drivers of innovation for both products and processes. In addition, it suggests that the effect of human capital on innovation is mediated by technological capabilities. This idea about mediation arises from a review of the literature, although it has never been specifically addressed. The research uses a sample of 200 Spanish manufacturing firms to test the hypotheses. Findings provide evidence of the direct effect proposed and also show that the relationship between human capital and both product and process innovation is mediated by technological capabilities. However, according to our findings, this mediation is only partial for product innovation. The implications of these results for academia as well as for practitioners are discussed.

Key words: Technological capabilities; human capital; process innovation; product innovation.

1. INTRODUCTION

Today there is a general consensus about the significance of innovation for firms. Innovation is seen as a source of competitive advantage and, therefore, an antecedent of company performance (Damanpour and Evan, 1984; Yen, 2013; McGuirk et al., 2015). The reason for this is that innovative firms are usually better able to respond to environmental changes and challenges (Damanpour and Gopalakrishnan, 2001; Leal-Rodriguez et al., 2015).

Based on this assumption about the strategic relevance of innovation, many studies have tried to identify the main variables that foster it. Following the resource-based view, some researchers suggest that innovation in firms does not depend only on external conditions but also on their resources and capabilities (Triguero and Corcoles, 2013). This paper focuses on one intangible resource - human capital - and one type of organisational capability - technological capability-. Literature points to the importance of these two variables as determinants of innovation in companies.

As regards technological capabilities, Zhou and Wu (2010) suggest that firms should build them to develop innovation because they are dynamic capabilities that can increase companies' absorptive capacity - another important driver of innovation. Other researchers also highlight the key role that technological capabilities play as determinants of product innovation and process innovation (Afuah, 2002; Coombs and Bierly, 2006; Wang et al., 2006; Hsieh and Thai, 2007; Tsai et al., 2008; Zhou and Wu, 2010).

Human capital is considered to be a significant antecedent of innovation as well (Subramaniam and Youndt, 2005; Lopez-Cabrales et al., 2006; Wang et al., 2006; Foss, 2007; De Winne and Sels, 2010; Bornay-Barrachina et al., 2012; Yen, 2013; Delgado-Verde et al., 2015; McGuirk et al., 2015). Previous studies suggest that human capital enhances innovation because employees' knowledge, skills and abilities influence a firm´s ability to create and use new knowledge (Wang et al., 2008; De Winne and Sels, 2010; Yen, 2013). Based on this assumption, it is reasonable to suggest that the main reason human capital enhances innovation is because it fosters companies' technological capabilities.

Despite the relevance the literature gives to both technological capabilities and human capital as drivers of innovation, empirical research examining the links between these three variables is scarce. There are some papers that provide evidence about the relationship between technological capabilities and innovation, although only for product innovation (Wang et al., 2006; Hsieh and Tsai, 2007; Tsai et al., 2008). There is also some research that focuses on the link between human capital and innovation (Bornay-Barrachina, 2012; Yen, 2013; Delgado-Verde et al., 2015), and on the relationship between human capital and technological capabilities (McKelvie and Davidson, 2009). However, there are no studies that examine the connections between human capital, technological capabilities and innovation in a single model.

This paper attempts to fill this gap in the literature and studies the effects of both technological capabilities and human capital on innovation, suggesting that technological capabilities mediate the relationship between human capital and innovation. The reason why this study focuses on technological innovation -product innovation and process innovation-, is that it is usually considered to be especially relevant in achieving and sustaining long-term competitive advantages in dynamic environments (Leal-Rodríguez et al., 2015).

The analysis of these relationships contributes to the literature, in particular to obtaining a better understanding of how human capital fosters product and process innovations. It also contributes to the literature on the resource-based view and dynamic capabilities by testing the relationships between one intangible resource, one type of dynamic capabilities and technological innovation.

