The Link between Gender Diversity and Innovation: What is the Role of Firm Size?

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Abstract
Recent studies have included gender diversity as a driver of innovations at firm level. This paper analyses the effect that firm size may exert on the link between gender diversity and the probability of innovating. We use a panel data set constructed from various waves of the Spanish Community Innovation Survey that contains 5,383 firms during the period 2007–2012. Applying a multivariate probit model and controlling for endogeneity, we analyse the effect of gender diversity on different innovation outputs—product, process, marketing and organizational innovations. Our results confirm our hypothesis that firm size exerts a moderating role between gender diversity and the probability of innovating. We highlight two results. First, small firms have greater difficulties in capturing the advantages of gender diversity during the innovation process as compared to large firms. Second, the impact of gender diversity on innovation outcomes differs according to the innovation type.

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1. Introduction

A large number of economists interested in the determinants of R&D and innovation at firm level departed from the augmented production function (Griliches, 1979). Later on, their empirical analysis incorporated structural, three-step, models to estimate the determinants of R&D investments, the effect of R&D on innovation and, finally, the impact of innovation on productivity (Crépon et al., 1998). Simultaneously, data availability has increased with the appearance of different waves of Community Innovation Surveys (CIS). These theoretical and empirical developments have led to the rise of the economics of innovation, but with several limitations. One of the main constraints is that innovation has been interpreted as an immediate phenomenon, where internal dynamics have been partially analysed. As a result, mainstream innovation studies seldomly focus on the person and interpret innovation as a gender-neutral process. However, women are still marginalised and they are less visible as innovators than are men (Nählinder et al., 2015).

Previous studies on firm performance offer different interpretations about the role that gender diversity plays in a firm's performance. Some theoretical arguments emphasise potentially negative impacts that diversity may have on firm performance such as similarity-attraction (Byrne, 1971), social identity (Tajfel, 1981) or discrimination (Meyerson and Fletcher, 2000), while other theoretical arguments have advocated for the positive impact of gender diversity on group performance such as the social cognitive theory (Bandura, 1977; Lee and Farh, 2004). Despite these theoretical works, the link between gender diversity and firm performance, and more specifically innovation, has not often been investigated empirically in the literature.

Nevertheless, in recent years an increasing empirical literature has found that gender composition may affect a firm's innovation capacity (for a review see Fernández-Sastre, 2015). However, to the best of our knowledge, there are no studies that examine whether firm size affects the role of gender diversity on a firm's innovative capacity. The aim of this paper is to investigate whether the effects of gender diversity on firm innovation depend on firm size. We suggest that firm size may exert a moderating effect on the relationship between gender diversity and innovative capacity. In this line, small firms are characterised by having more flexible organizational structures than larger firms but at the same time their structures may not have as many managerial tools to cope with the problems that gender diversity may cause. Accordingly, small firms may find it more difficult to capture the maximum potential of a gender-diverse workforce. However, as far as we know, there is no empirical evidence on the moderating effect that firm size may exert on the relationship between gender diversity and innovation.

Departing from previous evidence, we exploit a firm-level database drawn from the Spanish Technological Innovation Panel (henceforth PITEC) between 2007 and 2012. The data is collected following the Oslo Manual guidelines (OECD,

1997) and, as such, it can be considered as a CIS dataset. Our empirical work is based on unbalanced panel data consisting of 5,383 Spanish manufacturing and service innovative firms. We apply a multivariate probit model where the dependent variable is a specific type of innovation. By controlling for potential endogeneity, our results confirm that firm size is a relevant moderator when considering the impact of the gender structure of firms on innovation. Specifically, small firms have more difficulties in capturing the potential advantages of more gender diversified structures, than do large firms.

This paper contributes to existing literature in two dimensions. Firstly, previous analyses of the effect of gender diversity on innovation did not consider the effect of firm size; we analyse the moderating role of firm size on gender diversity. Secondly, we consider the different impact that gender diversity may have according with the type of innovation. Hence, we take into account that the requirements to develop non-technological (organizational and marketing) and technological (product and process) innovations may differ.

