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Linking workforce diversity in education, technological innovation strategies and firms´ organization

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Abstract:
This paper analyses the relationship between workforce diversity in education and skills and the propensity to engage in technological innovation (TI) activities in in the Uruguayan manufacture industry. We have distinguished between embodied and disembodied TI. Results show a positive and significant relationship between both diversity in education and skills and disembodied TI activities. Moreover, the moderating role of flexible forms of work organization is positive and significant for diversity in education when firms engage in disembodied TI.

Keywords: diversity in education; diversity in skills; disembodied technological innovation; work organization
JEL codes: O32 M14 L60

Resumo:
O artigo analisa a relação entre a diversidade em educação e competências da força de trabalho e a propensão inovadora das empresas na indústria uruguaia de transformação. Com o intuito de identificar diferentes estratégias inovadoras, distingue-se entre inovações incorporadas em bens de capital de aquelas desincorporadas que a empresa desenvolve. Observa-se um efeito de mediação positiva das formas avançadas de organização do trabalho na relação entre diversidade e propensão inovadora, mas somente quando em aquelas empresas que desenvolveram inovações não incorporadas.

Palavras chave: diversidade em educação; inovação tecnológica não incorporada, organização do trabalho
Código JEL: O32 M14 L60

1. Introduction

Since the earlier works on industrial economics and management studies, the determinants of innovation propensity have been studied from the Schumpeterian perspective which emphasizes the role of competitiveness and appropriability (Cohen 2010), the dual effect of innovation experience (Cohen and Levinthal, 1990) and several observable characteristics of the firms (e.g. size, age, sector of activity) (Ahuja et al., 2008). However, the roles of people and the way they are organized, as an explanation for the adoption of technological innovation (TI), are still a “black box” (Arrighetti, et al., 2014).

Workforce diversity has recently emerged as a subject of intense study to explain innovation. Race, gender, age, sexual orientation, national origin, tenure, and educational and functional backgrounds have been the most widely studied dimensions of workforce diversity (Laursen, et al., 2005; Shore et al., 2009; Bell et al., 2011; García-Martinez et al., 2017). Nevertheless, empirical evidence is far from conclusive (Lund and Gjerding, 1996; Lee and Walsh, 2016) and there is almost no evidence from less developed contexts.

This paper aims to analyse the relationship between workforce diversity in education and skills (WDES) and the propensity to perform TI activities, distinguishing between embodied and disembodied TI (Cassiman and Veugelers, 200). The level of education and skills are perhaps the most important sources of knowledge, expertise and capabilities of firms (Pelled, 1996; Dahlin et al., 2005; D'Este et al., 2014). As a result, WDES may positively impact the innovation process since it increases the knowledge base, and takes in different points of view, (Østergaard et al., 2011; Parrotta et al., 2014). However, WDES is also a challenge for firms since it might lead to conflict, distrust and negative effects for out-group members (Shore et al., 2009).

Furthermore, the controversial relationship between WDES and the propensity to innovate can be strongly conditioned by the way people are organized within the company. Faems and Subranamian (2013) call for considering how the workforce is structured and managed to analyse the impact of workforce diversity in education and innovation. Also, for people to apply knowledge in a creative way they must have opportunities to do so (Hao et al., 2012). Relatedly, it has been stated that decentralised knowledge management is positively associated with the effective adoption of TI (Hao et al., 2012). However, due to conflict between employees, the development of effective working relationships is more difficult in diverse workplaces than in homogeneous ones (van Knippenberg et al., 2004). In order to shed new light on this point, this paper considers how the organization of work moderates the relationship between diversity in education and skills and the adoption of TI activities.

We estimate these relationships by using panel data techniques for Uruguayan industry between 2004 and 2012.

The paper contributes to the related literature in several ways. First, we developed a longitudinal analysis of workforce diversity in education and skills as a determinant factor to explain the adoption of TI activities. Second, we carried out a firm level analysis that considers the composition of the firm’s entire workforce rather than the just top management or the R&D team. Third, distinguishing between embodied and disembodied TI activities allows us to shed light in the relationships between diversity in education and skills and the adoption of different TI activities (Evangelista et al.1997; Cassiman and Veugelers, 2000; Chamberlin and Doutriaux, 2010). Finally, the paper contributes to advance in the knowledge of innovation in the Latin-American context. In this sense, in spite of the long research tradition on innovation, industry and development in Latin America, this region has received little attention in the academic literature on innovation and human resource management.

2. Theoretical Framework

Theories that are useful to understanding the relationship between WDES and the adoption of TI activities are both varied and broad in scope.

The resource based view (RBV) theory posits that internal firm resources are drivers for competitive advantage (Wernerfelt, 1984; Barney, 1993). Within this theory, the knowledge based view (KBV) considers knowledge as the most important competitive resource of a firm since it is usually difficult to imitate and is socially complex (Grant, 1996). According to this theory, WDES increases the knowledge base of the firm, which in turn contributes to developing distinctive capabilities; for instance, identifying and exploiting new and different sources of information (Zahra and George, 2002) or broadening points of view (Lundvall and Johnson, 1994). In this sense, highly qualified workers with heterogeneous professional profiles have a wider variety of approaches to tackle a particular technological challenge, improving the likelihood of success in innovation. In addition, diversity in a firm's knowledge base increases the ability to exploit knowledge from external sources (Ostergard et al., 2011), which is particularly important in less developed contexts where systemic linkages are weak and highly qualified workers are more informed about the sources of information and knowledge (Sutz, 2012). In sum, according to this theory WDES is expected to be positively related to the adoption of embodied TI but particularly important for disembodied TI activities, which are more intensive in the use of knowledge (Yoon and Lee, 2012).

From a different but complementary perspective, the evolutionary economics of innovation sees diversity as one of the pillars of its approach (Silverberg, et al., 1988). Within this perspective, diversity appears as one of the main factors in the evolutionary path of a firm (Nguyen et al., 2005), and, in turn, it allows firms to build new competencies (Malerba and Orsenigo, 2000). Moreover, from the intersection of industrial economics and industrial relationship, variety has been seen as a key feature of an industrial regime (Coriat, 1995).

Others perspectives support negative effects of workforce diversity on the adoption of TI. According with the transaction cost theory (Coase, 1937), workforce diversity may lead to an increase in transaction costs related to communication, coordination and the motivation of a heterogeneous workforce (Williamson, 1981). Moreover, the similarity-attraction theory (Horwitz, 2005) points out that diversity may run contrary to the effectiveness of the group since individuals that are more similar are supposed to be more effective when working together. As a result, workers are aligned along social identity in a way that might cause conflict when a large number of different professional categories and viewpoints coexist (Schneider and Northcraft, 1999). This situation often results in competitive behaviour and less cooperation and communication than in homogeneous groups.