The next section of the paper offers a review of the relevant literature that has focused on the above-mentioned relationships and the formulation of the hypotheses of this research. The hypotheses are then tested using a structural equation model with a sample of 200 Spanish manufacturing firms. The paper finishes by presenting and discussing its main findings and its implications for both practitioners and future research.

2. THEORETICAL FRAMEWORK

2.1. Innovation and technological capabilities

Innovation is usually defined, following Damanpour (1991), as the adoption of a "device, system, policy, program, process, product or service that is new for the adopting organization" (p. 556).

Different typologies of innovation have been proposed in the literature. One of the most extended ones deals with the dual core theory and makes a distinction between administrative and technological innovation, depending on whether the innovation affects the social/administrative structure or the operational/technological area of the company (Damanpour and Evan, 1984). Within the context of technological innovation, the literature distinguishes between product and process innovations (Walker et al., 2015). Product innovation refers to the development of new products and their introduction into a firm´s market (Dougherty and Hardy, 1996). Process innovation is the introduction of any technological operation that is new for the adopting organisation (Collins et al., 1988), and the changes the firm makes in the way it manufactures or serves its products (Tushman and Nadler, 1986). Process innovations include the incorporation of new elements into the production operations or services of an organisation and changes in the specifications of tasks, working mechanisms or the equipment used to create a product or to provide a service (Damampour, 1991).

In dynamic markets, product and process innovations are usually associated with the achievement of a competitive advantage, which, in turn, improves the firm's overall performance (Damanpour and Evan, 1984; Hult and Ketchen, 2001; Garcia and Calantone, 2002; Walker et al., 2015). Regarding product innovation, the literature suggests that a critical factor for a company's survival and growth is that it is able to introduce new products into the market (Wind and Mahajan, 1997). It is also argued that the development of new, unique and superior products allows a company to outperform competitors (Griffin and Page, 1996; Hult and Ketchen, 2001; Droge et al., 2008). Process innovations, according to the literature, can be beneficial for firms because they can help to reduce the costs of production or delivery, increase the quality of products and services, or produce new or significantly improved products (OECD, 2005).

Due to the general consensus on the relationship between innovation and performance, a great number of studies have attempted to identify the variables that enhance innovation. Research has highlighted the critical role of organisational capabilities as antecedents of innovation and, among them, that of technological capabilities (Afuah, 2002; Coombs and Bierly, 2006; Wang et al., 2006; Hsieh and Thai, 2007; Tsai et al., 2008; Zhou and Wu, 2010, Triguero and Corcoles, 2013; Shafia et al., 2016).

Day (1994) defines organisational capabilities as "complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets" (p. 38). They are usually classified into operational capabilities and dynamic capabilities (Helfat and Peteraf, 2003; Cepeda and Vera, 2007). Operational capabilities refer to the abilities of the firm to deploy and coordinate different resources that enable it to carry out its processes effectively and efficiently, while dynamic capabilities are usually understood as the abilities of the company to renew its operational capabilities. According to Teece et al. (1997), these are "the ability of the company to integrate, build and reconfigure internally and externally competencies to address rapidly changing environments". The literature also highlights the relevance of dynamic capabilities as a source of sustainable competitive advantage (Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Verona and Ravassi, 2003, Teece, 2007).

Technological capabilities can be regarded as dynamic capabilities. Tsai et al. (2008), following Nicholls-Nixon (1995), define them as "a firm´s current, and potential, ability to absorb and apply its firm-specific technology to solve technical problems and to enhance the technical functioning of its finished or developing products" (p. 98). Wang et al. (2006) also suggest that the concept of technological capabilities refers to the ability of a firm to transform existing knowledge to develop new products and processes. From these definitions we can conclude that technological capabilities to a firm´s ability to identify technological opportunities, absorb substantial technological information and knowledge and develop new processes or products that respond to previously cited opportunities. Thus, technological capabilities include the three types of dynamic capabilities identified by Teece (2007): the ability to sense opportunities and threats, the ability to seize them and the ability to manage them.