The paper is organized as follows. Section 2 presents a literature review and our hypotheses. The following section explains the data and the econometric methodology. Section 4 presents the results and the final section contains the conclusions.

2. Literature Review

According to previous studies (Laursen and Salter, 2006; Koellinger and Block, 2016), there are differences in learning and interacting processes at gender level. On the one hand, gender diversity fosters creativity and generates more efficient solutions (Lazear, 1999; Baer et al., 2013). On the other hand, gender diversity may reduce group cohesiveness and decrease employee satisfaction (Roberge and Van Dick, 2010). In this vein, the role of gender on innovation has gained a wider interest among researchers (Alsos et al., 2013). However, there is no clear evidence regarding the impact of gender diversity on innovation at firm level.

Furthermore, the influence of gender diversity may differ according with the nature of the type of innovations. First, technological innovations (product and process innovations) are closely related to the change or adoption of new technologies. Consequently, they require the development of new technical knowledge and inventions. Second, non-technological innovations (organizational and marketing innovations) are more closely related with the relations in the workplace but also with external agents. Hence, both types of innovations are distinguished by the role of technology. Non-technological innovations do not necessarily involve a change in the technology, but they may be related to the use of new business methods, a new organizational concept or other non-tangible ways of changing business activities.

These differences imply that the employees' skills necessary to develop these innovations should be different. The nature of the tasks performed in each type of innovation may depend on how people interrelate in the workplace (Gist et al., 1987; Gladstein, 1984; Yu and Singh, 2002; Haas, 2010). Therefore, the influence that gender composition has on the development of technological innovations may be different from the influence that it has on non-technological innovations.

Regarding technological innovations, product and process innovations may benefit from the fact that gender diversity increases creativity and improves problem solving, since a more diverse group possesses a wider range of perspectives (Morrison, 1992; Robinson and Dechant, 1997; Lattimer, 1998). Previous literature finds that gender composition may positively affect those tasks that require creative (Polzer et al., 2009) or complex work (Wegge et al., 2008). This would be in line with Díaz-García et al. (2013) whose results give support to the fact that gender diversity may help to not only improve internal performance but also to increase a firm's absorptive capacity. The complexity of technological innovations makes it necessary for firms to use external knowledge and develop their absorptive capacity (Cohen and Levinthal, 1989, 1990).

With respect to non-technological innovations, gender-diverse teams may accelerate the development of organizational and marketing innovations. Croson and Gneezy (2009) show that men and women differ in their risk and social preferences and reaction to competition, hence different management styles appear. Kang et al. (2007) point out that women may be better at identifying customer needs and opportunities for firms that seek to meet these needs. Hence, gender diversity may have a positive impact on the development of marketing innovations. Furthermore, teams composed of both sexes have a greater understanding of market segments formed by both male and female customers (Thomas, 2004). Concerning organizational innovations, they are more "people-oriented" hence gender-diverse environments may have a positive impact (Torchia et al., 2011). Consequently, given that non-technological innovation may be more people-oriented, we consider the following hypothesis:

Hypothesis (1): Gender diversity has a larger effect on the probability of introducing non-technological innovations than for technological innovations.

In this relationship, firm size has been noticed previously as a moderator (Brewer and Kramer, 1986; Arnegger et al., 2014). Based on the resource dependence theory, gender diversity in large firms may exert a positive impact on innovation. Large firms are usually more complex and the problems they need to solve are more specific. Hence, a gender-diverse environment may improve dealing with challenging tasks. Furthermore, large firms have more product-lines and they are present in more geographical markets. Finally, large firms have higher incentives to control their workflows and production processes than small firms, simply because inadequacies in their workflows would have a greater impact than on a small firm.

From the point of view of social identity theories, larger firms may be able to diminish more conflicts and to increase cohesion and cooperation. Gender diversity makes decision-making into a time-consuming process and affects problem-solving procedures. Nevertheless, these costs may be lower in large firms. According to Blau (1977), people prefer to interact with those who share attributes similar to their own. However, there are more opportunities for within-group interaction among members of diverse genders in larger groups than in smaller groups. This result is simply a result of the availability of potential partners for interaction. Similarly, Wegge et al. (2008) find that gender diversity has a greater positive influence on performance in larger groups.