In sum, there is a trade-off in the relationship between workforce diversity and the adoption of TI activities that would be determined by the number and balance of different categories. However, as several scholars suggested, the creativity benefits of diversity are more relevant for the generation of new knowledge than the cost of coordination and communication that typically affects the general functioning of diverse organizations (García-Martínez et al., 2017). In addition, the potential negative cost effects of workforce diversity in education and skills are expected to be higher in the presence of a large number of differentiated categories which in turn are related to the context (e.g. developed or non-developed), firm size and industrial sector. In less developed countries, industries or regions, there is usually less differentiation in categories of professionals and skilled workers (Zuniga and Crespi, 2013; Bianchi et al., 2011).

Empirically, evidence connecting workforce diversity in education and skills is often focused on composition of the top management team (Li et al., 2016) and on the multi-dimensional nature of diversity, generally to explain performance but not the propensity to engage in TI activities (Bantel and Jackson, 1989; Pitcher and Smith, 2001). Williams and O´Reilly (1998) highlight that workforce diversity in education enhances the innovation process. Teams more diverse in education have the ability to create solutions for complex problems (Bantel and Jackson, 1989). They are able to integrate different perspectives and opinions encouraging mutual, novel and creative solutions (Faems and Subranamian, 2013). From another perspective, Dahlin et al. (2005) showed that team diversity in education levels provided information-processing benefits that outweighed the limitations associated with social categorisation processes. They also demonstrated, along the lines of Cohen and Levinthal (1990), that the relationship between workforce education and skills diversity and innovation can be quadratic in the form of an inverted U. That is, the effects of workforce diversity are positive up to a saturation point beyond which the organisation of a large number of different categories of workers (e.g. professions or skill profiles) may lead to diseconomies of specialisation and higher transaction costs due to asymmetries of information and social conflicts.

On the other hand, TI is a rich concept that refers to different activities that require different types of knowledge from the firm's members. In this regard, we use a basic distinction between embodied and disembodied TI (Cassiman and Veugelers, 2000; Evangelista et al., 1997). As these early works have pointed out, innovation activities embodied in good and service purchased, are the most frequent TI activity when considering the manufacturing industry as a whole (Evangelista et al., 1997). Moreover, disembodied activities, mainly based on R&D, are less frequent and usually show higher requirements for workforce qualifications and a significant correlation with employee educational attainment (Pacelli et al., 1998; Zuniga and Crespi, 2013). Actually, some works have defined TI strategies based on artefact acquisition as technological upgrading rather than innovation activities (Santamaría et al., 2009; Pellegrino et al., 2012). Therefore, the presence of different skills profiles as a part of broad, varied and balanced knowledge bases and different views increases the likelihood of carrying out disembodied TI activities.

Given the above arguments, we propose the following hypothesis:

H1a. There is a positive association between workforce diversity in education and skills and the likelihood of adopting TI in less developed contexts.

H1b. The positive association between workforce diversity in education and skills and the likelihood of adopting TI is higher for disembodied than for embodied TI for the case of developing countries.

Workforce diversity and innovation have a complex and controversial relationship, potentially moderated by contingent factors such as the way that people are organised within the firm (Yang and Konrad, 2011). The academic literature in this field has dealt with the relationship between organizational and technological innovation, but there is usually a blurred distinction between the adoption of organizational innovations, the structure of the organization and the way work is regularly organized in firms. In this sense, it is important to distinguish between the adoption of organizational innovations, such as implementing new managerial and working concepts and practices (Armbruster et al., 2008), and the organization of work in the firm which defines how activities such as task allocation, coordination and supervision are directed toward the achievement of organizational aims. Several researchers have paid attention to the relationship between organizational and technological innovations (Sapprasert and Clausen, 2012; Camisón and Villar-López, 2014). However, understanding the relationship between workforce diversity and the propensity to adopt TI activities should involve taking into consideration the firm's work organization. The distinction between the two things is not very intuitive, and in fact, organizational innovations and organizational structure are closely related. The organizational structure of firms is the result of a continuous process of incorporating organizational innovations that ultimately changes the way the work is regularly organized (Teece, 1992). Firms with more flexible organizational structures are those which have implemented practices that facilitate the interaction of employees with different profiles, have reduced vertical differentiation among hierarchies and have promoted work in inter-functional groups. These structures favour the development of new ideas or complex problem solving associated with the decision to pursue innovations and in particular the internal development of them (Kimberly and Evanisko, 1981; Teece, 1992; Bresman and Zellmer-Bruhn, 2013).

The role played by the organizational structure in the relationship between WDES and the adoption of TI is not clear. On the one hand, the presence of heterogeneous workforce profiles may favour sustaining close relationships between internal functions of the firm, reduced transactions costs of externalization and also improving the ability to access information and knowledge for the internal development of TI (Kochan et al., 2003). Moreover, it has been stated that flexible approaches to work organization may also facilitate the exploitation of group capacities associated with members' educational backgrounds, which facilitates the application of routines and in turn contributes to building distinctive TI capabilities (Camisón and Forés 2010). Flexible organizational routines improve initial steps in TI, by enabling to overcome potential difficulties in managing a varied skilled workforce during the implementation phase (Østergaard et al., 2011).

However, the development of effective working relationships is more difficult in diverse workplaces than in homogeneous ones (van Knippenberg et al., 2004). Harrison and Klein (2007) suggested that favourable outcomes from diversity are conditioned by the effective participation of employees in the decision making process. Williams and O´Reilly (1998) noted that the positive effects of employee diversity on the innovation process are associated with the initial steps (creative, searching, etc.). They highlighted that diversity has potential negative effects after the search phase, when solutions are implemented. In addition, negative effects could increase increased by the presence of flexible organizational structures.

Regarding the context under study, certain organizational patterns observed in Latin American countries may limit processes related to creativity and development of products and processes (Elvira and Davila, 2005). For instance, it has been mentioned that inequality and power distance are accepted, which in many cases translates into observing very vertical organizations, with a clear paternalism on the part of line managers and above (Hofstede, 1980; Osland et al., 1999; Pellegrini and Scandura, 2008). Likewise, “personalized” relationships between managers and operators are fairly typical and are valued by operators in Latin America (Albert, 1996). Bello-Pintado (2011) stated that flexible organizations are only a small proportion of the total number of firms in the Uruguayan manufacturing sector; however, he found a positive correlation between flexible organizational forms and organizational performance measures such as productivity, quality or innovativeness. This evidence supports the view that in low-development contexts where product and process innovations are widely based on the use of embedded technology, the presence of flexible organizational structures may favor innovation in products and processes. This approach to organization of work allows professionals to expand their own knowledge and experience to make better decisions. Also, the more flexible the organization is, the greater the creative and learning capabilities of heterogeneous employees (Bresman and Zellmer-Bruhn, 2013). Therefore, it is expectable that the positive association between workforce diversity in education and the propensity to adopt TI will be positively moderated by the presence of flexible organizational forms.

Based on these arguments, we propose the following hypothesis:

H2a. The positive association between workforce diversity in education and skills and the likelihood of adopting TI is positively moderated by the presence of flexible organizational forms.