The concept of technological capabilities is closely related to the concept of absorptive capacity, which is considered to be one of the most important enhancers of innovation (Zahra and George, 2002). Cohen and Levinthal (1990) define absorptive capacity as "a firm´s ability to recognize the value of new information, assimilate it and apply it to commercial ends" (p. 128). Technological capabilities are also a firm´s ability to identify relevant information and apply it to commercial ends, but focusing on technological information and how it is used to enhance technological innovations (Wang et al., 2006; Tsai et al., 2008).

The idea that technological capabilities increase a firm´s absorptive capacity and that this variable then fosters innovative activities (Wang et al., 2006; Hsieh and Tsai, 2007; Tsai et al., 2008; Zhou and Wu, 2010) is the underlying assumption of most of the studies that propose a link between technological capabilities and innovation (Zhou and Wu, 2010). In this vein Coombs and Bierly (2006) highlight the importance of technological capabilities as a source of competitive advantage and, in particular, as a driver of product and process improvement. Elsewhere, Song et al. (2007) affirm that technological capabilities have to do with forecasting technological change in the industry and the development of new products, manufacturing processes and technology. Finally, according to Wang et al. (2006), technological capabilities usually enable firms to develop new products or services or to deliver them in innovative ways. In summary, the literature proposes that technological capabilities enhance technological innovation.

Furthermore, some studies have provided empirical evidence of the impact of technological capabilities on technological innovation, in particular on product innovation. For instance, Moorman and Slotegraaf (1999) find that technological capabilities foster new product creativity and increase product development speed, and Wang et al. (2006) provide evidence of a positive relationship between technological capabilities and new product performance. Tsai et al. (2008) found a positive relationship between technological capabilities and innovative performance, measured in their study as the degree to which a firm's products feature productivity, newness and uniqueness. Hsieh and Tsai (2007) come to a similar conclusion since they find a positive relationship between technological capabilities and the adoption of a launching strategy for innovative products; that is, a strategy that seeks a highly innovative product. Zhou and Wu's (2010) findings show that technological capabilities have a positive effect on product innovation in the case of incremental innovation (exploitation) and have an inverted U-shaped relationship with radical innovation (exploration). Finally, using a panel of Spanish companies, Triguero and Corcoles (2013) find a positive relationship between technological capabilities, measured as a firm's accumulated R&D intensity, and its persistence in innovative activities.

Based on existing research, we propose:

H_1: Technological capabilities have a positive effect on technological innovation.

H_{1a}: Technological capabilities have a positive effect on product innovation.

H_{1b}: Technological capabilities have a positive effect on process innovation.

2.2. Technological innovation and human capital: the mediating role of technological capabilities

According to Schultz (1961), existing research usually defines human capital as the knowledge, skills and abilities that reside within and are used by individuals (Subramaniam and Youndt, 2005; Lopez-Cabrales et al., 2006; Foss, 2007; McKelvie and Davidsson, 2009; Yen, 2013). Hence, human capital involves all of the tacit knowledge embedded in a company (Sydler et al., 2014). Based on the resource-based view of firms, human capital is considered to be one of the main sources of a company's competitive advantage and performance (i.e. Wright et al. 1994; Kamoche 1996; Barney and Wright 1998; Wright and McMahan, 2011; Yen, 2013), and some studies suggest that human capital fosters innovation in firms (Subramaniam and Youndt, 2005; Lopez-Cabrales et al., 2006; Wang et al., 2008; De Winne and Sels, 2010; Bornay-Barrachina et al., 2012; Yen, 2013; Delgado-Verde et al., 2015; McGuirk et al., 2015).

According to Yen (2013), the reason human capital enhances innovation is that new information is more easily absorbed by a company when employees already have some knowledge. Thus, human capital influences a company´s ability to create new knowledge and to integrate it into the knowledge base of the firm. In the author´s words: "employees´ knowledge either facilitates or limits the extent to which new information is absorbed, understood, and integrated", thereby influencing a firm´s innovative capabilities. This affects the level of development of new products and processes. Other researchers share this idea (Wang et al., 2008; De Winne and Sels, 2010). Bornay-Barrachina et al. (2012) also highlight that a firm's ability to develop new products is dependent on its human capital because the knowledge employees possess is closely associated with the products and services of the firm.