Furthermore, large firms may have more sophisticated managerial systems of human resources (Pfeffer, 1977) that may mitigate problems related with diversity in the workplace. Large firms concerned about due process and employment practices may establish specific offices and procedures for handling employees' complaints (Gwartney-Gibbs and Lach, 1993; Welsh et al., 2002). At the same time, large firms also tend to make greater efforts at prevention and redress problems of discrimination since this may help to improve their public image.

Conversely, small firms may have more organizational flexibility and a larger capacity to modify their internal structure. Hence, their more flexible structure may facilitate to take advantage of the gender composition of their workforce.

Women may be instrumental in doing so as females are used to running smaller firms (Bögenhold and Klinglmair, 2015). Despite this consideration, we consider that the advantages for large firms to benefit from gender diversity dominate. We propose the following hypothesis:

Hypothesis (2): Firm size exerts a positive impact on the impact of gender diversity on innovation.

3. Data and Methodology

3.1. Database

Our database belongs to the PITEC, which is the result of collaboration between the Spanish National Statistics Institute and the Foundation for Technological Innovation (COTEC). It contains data from a panel of more than 12,000 firms between 2003 and 2012 and it includes a large number of variables related to innovation and economic activity.[1] PITEC has several advantages. First, it compiles the Spanish CIS questionnaire about firms' R&D activities following the Oslo Manual guidelines (OECD, 1997). This allows us to use widely-accepted innovation indicators and variables. Second, it is panel data and hence it tracks firms over time.

[1] A more detailed description can be found on the Spanish Foundation for Science and Technology (FECYT) website.

Although the time span is from 2003 to 2012, the database only includes information on organizational and marketing innovations since 2008. Given that we include lagged explanatory variables, our sample dataset runs from 2007 to 2012. We applied three filters to our sample. Firstly, we used only firms that had provided full information during the selected period. Secondly, we discarded companies with any employment-related problems (such as companies in sectors of high seasonality, in employment regulation, etc.). And, finally, we eliminated firms with outliers related to the total number of employees. Our final sample contains 26,956 observations corresponding to 5,383 manufacturing and service firms.

Table 1. Gender composition and innovation activity. Period 2007-2012.

	Firm size (number of employees)				**Test of mean (H0: Null hypothesis) Prob.(H0) if H1 is X≠μ**		
	(1) Less than 10	(2) From 10 to 49	(3) From 50 to 249	(4) 250 or larger	**(1)=(2)**	**(2)=(3)**	**(3)=(4)**
Gender composition							
% female workers	29.32	28.23	29.17	35.70	0.0253	0.0026	0.0000
% of firms developing each type of innovation							
Product	38.86	54.91	63.06	62.20	0.0000	0.0000	0.3267
Process	30.65	51.76	64.36	69.33	0.0000	0.0000	0.0000
Marketing	19.54	30.21	32.63	36.54	0.0000	0.0003	0.0000
Organization	23.06	39.49	49.53	61.16	0.0000	0.0000	0.0000
Obs.	2,728	10,926	8,780	4,526			

Source: own elaboration from PITEC

Table 1 shows the gender data composition for the total workforce and the innovation capacity of firms. The data is classified by firm size. We observe a predominance of male employees in all the categories, but in particular among smaller firms. Despite the mean test among size groups showing significant differences, the largest statistically significant difference is for firms classified in the largest size category.

With respect to different types of innovations, Table 1 shows that larger firms introduce more technological innovations than smaller firms. However, the introduction of non-technological innovations is less common, especially among marketing innovations, with a value of 19.54% among firms with less than 10 employees and 36.54% for firms with 250 or more employees. Hence, our preliminary statistical descriptive analysis shows significant differences between the gender composition and the innovation capacity in firms of different sizes.