H2b. The positive moderation of flexible organizational forms is higher for the adoption of disembodied than embodied TI.

3. Methods

The empirical strategy is based on analysis of panel data from the Uruguayan Industrial Innovation Survey (UIIS). Three waves of the UIIS were merged, covering the 2004-2012 period. The structure of the final dataset is an unbalanced panel which includes only the firms that were surveyed in at least two waves. Said panel includes 1,721 observations from 668 firms, of which 385 were surveyed in three waves and 283 in two.

The UIIS examines whether firms engaged in TI activities and its questionnaire enables to discern between disembodied and embodied TI. In addition, the survey captures the organizational structure of firms through the degree of centralization, use of incentives, vertical differentiation, mechanisms adopted to promote participation of employees and the use of improvement groups. In addition, the questionnaire includes information about WDES, in terms of different professional profiles (*education*) and the job categories in the firm (*skills*).

3.1 Dependent variable: technological innovation (disembodied vs. embodied)

We considered three dummy dependent variables that indicate if the firm has conducted different types of TI activities. First, we distinguished between firms that carried out any TI activities and those firms that did not (*inn_tech*). Second, in order to test different relationships between WDES and both embodied and disembodied TI activities, we divided the innovative firms into those that develop disembodied TI (internal and external R&D and reception of technology) (*disembodied*) and those that only develop TI based on knowledge embodied in artefacts (acquisition of capital goods or software to innovate) (*embodied*).

Embodied TI activities are the most common in manufacturing industries, both in developed (Ballot et al., 2015) and in developing countries (Zuniga and Crespi, 2013) like Uruguay (Bianchi et al., 2015). Empirical evidence stresses that firms that conduct TI are usually engaged in a TI strategy that includes acquiring embodied knowledge (Crespi and Tacsir, 2012; Evangelista et al., 1997), although this does not imply a trend in the other direction from embodied to disembodied TI. Therefore, the second dependent variable (*embodied*) takes a value of 1 for all the firms that conducted any disembodied TI, regardless of whether they also carried out embodied TI.

In this regard, it is worth considering that 46.6% of the observations included in our dataset correspond to firms which have conducted TI activities. Among the firms that conducted TI activities, 55.61% have done disembodied TI and 87.03% have done embodied TI. In turn, among the firms that carried out disembodied TI, 76.68% also carried out TI activities embodied in artefacts.

3.2 Independent variables: workforce diversity in education and skills (WDES)

As Harrison and Klein (2007) stressed, workforce diversity is a polysemous concept that encompasses multiple dimensions. In this sense, regarding our interest on workforce educational and skills diversity as an indicator of the breadth of knowledge sources, we focus on a specific dimension of diversity: variety. It is defined as the composition of differences in kind, source, or category in relation to information, knowledge or experience among unit members.

According to the information available in the UIIS database, we measure WDES within a firm through two variables comprised of different indicators and calculate Blau’s heterogeneity index (1) (Blau, 1977).

$$1 - \sum_{i=1}^{k} p_i^2 \quad (1)$$

where k is the total number of diversity-related characteristics, i is the characteristic of interest and p_i is the proportion of individuals with characteristic i among the totality of individuals with k characteristics in the firm. Higher values of the Blau index indicate more variety in the attribute of interest and meanwhile it considers the relative weight of each characteristic i as an indicator of how balanced the diversity is.

The first independent variable (*education*) captures the variety of specific professional profiles. It indicates in particular the breadth of knowledge backgrounds, which affects the potential innovation paths that the firm is able to see potentially feasible (Lund and Gjerding, 1996; Sutz, 2012). This measure only captures the formal training of a particular type of employees and neglects the potential diversity originating from training in the workplace and learning by doing (Jensen et al., 2007). However, this information is not available in either the UISS nor in the CIS type survey.

We compute *education* (k=10), taking into account the ten professional backgrounds (i) registered by the UIIS: 1) Physics and chemistry, 2) Mathematics and statistics, 3) Biology, biochemistry and biophysics, 4) Medicine, 5) Engineering, 6) Architecture, 7) Systems engineering, 8) Agricultural engineering and veterinary medicine, 9) Accounting and law, 10) Humanities and social sciences. The proportion of individuals (p_i) is calculated as the ratio between the number of professionals with each background *i* and the total number of professionals in the firm's workforce.

The second independent variable (*skills*) considers all job categories among the firms. It accounts for four employment categories (k =4) related to educational attainment (i): 1) professionals, 2) technicians, 3) administrative employees and 4) factory employees, each of which as a share (p_i) of the firm's total workforce.

This second indicator informs about the distribution of skills within a firm, measured as the number of categories which in turn complements the knowledge provided by *education.* Moreover, since variety of skills in the firm measures educational attainment in the firm, it does not capture learning by doing

We assume that these are different measures of WDES and that they can have different results. To compare the different results, we applied a standardization by multiplying each Blau index by $k/(k\ -1)$ (Biemann and Kearney, 2010).

We use lagged independent variables. As usual, it meant losing observations, but it allowed us to control for endogeneity problems related to the simultaneity of TI activities and variety indicators (Secchi et al., 2014; Quintana-García and Benavides-Velasco, 2008).

Finally, we use a specific control variable to distinguish between the effect of workforce skill level and WDES. It is a necessary control because *education* and *skills* indicators are based on count variables of educational attainment, which is directly related to workforce skills and, in turn, it is likely related to the decision to engage in TI activities (D'Este et al., 2014; Lund Vinding, 2006). Considering the empirical background on the innovation behaviour of Uruguayan industry (Bianchi et al., 2011), we use a variable (*p_prof*) computed as the ratio between the number of professionals and the whole workforce of the firm.

Table 1. Name and type of variables included in the estimations

Variable	Name	Type	
1. Technological innovation	*inn_tech*	Dichotomous	Dependent
2. Embodied Innovation	*embodied*	Dichotomist	Dependent
3. Disembodied Innovation	*disembodied*	Dichotomous	Dependent
4. Blau index professional WDES	*education*	Interval	Independent
5. Blau index total WDES	*skills*	Interval	Independent
6. Organization of work index	*OW*	Ordinal	Moderating
7. Professional employees (%)	*p_prof*	Interval	Control
8. Size of firm (log)	*logSize*	Interval	Control
9. FDI	*FDI*	Dichotomous	Control
10. Age	*logAge*	Interval	Control
11. Exports (%)	*export*	Interval	Control
12. Dummy of activity sector		Dichotomous	Control

3.3 Moderating variable

To analyse the moderating effects of the organisation of work on the relationship between WDES and TI propensity, we adapt classifications previously developed by Camisón and Villar-López (2014) and Lund and Gjerding (1996) using information from a specific section of the UIIS devoted to work organisation.