We have not found research that examines whether technological capabilities mediate the link between human capital and innovation, but there are studies providing evidence of both the direct effect of human capital on innovation and the relationship between human capital and technological capabilities.

The association between human capital and innovation is generally supported by research findings. For instance, one of the conclusions of Yen's (2013) case study, which used eight banks in Taiwan, is that human capital is the most important factor influencing banks´ innovative capability. Some studies using samples of Spanish firms also provide evidence to support the idea that human capital fosters innovation. Bornay-Barrachina et al. (2012) find a significant relationship between human capital and the number of improved and new products developed by a firm and how radical those new products are. Delgado-Verde et al. (2015) also find a positive relationship between human capital and innovation, in particular radical innovation, in their sample of Spanish technologically-intensive manufacturing firms. Finally, one of Spithoven's (2013) findings is that human capital has a positive effect on innovation sales through its effect on R&D intensity. Only the findings of Subramaniam and Youndt (2005) are contrasting. They report that human capital needs to interact with social capital in order to have a positive effect on radical innovation.

Some evidence suggests a link between human capital and technological capabilities. McKelvie and Davidsson (2009), using a sample of Swedish firms, analyse the relationship between some resources, human capital among them, and the development of some dynamic capabilities. Their findings show that human capital is positively associated with the capabilities of idea generation and market disruption, and partially related to that of new process development. Lopez-Cabrales et al. (2006) do not focus on human capital but on a related concept: core employees. They propose that core employees are positively associated with different organisational capabilities, among them technical capabilities. Their findings provide support for their hypothesis that there is an association between core employees and technical capability for innovation.

On the whole, existing research seems to support the idea that:

H_2: There is a positive relationship between human capital and technological innovation, which is mediated by technological capabilities.

> *H_{2a}: There is a positive relationship between human capital and product innovation, which is mediated by technological capabilities.*
>
> *H_{2b}: There is a positive relationship between human capital and process innovation, which is mediated by technological capabilities.*

3. METHODOLOGY

3.1. Sample and data collection

Some research on innovation in Europe has used the Community Innovation Survey (CIS), which collects detailed information about innovative activities and outputs in different European countries, including Spain. However, this paper does not use the CIS because it does not contain information about some important variables included in our research model, in particular, human capital and technological capital. Instead, we conducted our own survey. The population this study focuses on includes Spanish manufacturing firms with more than 100 employees and an age of five or more years. These criteria were adopted in order to guarantee that the companies in the sample had a well-developed innovation system and technological capabilities. 2,113 manufacturing companies fulfilled these criteria in the SABI (Iberian Balance Analysis System) database. The company was the unit of analysis in this study.

Data collection was carried out through surveys. Drawing on previous research, the authors prepared a questionnaire to collect the data, which was pretested. A firm specialised in surveys managed the data collection process. Following the authors' instructions, this firm contacted the R&D manager or, if this was not possible, the CEO, and asked them to answer the questionnaire by phone.

The specialised firm called randomly chosen companies in the population. 1,044 companies were contacted, and 200 companies make up the final sample. Thus, the response rate was 19.16% of the companies contacted. 25% of the companies in the sample had fewer than 143 employees, 50% had fewer than 210 employees and 75% had fewer than 350 employees. We checked for non-response bias by comparing the industries in the population and the final sample in terms of size ($F = 0.942$, $p = 0.332$), return on assets ($F = 0.850$, $p = 0.357$) and return on equity ($F = 0.108$, $p = 0.742$). No significant differences were found between the sample and the population with regard to these variables.

3.2. Measures

The variables included in the research model were considered to be first order factors and were measured using multi-item five-point Likert scales. All of them were developed based on existing research.