3.2. Econometric Model Specification

In order to estimate the impact of gender diversity on innovation, we use an innovation production function where a firm's innovation output depends on gender diversity and several control variables. Equations (1)-(4) specify the estimated innovation production function:

$$\Pr(Product)_{i,t} = \beta_{10} + Z_{i,t-1}\beta_{11} + \beta_{12}gender_{i,t-1} + \eta_{1i} + \delta_{1t} + \varepsilon_{1i,t} \quad (1)$$
$$\Pr(Process)_{i,t} = \beta_{20} + Z_{i,t-1}\beta_{21} + \beta_{22}gender_{i,t-1} + \eta_{2i} + \delta_{2t} + \varepsilon_{2i,t} \quad (2)$$
$$\Pr(Marketing)_{i,t} = \beta_{30} + Z_{i,t-1}\beta_{31} + \beta_{32}gender_{i,t-1} + \eta_{3i} + \delta_{3t} + \varepsilon_{3i,t} \quad (3)$$
$$\Pr(Organization)_{i,t} = \beta_{40} + Z_{i,t-1}\beta_{41} + \beta_{42}gender_{i,t-1} + \eta_{4i} + \delta_{4t} + \varepsilon_{4i,t} \quad (4)$$

where $Pr()_{i,t}$ is the probability of innovating for firm i at time t. Following the Oslo Manual (OECD, 2005), *Product*, *Process*, *Marketing* and *Organization* identify firms that have carried out product innovations (either goods or services), process innovations, marketing innovations and organizational innovations, respectively.[2] It must be noted that we are not able to capture a firms' innovative intensity, merely its propensity to innovate. Furthermore, $gender_{i,t-1}$ is the Blau Index, defined in Section 3.3, $Z_{i,t-1}$ is the vector of a firm's characteristics[3], η_i is a time-invariant, firm-specific dummy, δ_t is a time dummy, and $\varepsilon_{i,t}$ is a random error term.

Since our dependent variable in Equation (1) is a binary variable of innovation output, the use of a probit or logit model is recommended. However, the four different types of innovation considered in the analysis are likely to be caused by common, unobservable factors, which leads to the possibility that the error terms will be correlated across equations. Similar to Fernández-Sastre (2015), we use a multivariate probit model to estimate Equations (1)-(4). The multivariate probit model takes into account this potential correlation by estimating the correlation between the residuals of two different equations (Product vs. Process; Process vs. Marketing; Process vs. Organization; Product vs. Marketing; Product vs. Organization; and Marketing vs. Organization). Hence, 6 parameters ρ capture non-observable variables which affect the probability of introducing each type of innovation. Applying a multivariable probit is necessary in order to control for these unobserved variables. A Chi-square test of independence shows that the differences between the parameters are statistically significant, indicating that a multivariate probit model is preferred (see Tables 3 and 4 in Section 4).

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[2] See Table A1 in the Appendix for a more detailed explanation.
[3] See Table A1 in the Appendix for more details.

The econometric problem that appears is that gender diversity may be an endogenous variable relative to the dependent variable, and thus correlated with $\varepsilon_{i,t}$. This suggests that estimating Equations (1)-(4) may produce inconsistent results and lead to misleading inferences. To address it, we employ a control function correction method (Blundell and Powell, 2003). Hence, in the first stage we estimate Equation (5):

$$gender_{i,t} = \beta_{50} + X_{i,t-1}\beta_{51} + \eta_{5i} + \delta_{5t} + \varepsilon_{5i,t} \qquad (5)$$

where *gender* depends on a set of explanatory variables ($X_{i,t-1}$) such as firm size (log number of employees), firm age (in logs), a dummy variable identifying if a firm exports, a dummy variable identifying firms belonging to a group, the human capital stock, capital labour intensity at sector level and the sector average value of the Blau Index.[4] The equation includes also a time-invariant dummy (η_i) and a time-variant dummy (δ_t). This equation is estimated by the Generalized Linear Model, from which we obtain predicted values of gender diversity (*gender'*) and its residuals. Variable *gender'* is then introduced in Equations (1)-(4). The methodology is similar to a two-stage least squares (Wooldridge, 2002; Blundell and Powell, 2003).