Similarly to Smith et al. (2005), to capture the progressive positive increment in advanced work organization, we used an additive index (*OW*) which counts five ways in which the firm may have implemented: continuous improvement groups, inter-functional working groups, permanent internal communication practices, vertical differentiation (reduction in hierarchical levels). The descriptive statistics indicate that, on average, Uruguayan manufacturing firms have more traditional forms of work organization, with the index taking a value of 1.342 in a 0-5 scale (Table 2).

3.4 Control variables

Our analytical model is completed with four firm-level control variables that have been analysed as determinants of TI activities in the literature from economics and innovation management (Cohen, 2010; Ahuja et al., 2008; Becheikh et al., 2006).

First, we consider *firm size* (*logSize*). Previous studies about innovation in Latin America stressed that the relatively small size of the firms can affect access to the minimum financial and human resources needed to conduct disembodied TI activities (Crespi and Tacsir, 2012; Chudnovsky et al., 2006). Therefore, we expect a positive relationship between the firm's size and TI propensity. We measured size as the total number of employees in the firm, using a logarithmic transformation to deal with non-normality in the distribution of the variable.

On another hand, the evidence about the knowledge diffusion effect of *foreign direct investment* (*FDI*) in developing countries shows the relevance of internal capabilities and human resources (Marín and Sasidharan, 2010). Hence, we expect a positive relationship between FDI and innovation propensity, when controlling for WDES. We measured FDI as a dummy variable which takes a value of 1 if the foreign capital is equal to or greater than 10% of the entire capital of the firm, which is the most common threshold used in Latin America to distinguished firms with foreign capital (Chudnovsky and López, 2007).

The *age of the firm* (*logAge*) is measured as the difference between the year of the survey wave and the year when the firm opened for business. In addition, we used a logarithmic transformation to deal with the non-normal distribution. There is evidence that a firm’s age negatively affects innovation intensity in high-tech industries in developed countries (Balasubramanian and Lee, 2008), while in low-tech industries older firms may have more internal assets to conduct TI activities, in particular embodied TI activities (Thornhill, 2006). Hence, we expect a positive relationship between the age and the innovation propensity of the firm.

The correlation matrix between variables of interest (Table 2) shows expected results in line with our hypothesis, in particular significant correlation between the Blau indexes of TI activities. However, the symmetric results between embodied and disembodied TI is unexpected. Regarding the distribution of these variables, these results suggest that the economic estimations should be interpreted with caution, but also support the idea of a moderating role of advanced organizational forms in the relationship between educational variety and innovation propensity.

Finally, estimations are controlled for by the *firm’s activity sector*. We recoded the International Standard Industrial Classification (ISIC) to consider seven groups of activity. Each of them is introduced as a dummy variable in the models: a) food, beverages and tobacco; b) textiles, clothing, leather and shoes; c) wood and paper; d) chemical, rubber and minerals; e) metallurgy and transport vehicles; f) machinery and equipment (industrial, office, electrical, communications and medical); and g) others (print and furniture). Previous works highlighted the relevance of the activity sector as an indicator the structure of the market faced by the firm and technological characteristics of the firm (Ahuja et al., 2008). However, previous empirical studies on the Uruguayan economy showed high intersectoral and intrasectoral heterogeneity (Bianchi et al., 2015; Cassoni 2012). Moreover, few sectors show a significant correlation with the dependent variables (Table 3). Hence, we will test sectoral effects but we do not expect significant differences among sectors.

Table 2. Descriptive statistics and correlation matrix

Variable	Mean	s.d.	Min.	Max	N	1	2	3	4	5	6	7	8	9
1. inn_tech	0.466	0.498	0	1	1721									
2. embodied	0.443	0.497	0	1	802	0.546*								
3. disembodied	0.556	0.497	0	1	802	0.633*	-1.000							
4.education	0.545	0.242	0	0.952	1087	0.173*	-0.160*	0.160*						
5.skills	0.543	0.255	-0.013	1.333	1721	0.202*	-0.173*	0.173*	0.096*					
6.OW	1.342	1.393	0	5	1721	0.326*	-0.290*	0.290*	0.152*	0.139*				
7.p_prof	0.060	0.076	0	0.631	1721	0.206*	0.265*	0.265*	0.097*	0.438*	0.217*			
8.logSize	4.136	1.076	2.302	7.809	1721	0.269*	-0.092*	0.092*	0.324*	-0.127*	-0.066*	0.411*		
9.FDI	0.159	0.366	0	1	1721	0.107*	-0.055	0.055	0.189*	0.138*	0.137*	0.198*	0.318*	
10.logAge	3.158	0.861	0	4.962	1707	0.114*	-0.100*	0.100*	0.100*	0.213*	0.051*	0.128*	0.190*	0.283

*p<0.05

Table 3. Sectoral distribution of observations and correlation matrix

Industry	N	%	*inn_tech*	*embodied*	*disembodied*	*Blau_prof*	*Blau_tot*	*OS*	*p_prof*	*log_Size*	*FDI*	*log_Age*
Machinery	120	6.97	-0.040	0.033	0.041	-0.055	0.065*	0.034	0.058*	-0.123*	-0.057*	-0.030
Textiles	254	14.76	-0.063*	-0.024	-0.046	-0.0494	-0.187*	-0.066*	-0.179*	-0.004	-0.087*	-0.007
Wood	94	5.46	-0.014	-0.011	-0.145*	-0.007	-0.018	-0.029	0.000	-0.033	0.048*	-0.038
Chemicals	385	22.37	0.096*	-0.069	0.113*	0.067*	0.237*	0.153*	0.310*	-0.045	0.074*	0.117*
Metallurgy	163	9.47	-0.039	-0.019	-0.024	-0.089*	-0.028	-0.019	-0.059*	-0.050*	0.021	-0.012
Food	602	34.98	-0.023	0.040	0.028	0.107*	0.059*	-0.084*	-0.107*	0.207*	0.032	-0.050*
Others	103	5.98	0.078*	0.072*	0.070*	-0.127*	-0.105*	0.012	-0.050*	-0.102*	-0.076*	-0.008

*p<0.05

Considering the existence of significant correlation between several of the explanatory and control variables, we test for multicollinearity through the *variance inflation factor* (VIF) and its inverse, the *tolerance indicator* (Table 4), both of which show that there is no sign of serious multicollinearity problems on the left hand side of the models.

Table 4. Collinearity diagnostics

Variable	VIF	Tolerance	R-squared
education	1.25	0.7969	0.2031
skills	1.43	0.6999	0.3001
OW	1.16	0.8595	0.1405
p_prof	1.65	0.6054	0.3946
logSize	1.91	0.5249	0.4751
FDI	1.25	0.7982	0.2018
logAge	1.11	0.9049	0.0951
Mean VIF	1.39		

3.5 Models and estimations

We tested the hypotheses outlined in this paper by means of discrete choice panel data models. In order to evaluate the robustness of the estimations, *logit* fixed effects and random effects with robust standard errors were tested.