Human capital has been understood as the knowledge, skills and abilities residing within and used by individuals. This paper measures this construct using the 5-item scale proposed by Subramaniam and Youndt (2005). Respondents were asked to indicate their degree of agreement (1 = “strong disagreement" and 5 = "strong agreement") with 5 sentences regarding their employees: if they (i) are highly skilled, (ii) are creative and bright, (iii) are experts in their particular tasks, (iv) are able to develop new ideas and knowledge, and (v) are widely considered to be the best in their industry.

The Zhou and Wu (2010) scale was used to measure *technological capabilities*. Respondents were asked to evaluate, in comparison to their major competitors, their firm´s capabilities in the area of: (i) technological information acquisition, (ii) new technological opportunity identification, (iii) technological change response, and (iv) state-of-the-art technological mastery. Scales ranged from 1 = very bad, to 5 = very good.

Technological innovation. This study focuses on product innovation and process innovation. These two variables were measured using scales taken from Gunday et al. (2011). After the depuration of the scale, product innovation was measured using 3 items: (i) improving newness in current products, (ii) developing new products with new components and materials and (iii) decreasing manufacturing costs in product components and materials. Another 3 items were used to measure process innovation: (i) increasing output quality, (ii) decreasing variable costs and/or increasing delivery speed and (iii) determining and eliminating non-value-adding activities. Respondents were asked to evaluate the performance of their firms in these activities in comparison to their competitors (1 = below average; 5= above average).

Control variables. This paper includes three control variables that are usually considered to have an impact on innovation. Market dynamism (3 items) and technological turbulence (3 items) were measured with the scales proposed by Su et al. (2013). Finally, company age was measured as the number of the years since the firm's creation. The last variable was re-coded using the same scale as the other variables.

Post-hoc approaches were used to evaluate the impact of common method bias. This potential problem was tested by using the Harman factor test (Podsakoff and Organ, 1986). The results of principal component analysis indicated that common method variance is not a serious problem in our research because there were several factors with an eigenvalue greater than 1.

3.3. Statistical analysis

The proposed hypotheses were tested using structural equation modelling (SEM). The structural model was estimated through partial least squares (PLS) and using the software package SmartPLS 3.2.6. (Hair et al., 2014). PLS was selected for testing the model proposed in this paper because it is appropriate for small samples and does not require a strong theoretical background (Chin and Newsted, 1999). PLS calculates the amount of explained variance of the constructs of the predictive variables and the coefficients and statistical significance of the structural relations.

Using PLS involves the following two-stage approach. First, the measurement model is assessed, and then the structural model is evaluated. Assessing the measurement model requires the analysis of the attributes of the measures. We examined Cronbach's alpha, average variance extracted (AVE), and composite reliability (CR) to address convergent validity. All measures surpassed the commonly-used threshold values of 0.7 for Cronbach's alpha, 0.5 for AVE and 0.7 for CR (Bagozzi and Yi, 1998; Fornell and Larcker, 1981). To assess discriminant validity, following Fornell and Larcker (1981), we compared the square root of the AVE values (diagonal elements in Table 1) with the correlations among constructs (elements below the diagonal). On average, each construct relates more strongly to its own measures than to the others. In addition, the Heterotrait-Monotrait Ratio (HTMT) values (elements above the diagonal) are below 0.85 (Table 1).