The first model, used to test *H1a* and *H1b*, is specified as:

$$P(y_{it} = 1) = \beta_0 + \beta_1 education_{t-1} + \beta_2 skills_{t-1} + \beta_3 (z_t) + \varepsilon_{it} \qquad (2)$$

where *y* is the dichotomous independent variable taken at time *t*, *i* refers to the type of TI activity (*inn_tech*, *disembodied*, *embodied*); $education_{t-1}$ is the independent variable which measures firm's professional profiles lagged one period; $skills_{t-1}$ is the independent variable that measures firm's total skills through job categories, also lagged one period, and (*z*) is a vector of control variables at time *t*. Finally, ε is the error term. We included the square of the independent variables in order to test a quadratic (inverted U shaped) distribution.

Second, we tested for the moderating effects of the type of work organization on the relationship between WDES and TI activities (*H2a* and *H2b*) through the following specification:

$$P(y_{it} = 1) = \beta_0 + \beta_1 education_{t-1} + \beta_2 skills_{t-1} + \beta_3\, OW_{t-1} + \beta_4 (OW_{t-1} * education_{t-1}) + \beta_5 (OW_{t-1} * skills_{t-1}) + \beta_6 (z_t) + \varepsilon_{it} \qquad (3)$$

where all the terms presented in equation (2) remain, and we add the indicator of advanced forms of work organization (*OW*) to the equation with a one-period lag, as well as interaction terms between the independent variables and the moderating ones.

The option with fixed effects is clearly better for managing endogeneity problems between explanatory and dependent variables. Moreover, it arguably is better to capture the firm-specific features that affect TI propensity. However, this specification is not free of problems. First, as was demonstrated in the empirical literature, when specific features of the firms are captured through fixed effects models, the effects of other relevant exogenous variables may be hidden (Cohen, 2010). Second, in our dataset the variation among the cases is low, which affects the goodness of fit of the model. Finally, when considering the strengths and weaknesses of each specification (Table 5) we find that there is a slight advantage for the random effects option (prob>chi2 > 0.05) over the fixed effects one.

Table 5. Hausman test to compare fixed vs. random effects models results

	Coefficients			
	(b)	(B)	(b-B)	sqrt (diag(V_b-V_B))
	fe	re	Difference	S.E.
education(lag)	-0.811	0.788	1.599	0.975
skills(lag)	-1.193	0.760	1.954	0.772
OW(lag)	-0.213	0.207	-0.421	0.150
p_prof	13.939	7.731	6.208	5.787
logSize	1.604	0.744	0.860	0.824
FDI	-2.496	-0.717	-1.778	1.104
logAge	0.431	0.246	0.184	0.763

b = consistent under Ho and Ha; obtained from xtlogit
B = inconsistent under Ha, efficient under Ho; obtained from xtlogit

Test: Ho: difference in coefficients not systematic

chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 14.58
Prob>chi2 = 0.0680

Therefore, we ultimately selected the random effects specification models. The models were estimated in successive steps, incorporating each variable into each new estimation (Tables 6-8).

Table 6. Logit random effects model: Dependent variable TI

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
education	Coef	1.004**	1.104	0.899**	0.789**	0.311	0.316				
	SE	(0.411)	(1.184)	(0.404)	(0.400)	(0.547)	(0.544)				
	Margin	0.0146	0.351	0.0263	0.0486	0.570	0.561				
education_sq	Coef		-0.124								
	SE		(1.362)								
	Margin		0.927								
OW	Coef			0.223***	0.208***	0.0138	-0.321			0.245***	-0.0105
	SE			(0.0687)	(0.0689)	(0.149)	(0.210)			(0.0630)	(0.148)
	Margin			0.00115	0.00257	0.927	0.127			9.81e-05	0.944
*education*OW*	Coef					0.380					
	SE					(0.251)					
	Margin					0.129					
skills	Coef				0.761*		-0.166	0.804**	1.707	0.652*	0.0182
	SE				(0.443)		(0.609)	(0.370)	(1.430)	(0.357)	(0.473)
	Margin				0.0859		0.786	0.0300	0.233	0.0678	0.969
skills_sq	Coef								-0.804		
	SE								(1.215)		
	Margin								0.508		
*skills*OW*	Coef										0.456*
	SE										(0.245)
	Margin										0.0625
p_prof	Coef	9.360***	9.382***	8.435***	7.731***	8.465***	7.625***	9.091***	9.068***	8.053***	7.929***
	SE	(1.862)	(1.857)	(1.755)	(1.760)	(1.756)	(1.751)	(1.729)	(1.720)	(1.627)	(1.627)
	Margin	4.96e-07	4.37e-07	1.53e-06	1.12e-05	1.42e-06	1.34e-05	1.45e-07	1.35e-07	7.45e-07	1.10e-06
logSize	Coef	0.813***	0.816***	0.728***	0.745***	0.724***	0.752***	0.870***	0.871***	0.750***	0.765***
	SE	(0.135)	(0.138)	(0.130)	(0.129)	(0.129)	(0.129)	(0.108)	(0.108)	(0.105)	(0.106)
	Margin	1.86e-09	3.19e-09	1.93e-08	7.00e-09	1.88e-08	5.56e-09	0	0	0	0
FDI	Coef	-0.588**	-0.590**	-0.671***	-0.717***	-0.683***	-0.793***	-0.613**	-0.595**	-0.689***	-0.750***
	SE	(0.263)	(0.265)	(0.257)	(0.258)	(0.258)	(0.269)	(0.247)	(0.246)	(0.239)	(0.245)
	Margin	0.0253	0.0258	0.00896	0.00544	0.00807	0.00315	0.0132	0.0153	0.00393	0.00225
logAge	Coef	0.288**	0.289**	0.285**	0.246**	0.279**	0.232*	0.0517	0.0466	0.0589	0.0518
	SE	(0.130)	(0.129)	(0.126)	(0.126)	(0.125)	(0.127)	(0.119)	(0.119)	(0.115)	(0.116)
	Margin	0.0260	0.0257	0.0234	0.0497	0.0258	0.0669	0.664	0.695	0.607	0.655
machinery	Coef	0.263	0.265	0.115	0.0559	0.135	0.0724	0.156	0.158	-0.00214	0.00644
	SE	(0.420)	(0.421)	(0.416)	(0.415)	(0.417)	(0.419)	(0.355)	(0.355)	(0.351)	(0.356)
	Margin	0.531	0.529	0.782	0.893	0.746	0.863	0.661	0.657	0.995	0.986
textiles	Coef	-0.0515	-0.0515	-0.141	-0.102	-0.137	-0.117	0.187	0.200	0.118	0.0948
	SE	(0.338)	(0.338)	(0.327)	(0.321)	(0.326)	(0.314)	(0.258)	(0.259)	(0.247)	(0.246)
	Margin	0.879	0.879	0.666	0.751	0.674	0.710	0.469	0.439	0.632	0.700
wood	Coef	0.150	0.147	0.0733	0.109	0.0537	0.118	0.510	0.511	0.458	0.463
	SE	(0.541)	(0.540)	(0.537)	(0.541)	(0.535)	(0.523)	(0.377)	(0.374)	(0.363)	(0.363)
	Margin	0.781	0.785	0.891	0.840	0.920	0.822	0.176	0.171	0.207	0.203
chemical	Coef	0.0339	0.0345	-0.107	-0.169	-0.0996	-0.198	0.270	0.279	0.129	0.101
	SE	(0.248)	(0.249)	(0.239)	(0.235)	(0.236)	(0.234)	(0.236)	(0.236)	(0.225)	(0.227)
	Margin	0.891	0.890	0.653	0.472	0.673	0.398	0.253	0.237	0.568	0.656
metallurgy	Coef	-0.535	-0.535	-0.589	-0.622*	-0.564	-0.608*	-0.179	-0.184	-0.249	-0.264
	SE	(0.382)	(0.383)	(0.360)	(0.356)	(0.359)	(0.361)	(0.344)	(0.344)	(0.325)	(0.329)
	Margin	0.162	0.162	0.102	0.0802	0.116	0.0924	0.604	0.593	0.443	0.423
others	Coef	1.504***	1.508***	1.257***	1.173***	1.214***	1.127***	1.279***	1.263***	1.078***	1.070***
	SE	(0.407)	(0.413)	(0.396)	(0.394)	(0.395)	(0.389)	(0.363)	(0.362)	(0.342)	(0.341)
	Margin	0.000221	0.000256	0.00150	0.00288	0.00210	0.00379	0.000428	0.000478	0.00160	0.00169
food (omitted)			-	-	-	-	-	-	-	-	-
Observations		720	720	720	720	720	720	1,053	1,053	1,053	1,053
Firms		454	454	454	454	454	668	668	668	668	668

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7. Logit random effects model: Dependent variable disembodied TI

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
education	Coef	1.364**	-1.940	1.176*	1.104*	-0.681	-0.894				
	SE	(0.631)	(1.837)	(0.625)	(0.640)	(0.890)	(0.903)				
	Margin	0.0306	0.291	0.0598	0.0848	0.444	0.323				
education_sq	Coef		3.809*								
	SE		(2.030)								
	Margin		0.0606								
OW	Coef			0.205**	0.190*	-0.430	-0.260			0.186**	-0.402
	SE			(0.103)	(0.104)	(0.267)	(0.382)			(0.0812)	(0.449)
	Margin			0.0470	0.0679	0.107	0.496			0.0219	0.371
*education*OW*	Coef					1.096***					
	SE					(0.425)					
	Margin					0.00992					
skills	Coef				0.588		1.324	0.731	1.947	1.655	-2.805
	SE				(0.738)		(1.063)	(0.512)	(1.773)	(1.720)	(2.596)
	Margin				0.425		0.213	0.153	0.272	0.336	0.280
skills_sq	Coef								-1.034	-0.944	3.312
	SE								(1.421)	(1.386)	(2.243)
	Margin								0.466	0.496	0.140
*skills*OW*	Coef										2.651*
	SE										(1.542)
	Margin										0.0855
p_prof	Coef	6.321**	5.895**	5.632**	5.089**	5.689**	5.147**	7.198***	7.182***	6.619***	6.701***
	SE	(2.592)	(2.493)	(2.397)	(2.480)	(2.505)	(2.567)	(2.278)	(2.275)	(2.125)	(2.071)
	Margin	0.0147	0.0181	0.0188	0.0402	0.0232	0.0450	0.00158	0.00160	0.00184	0.00121
logSize	Coef	-0.0941	-0.149	-0.127	-0.124	-0.146	-0.140	0.176	0.183	0.121	0.120
	SE	(0.187)	(0.185)	(0.182)	(0.182)	(0.181)	(0.181)	(0.130)	(0.130)	(0.127)	(0.129)
	Margin	0.615	0.419	0.483	0.496	0.421	0.438	0.175	0.160	0.342	0.352
FDI	Coef	-0.317	-0.261	-0.407	-0.455	-0.435	-0.462	-0.172	-0.159	-0.235	-0.169
	SE	(0.373)	(0.370)	(0.359)	(0.366)	(0.357)	(0.362)	(0.330)	(0.328)	(0.315)	(0.318)
	Margin	0.395	0.480	0.256	0.214	0.222	0.202	0.602	0.628	0.456	0.594
logAge	Coef	0.226	0.214	0.206	0.191	0.204	0.196	0.221	0.217	0.211	0.193
	SE	(0.214)	(0.211)	(0.209)	(0.211)	(0.207)	(0.207)	(0.168)	(0.167)	(0.161)	(0.165)
	Margin	0.291	0.309	0.325	0.364	0.325	0.343	0.188	0.194	0.190	0.240
machinery	Coef	0.539	0.569	0.438	0.370	0.491	0.389	0.182	0.185	0.128	0.128
	SE	(0.743)	(0.732)	(0.721)	(0.724)	(0.722)	(0.724)	(0.563)	(0.560)	(0.536)	(0.541)
	Margin	0.468	0.437	0.543	0.609	0.496	0.591	0.746	0.741	0.811	0.813
textiles	Coef	-0.178	-0.157	-0.260	-0.272	-0.182	-0.164	-0.229	-0.199	-0.238	-0.229
	SE	(0.526)	(0.512)	(0.513)	(0.514)	(0.509)	(0.511)	(0.359)	(0.359)	(0.346)	(0.350)
	Margin	0.735	0.758	0.612	0.597	0.720	0.749	0.524	0.579	0.492	0.512
wood	Coef	-2.041**	-1.851**	-2.022**	-2.003**	-2.101**	-2.097**	-2.259***	-2.266***	-2.214***	-2.334***
	SE	(0.952)	(0.926)	(0.894)	(0.887)	(0.925)	(0.909)	(0.819)	(0.819)	(0.777)	(0.782)
	Margin	0.0319	0.0455	0.0237	0.0240	0.0231	0.0210	0.00581	0.00569	0.00439	0.00285
chemical	Coef	0.00578	0.0135	-0.105	-0.176	-0.123	-0.193	-0.136	-0.125	-0.203	-0.193
	SE	(0.396)	(0.385)	(0.387)	(0.396)	(0.384)	(0.394)	(0.322)	(0.322)	(0.312)	(0.316)
	Margin	0.988	0.972	0.787	0.656	0.749	0.624	0.672	0.699	0.516	0.542
metallurgy	Coef	-0.361	-0.382	-0.461	-0.511	-0.368	-0.435	-0.220	-0.216	-0.283	-0.265
	SE	(0.612)	(0.600)	(0.578)	(0.585)	(0.571)	(0.578)	(0.426)	(0.427)	(0.400)	(0.408)
	Margin	0.555	0.524	0.425	0.383	0.519	0.451	0.606	0.613	0.480	0.515
others	Coef	-0.0915	-0.149	-0.267	-0.343	-0.304	-0.421	-0.257	-0.274	-0.364	-0.430
	SE	(0.566)	(0.557)	(0.562)	(0.564)	(0.545)	(0.546)	(0.426)	(0.427)	(0.419)	(0.423)
	Margin	0.872	0.789	0.636	0.542	0.577	0.441	0.546	0.520	0.384	0.310
food (omitted)	Coef	-	-	-	-	-	-	-	-	-	-
	SE										
	Margin	-	-	-	-	-	-	-	-	-	-
Observations		408	408	408	408	408	408	508	508	508	508
Firms		291	291	291	291		370	370	370	370	370