Table 1. Reliability, validity and correlations

	Correlations							Descriptives				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*Mean*	*SD*	*CA*[a]	*CR*[b]	*AVE*[c]
1 Human Capital	***0.776***	*0.562*	*0.443*	*0.286*	*0.113*	*0.146*	*0.312*	3.738	0.654	*0.834*	*0.883*	*0.602*
2. Technol. capabilities	*0.474*	***0.836***	*0.375*	*0.341*	*0.081*	*0.066*	*0.201*	*3.680*	0.684	*0.851*	*0.900*	*0.691*
3. Product Innovation	*0.356*	*0.304*	***0.814***	*0.455*	*0.107*	*0.254*	*0.313*	3.634	0.775	*0.742*	*0.853*	*0.660*
4. Process Innovation	*0.237*	*0.299*	*0.352*	***0.797***	*0.159*	*0.157*	*0.371*	3.469	0.695	*0.716*	*0.841*	*0.638*
5. Firm's age	*0.100*	*0.064*	*0.092*	*0.122*	**-**	*0.144*	*0.017*	2.950	1.399	-	-	-
6. Market dynamism	*0.082*	*0.005*	*0.190*	*0.122*	-0.075	***0.863***	*0.440*	3.419	0.911	*0.792*	*0.831*	*0.557*
7. Technol. turbulence	*0.248*	*0.147*	*0.233*	*0.285*	-0.005	*0.322*	***0.792***	2.720	0.962	*0.700*	*0.831*	*0.622*

Diagonal elements (bold figures) are the square root of the variance shared between the constructs and their measures. Below the diagonal elements are the correlations among constructs. Above the diagonal elements are the Heterotrait-Monotrait Ratio (HTMT) values. [a]Cronbach Alpha. [b]composite reliability. [c] average variance extracted.

The second step is to test the structural model. To estimate indirect effects, this paper follows the procedure suggested by Preacher and Hayes (2008) and applies PROCESS v2.16 (Hayes and Scharkow, 2013). By using the latent variable scores provided by the PLS analysis with 5000 resamples, PROCESS generates 95% bias-corrected bootstrap confidence intervals for the indirect effects. An indirect effect is considered to exist when an interval of a mediating effect does not contain any zero, which means that the indirect effect is significantly different from zero at a 95% confidence level.

4. RESULTS

The results of the PLS model assessment are shown in Figure 1 and Table 2. The R^2 values for the endogenous constructs exceed the minimum of 0.1, which is usually recommended (Falk and Miller, 1992). Furthermore, following the Stone–Geisser-Criterion Q^2 (from the blindfolding procedure) exogenous constructs have predictive relevance for the endogenous constructs studied because their values are above zero (Chin 1998).

Figure 1. Path diagram

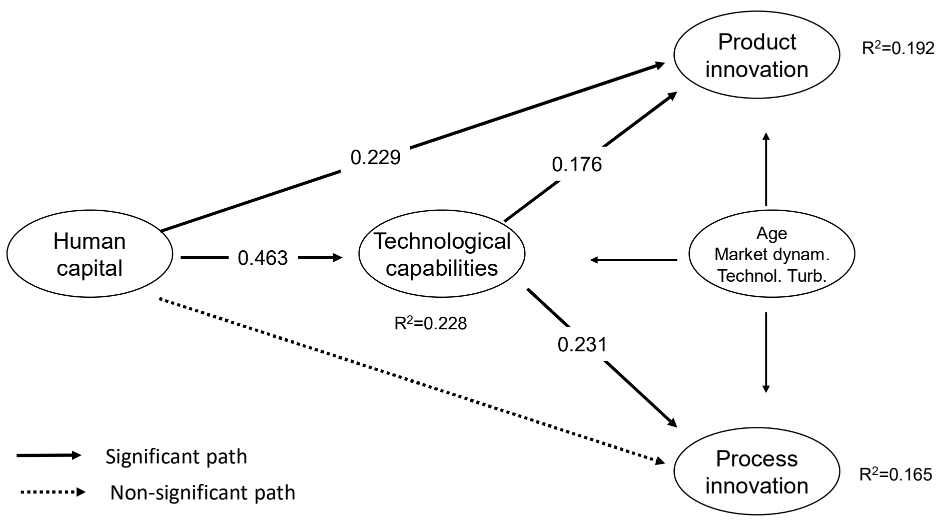

Table 2. Relationships of the structural model

Paths	*Stand. coefficient*	*t values*	*Support*
Technological Capabilities → Product Innovation	0.176*	2.159	Yes
Technological Capabilities → Process Innovation	0.231**	3.128	Yes
Human Capital→ Technological Capabilities	0.463***	7.467	Yes
Human Capital→ Product Innovation	0.229**	2.660	Yes
Human Capital → Process Innovation	0.057	0.657	No
Control variables			
Age → Technological Capabilities	0.014	0.203	
Age → Product Innovation	0.070	1.166	
Age → Process Innovation	0.105*	1.702	
Market Dynamism→ Technological Capabilities	-0.047	0.624	
Market Dynamism → Product Innovation	0.142*	1.684	
Market Dynamism → Process Innovation	0.052	0.693	
Technological Turbulence → Technological Capabilities	0.047	0.561	
Technological Turbulence → Product Innovation	0.106	1.336	
Technological Turbulence → Process Innovation	0.218**	2.731	
Indirect effects			
Human Capital→ Product Innovation	0.082*	1.975	
Human Capital→ Process Innovation	0.107**	2.724	
***p < 0.001, **p < 0.01, *p < 0.05 [based on a Student t(4999) distribution with one tail: t(.001,4999) = 3.092, t(.01,4999) = 2.327, t(.05,4999) = 1.645].			

H_1 proposed a positive relationship between technological capabilities and technological innovation. As expected, the findings provide support for such a relationship for both product innovation (β=0.176, p<0.05) and process innovation (β=0.231, p<0.01).

H_2 proposed a positive relationship between human capital and technological innovation, which is mediated by technological capabilities. The findings (see Table 2) provide evidence of the indirect effect for both product (β=0.082, p<0.05) and process innovation (β=0.107, p<0.01). There is also a positive relationship between human capital and technological capabilities (β=0.463, p<0.001) and between human capital and product innovation (β=0.229, p<0.01). However, there is no significant direct association found between human capital and process innovation.

These findings suggest a partial mediation of technological capabilities in the relationship between human capital and product innovation and a total mediation in the case of process innovation. But in order to provide more robust results for the mediation effects, as mentioned above, PROCESS v2.16 was applied. In our study, mediation requires $\beta_{HC\rightarrow TC} \times \beta_{TC\rightarrow PDIN}$ to be significant. As Table 3 shows, findings using this procedure confirm that technological capabilities partially mediate the relationship between human capital and product innovation (β=0.084, p<0.05; 95% CI ranges = 0.012-0.178). This mediation is partial because there is also a positive relationship between human capital and product innovation ($\beta_{CD}=0.230^{**}$). In addition, the findings show that there is a total mediation of technological capabilities in the relationship between human capital and process innovation (β=0.108, p<0.01; 95% CI ranges = 0.039-0.202) since there is no direct association between these two variables ($\beta_{CD}=0.059^{ns}$).

Table 3. Mediating effects

Mediation Paths	*Total effect*	*Direct effect*	*Indirect effect*			
			Coefficient	*Boot SE*	*95% LL*	*95% UL*
Human capital → Technological capabilities → Product innovation	$\beta=0.315^{***}$	$\beta=0.230^{**}$	$\beta=0.084^{*}$	0.042	0.012	0.178
Human capital → Technological capabilities → Process innovation	$\beta=0.167^{*}$	β=0.059	$\beta=0.108^{**}$	0.041	0.039	0.202

Note: ***p<0.001 **p<0.01 *p<0.05; Bootstrapping based on n = 5.000 subsamples

In summary, our findings provide support for H_1 and partial support for H_2.

5. DISCUSSION AND CONCLUSIONS

The purpose of this paper was to study the relationships among human capital, technological capabilities and product and process innovation. Innovation is widely considered to have a positive effect on performance, which explains the interest in the literature to identify the drivers of innovation. Based on the resource-based view and the dynamic capabilities approach, some studies suggest that two important determinants of innovation are human capital and technological capabilities. However, the empirical research on the effect of these two variables on innovation, especially process innovation, is scarce. Furthermore, the links among the three variables have not been studied together in a single model. By doing this, this paper contributes to the literature, although the main contributions lie in its findings.