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Logit random effects model: Dependent variable embodied TI

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
education	Coef	-1.364**	1.940	-1.176*	-1.104*	0.894	0.681				
	SE	(0.631)	(1.837)	(0.625)	(0.640)	(0.903)	(0.890)				
	Margin	0.0306	0.291	0.0598	0.0848	0.323	0.444				
education_sq	Coef		-3.809*								
	SE		(2.030)								
	Margin		0.0606								
OW	Coef			-0.205**	-0.190*	0.260	0.430			-0.186**	0.402
	SE			(0.103)	(0.104)	(0.382)	(0.267)			(0.0812)	(0.449)
	Margin			0.0470	0.0679	0.496	0.107			0.0219	0.371
*education*OW*	Coef						-1.096***				
	SE						(0.425)				
	Margin						0.00992				
skills	Coef				-0.588	-1.324		-0.731	-1.947	-1.655	2.805
	SE				(0.738)	(1.063)		(0.512)	(1.773)	(1.720)	(2.596)
	Margin				0.425	0.213		0.153	0.272	0.336	0.280
skills_sq	Coef								1.034	0.944	-3.312
	SE								(1.421)	(1.386)	(2.243)
	Margin								0.466	0.496	0.140
*skills*OW*	Coef										-2.651*
	SE										(1.542)
	Margin										0.0855
p_prof	Coef	-6.321**	-5.895**	-5.632**	-5.089**	-5.147**	-5.689**	-7.198***	-7.182***	-6.619***	-6.701***
	SE	(2.592)	(2.493)	(2.397)	(2.480)	(2.567)	(2.505)	(2.278)	(2.275)	(2.125)	(2.071)
	Margin	0.0147	0.0181	0.0188	0.0402	0.0450	0.0232	0.00158	0.00160	0.00184	0.00121
logSize	Coef	0.0941	0.149	0.127	0.124	0.140	0.146	-0.176	-0.183	-0.121	-0.120
	SE	(0.187)	(0.185)	(0.182)	(0.182)	(0.181)	(0.181)	(0.130)	(0.130)	(0.127)	(0.129)
	Margin	0.615	0.419	0.483	0.496	0.438	0.421	0.175	0.160	0.342	0.352
FDI	Coef	0.317	0.261	0.407	0.455	0.462	0.435	0.172	0.159	0.235	0.169
	SE	(0.373)	(0.370)	(0.359)	(0.366)	(0.362)	(0.357)	(0.330)	(0.328)	(0.315)	(0.318)
	Margin	0.395	0.480	0.256	0.214	0.202	0.222	0.602	0.628	0.456	0.594
logAge	Coef	-0.226	-0.214	-0.206	-0.191	-0.196	-0.204	-0.221	-0.217	-0.211	-0.193
	SE	(0.214)	(0.211)	(0.209)	(0.211)	(0.207)	(0.207)	(0.168)	(0.167)	(0.161)	(0.165)
	Margin	0.291	0.309	0.325	0.364	0.343	0.325	0.188	0.194	0.190	0.240
machinery	Coef	-0.539	-0.569	-0.438	-0.370	-0.389	-0.491	-0.182	-0.185	-0.128	-0.128
	SE	(0.743)	(0.732)	(0.721)	(0.724)	(0.724)	(0.722)	(0.563)	(0.560)	(0.536)	(0.541)
	Margin	0.468	0.437	0.543	0.609	0.591	0.496	0.746	0.741	0.811	0.813
textiles	Coef	0.178	0.157	0.260	0.272	0.164	0.182	0.229	0.199	0.238	0.229
	SE	(0.526)	(0.512)	(0.513)	(0.514)	(0.511)	(0.509)	(0.359)	(0.359)	(0.346)	(0.350)
	Margin	0.735	0.758	0.612	0.597	0.749	0.720	0.524	0.579	0.492	0.512
wood	Coef	2.041**	1.851**	2.022**	2.003**	2.097**	2.101**	2.259***	2.266***	2.214***	2.334***
	SE	(0.952)	(0.926)	(0.894)	(0.887)	(0.909)	(0.925)	(0.819)	(0.819)	(0.777)	(0.782)
	Margin	0.0319	0.0455	0.0237	0.0240	0.0210	0.0231	0.00581	0.00569	0.00439	0.00285
chemical	Coef	-0.00578	-0.0135	0.105	0.176	0.193	0.123	0.136	0.125	0.203	0.193
	SE	(0.396)	(0.385)	(0.387)	(0.396)	(0.394)	(0.384)	(0.322)	(0.322)	(0.312)	(0.316)
	Margin	0.988	0.972	0.787	0.656	0.624	0.749	0.672	0.699	0.516	0.542
metallurgy	Coef	0.361	0.382	0.461	0.511	0.435	0.368	0.220	0.216	0.283	0.265
	SE	(0.612)	(0.600)	(0.578)	(0.585)	(0.578)	(0.571)	(0.426)	(0.427)	(0.400)	(0.408)
	Margin	0.555	0.524	0.425	0.383	0.451	0.519	0.606	0.613	0.480	0.515
others	Coef	0.0915	0.149	0.267	0.343	0.421	0.304	0.257	0.274	0.364	0.430
	SE	(0.566)	(0.557)	(0.562)	(0.564)	(0.546)	(0.545)	(0.426)	(0.427)	(0.419)	(0.423)
	Margin	0.872	0.789	0.636	0.542	0.441	0.577	0.546	0.520	0.384	0.310
food (omitted)	Coef	-	-	-	-	-	-	-	-	-	-
	SE										
	Margin	-	-	-	-	-	-	-	-	-	-
Observations		408	408	408	408	408	408	508	508	508	508
Firms		291	291	291	291		370	370	370	370	370

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4. Findings

In line with the theoretical framework presented in section 2, our results show a significant correlation between TI propensity and WDES. Both measures – education and skills – positively explain the propensity to innovate (Columns 1, 3, 4, 7 and 9 of Table 6). Thus, the greater the WDES the higher the likelihood of conducting TI. Therefore empirical estimations support *H1a*.

On the other hand, in line with Cohen and Levinthal (1990) and Dahlin et al. (2005), we tested for the presence of a curvilinear relationship between variables, and we only confirmed a linear relationship (Columns 2 and 8 of Table 6). The interpretation of this result must take into consideration the context under study. Previous empirical works that have observed an inverted U-shaped relationship between diversity measures and innovation come from developed countries. The estimations could be indicating that the linear relationship observed, which expresses that the greater the WDES the greater the propensity to conduct TI, may indicate that the level of variety in less developed contexts is low to the extent that the turning point from a positive to negative association is not observed. Therefore, there is no evidence of a fall in the propensity to innovate.

In addition, estimation results for *skills* that capture the balance between the typical four categories of employees of the firm indicate a positive association with the likelihood to perform TI activities. An increase in the balance indicates a high number of skilled workers in the organization which in turn may be positively associated with the likelihood to conduct TI.

To test the hypothesis *H1b*, we selected the companies that perform TI activities and distinguished between those that exclusively purchase technology embodied in artefact from those that develop disembodied TI. The estimations support the hypothesis, with an observed positive association between the propensity to engage in disembodied TI and the variety of professional profiles – education (Columns 1 and 3, Table 7). A non-significant relationship is observed between *skills* and disembodied TI propensity (Columns 6 and 7, Table 7). In addition, a negative relationship between embodied TI propensity and both diversity in education and diversity in skills is observed (Table 8). However, the symmetrical values between disembodied (positive) and embodied (negative) TI propensity must be taken with caution. First, because a large number of firms that conduct disembodied TI activities also conducted embodied TI. Second, embodied TI activities are commonplace among the innovative firms in Uruguay (Bianchi et al., 2015) and in other developed and developing countries (Frank et al., 2016; Ballot et al., 2015). Therefore, the analysis of firm that conduct only embodied TI activities may reflect the idiosyncratic innovative behaviour of a specific number of firms rather than an innovative pattern. .

Another common result from developing and developed countries is that the proportion of innovative firms in the manufacturing sector at the national level is relatively low at around 30% (Ballot et al., 2015). Our results contribute to the study of determinants of innovation in less developed contexts by breaking down the possible explanations of the innovation determinants in innovative firms. Particularly in small economies, being characterised by an absence of big national corporations which limits overall investment capacity, both in physical capital and in human capital (Crespi and Tacsir, 2012). In addition, national studies on the knowledge base of Uruguayan manufacturing firms show idiosyncratic pathways of firms, rather than clearly defined innovation patterns, where the presence of professionals within the workforce of the firm is the best predictor of innovative collaboration to conduct TI activities.

The idiosyncratic nature of Uruguayan firms' innovation behaviour is also noticeable in our estimations of control variables. The activity sector dummy variables show a high dispersion and almost no significant relationship with TI propensity. The firm's size has a significant and positive relationship with the propensity to innovate, but, notably, this relationship is not significant when considering disembodied TI activities. In the same vein, the age of the firm shows a positive and significant relationship with TI propensity, but was below the significance threshold for disembodied TI. It is in line with the literature that shows that larger and older firms are more likely to conduct innovations based on purchasing technology but, when endogenous development of technologies is considered, the effects of size and age disappear.

On other hand, the negative and significant association between both variety in professional profiles (education) and variety in job categories (skills) with FDI does not have a clear explanation. This opens questions for further research on the technological content of foreign investment in Uruguay.

Regarding how the organization of work affects the relationship between WDES and the propensity to develop TI, results confirm that advanced organizational forms are positively associated with the likelihood of conducting TI activities (Columns 3, 4 and 9, Table 6). Moreover, we observe that the relationship between *education* and the likelihood of performing disembodied TI is positively moderated by the adoption of flexible organizational forms (Columns 5 and 10, Table 7). It confirms the assertion that having varied capabilities is as important as the opportunities to apply them through advanced forms of organization. In sum, these results support *H2a* and *H2b*, which is as expected according to international literature (Camisón and Villar-López, 2014; Battisti and Stoneman, 2010).

Finally, it is worth noticing that the use of two measures of WDES (education and skills) allow us to follow a more robust analysis for our research question. Both measures - professional and total workforce educational variety - show significant effects on TI propensity. However, the use of both indicators in the same estimation does not yield better results. (Column 6, Tables 6 and 7).

5. Conclusions

This paper deals with the linkage between WDES and the propensity to innovate, considering the moderating role of the form of work organization in the firm. In doing so, we developed theoretical reasoning to present four hypotheses that were tested through a firm-level analysis that took into account the whole firm's workforce and its organization following a longitudinal approach. In this regard, the first remark that arises from the findings is the confirmation of a significant and positive relationship between diversity in education and innovation and the relevance of advanced work organization forms to mobilise this relationship.

Hence, this paper contributes to the stream of research on innovation and organization of firms by offering theoretical arguments and empirical evidence of the relevance of considering innovative capabilities both at personal and organisation level simultaneously. In doing so, we linked WDES which incorporates indictors of individual capabilities, organisational structure and innovative propensity. Moreover, this paper contributes by applying the distinction between embodied and disembodied TI as innovation strategies. It allows us to identify how the link between individual education variety and work organization affects innovation strategies based on R&D and others intangible sources of knowledge, which is very important in less developed contexts.

The paper analyses the manufacturing industry in a small developing country. The literature on the economics of innovation has always emphasised the localised nature of innovation and the firm-level specificity of routines of routines, knowledge variety and organization. However, research in this area has traditionally looked for general patterns, based on theoretical propositions, which help to understand the firm's innovation propensity. These types of patterns, like the saturation effect on absorptive capacities and the consequently inverted U-shaped relationship between educational variety and innovation propensity did not appear in the Uruguayan context. Therefore, another contribution of the paper is to contrast the general premise of the U-shaped curve in a different context.

The results have several implications not only for potential directions of future research, but may also have applications for policy makers and managers. First, in the current Uruguayan context, and arguably extendable to most Latin American industries, the results highlight the relevance of investing in human resources inside the firm as a determinant of innovation. Typically, highly skilled workers (professionals and technicians) in non-developed countries are scarce. According to our results, the challenge for firms is to attract professionals and also to integrate individuals with different background onto teams in a way that favours the innovation process. In doing so, the organizational structure may facilitate the adoption of innovation activities, promoting interaction between different profiles and categories of workers and reducing potential social negative effects of diversity. Both things can be driven by innovation policy, which could demand diversity to give financial support for TI projects. In addition, policy makers can promote collaborative programs between firms, universities and technological centres which may favour the presence of educational diversity of firms, in order to deal with some difficulties associated with the small scale of firms in less developed contexts.

Finally, in consideration of these findings and remarks, this paper offers new research questions. First, it explores new data sources that allow for other measures of variety associated with education, particularly salary levels. It may offer more accurate measurements of the linkage between individual knowledge and organisational dimensions. Second, a new study might deal with the idiosyncratic nature of innovation propensity found in this paper. It could be done by considering both innovation outcomes and innovation activities as dependent variables, and meso and macro context variables as sectorial performance and technology classifications.

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