First, they provide evidence that technological capabilities are positively related to both product innovation and process innovation. These results are consistent with the conclusions obtained in the few empirical studies that also examine this relationship (Moormand and Slotegraaf, 1999; Wang et al., 2006; Hsieh and Tsai, 2007; Tsai et al., 2008), all of which focus on product innovation. The relationship between technological capabilities and process innovation had not been examined in previous research. Thus, this study provides additional evidence to support the link between technological capabilities and product innovation. It also shows that technological capabilities are positively related to process innovation.

Second, the findings show that there is a positive relationship between human capital and both product and process innovation, in line with the few previous empirical studies that examine the link between human capital and different measures of innovation (Bornay-Barrachina et al., 2012; Yen, 2012; Spithoven, 2013; Delgado-Verde et al., 2015).

More importantly, this paper shows that the relationship between human capital and product and process innovation is mediated by technological capabilities. This conclusion is very important to facilitate understanding of how human capital benefits innovation. Since this mediation had not been tested in previous research, this result constitutes a major contribution to the literature.

Finally, our findings point to different types of mediation for product innovation and process innovation. In particular, they show that the link between human capital and process innovation is totally mediated by technological capabilities, meaning that human capital has a positive impact on process innovation by fostering a firm´s ability to identify technological opportunities, acquire substantial technological information and use it effectively. According to this paper´s results, this is one reason why human capital affects product innovation, although not the only one. The direct relationship found between these two variables suggests that there are other mechanisms through which human capital fosters product processes. It is reasonable to think that human capital can also promote other dynamic capabilities that are essential for product innovation success, such as those related to the identification of changes in consumers' preferences, the acquisition of information about them, and the use of this information for the development of products that respond to those new preferences. But this conclusion is speculative since it has not been tested in this study.

Some managerial implications can be derived from these findings. One of them is that firms seeking to enhance innovation in products or processes should invest in the development of their technological capabilities; that is to say, in the firm´s ability to identify technological opportunities and to acquire and use technological information. The study also shows that firms can develop these abilities by investing in their employees´ knowledge, skills and abilities; in other words, their human capital. Moreover, our results suggest that the human capital effect on product innovation is not only due to the impact of human capital on technological capabilities, but that it goes beyond, which emphasises the relevance of improving human capital in order to create the capacity to develop new products. This paper has not studied how to increase human capital, but previous literature has shown that human resource management practices (hiring, training, rewarding, etc.) are the main mechanisms for carrying this out.

This paper has some limitations that should be mentioned. The first of these is its cross-sectional design, which does not explain the casual relationship between human capital, technological capabilities and innovation. The use of a longitudinal study design could avoid this limitation. Another one is that data were obtained from only one respondent, which may result in a common method variance bias. Finally, this paper fails to explain why technological capabilities only partially mediate the relationship between human capital and product innovation. We have speculated that one likely reason for this finding is that human capital also fosters other dynamic capabilities that are essential for new product development success, such as those related to the identification of changes in market and consumer preferences, but it would be interesting if future research examined this issue.

Apart from addressing the paper´s limitations, future research could advance by adding other variables to our model that could mediate or moderate the relationships we propose. Research has found that the effect of technological capabilities on innovation is moderated by variables like strategic flexibility (Zhou and Wu, 2010) or market turbulence (Wang et al., 2006). Zhou and Wu (2010) also find that the interaction between the variables human capital and social capital has a positive effect on radical innovation. Thus, it would be interesting to include social capital in our model and to examine how this variable interacts with human capital and technological capabilities to enhance innovation. For future research we also suggest distinguishing the different elements of human capital following the recommendations of recent studies (McGuirk et al., 2015). Finally, our model would benefit from the study of the likely complementarities between process innovation and product innovation, as Hullova et al. (2016) suggest.

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