3.3. Explanatory Variables

[4] We have included the (lagged) variables human capital stock, capital labour intensity at sector level and the sector average value of the Blau Index as instrumental variables in the equation. Human capital composition may affect the probability that there are more or less females as women have increased their education level. Furthermore, sectoral characteristics such as gender diversity and labour intensity may be indicative of female or male workers predominating in these sectors.

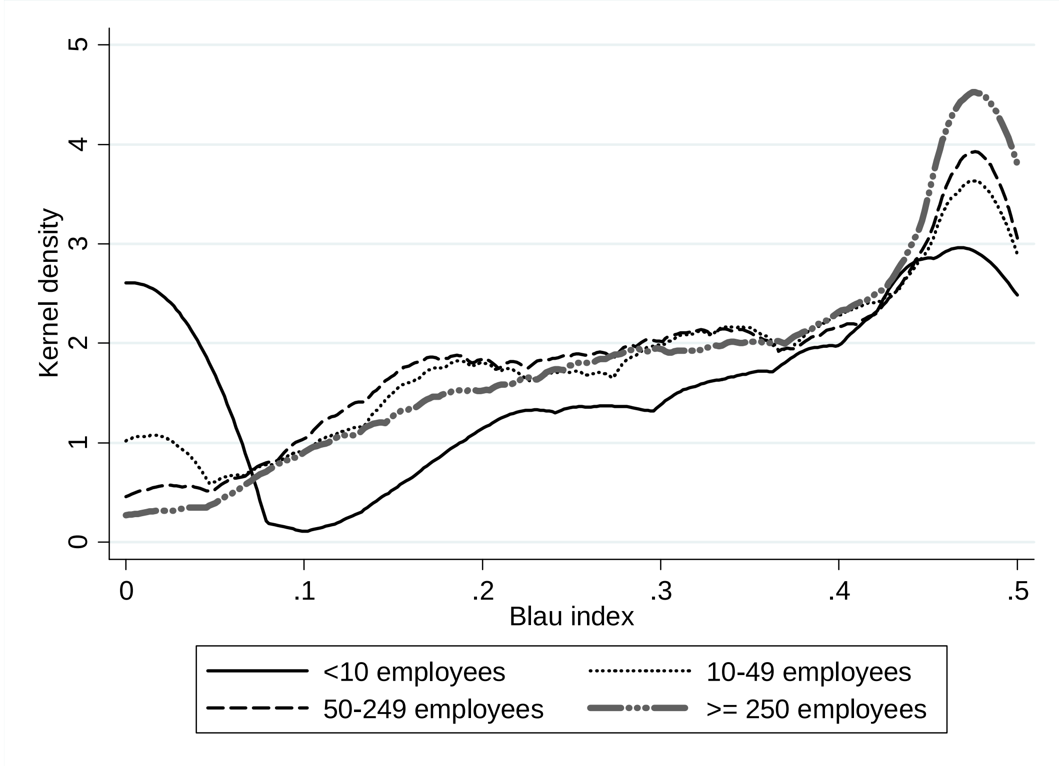
Gender diversity is estimated through the Blau Index, which has been commonly used to measure demographic heterogeneity. Although there are other options for measuring diversity (see Harrison and Klein, 2007), the Blau Index is preferred, in comparison to other measurement methods. The formulation of the Blau Index is as follows:

$$B = \left[1 - \sum_{i=1}^{N} p_i^2\right]$$

where B is the value of the Blau Index, and p_i is the proportion of members in the i^{th} of the N categories. In our case, N=2, since there are only two categories: men or women. The value of our index ranges from 0 to 0.5, where 0 equals single-sex teams and 0.5 equals egalitarian teams.[5]

[5] A weakness of this index is that it does not consider the number of employees, giving the value 0.5 to 2-member teams composed of one woman and one man and also giving the same index value to bigger teams e.g. a 50-member team of 25 women and 25 men.

Figure 1. Kernel densities of the Blau Index of the total workforce



Source: own elaboration

Figure 1 shows the distribution of the Blau Index, which has been classified according to four different firm sizes. The results show that smaller firms obtain a bimodal distribution which is concentrated among the most extreme values, while for larger firms there is a mode in the intermediate values (around 0.4 in the Blau Index for the whole company). We also see that larger firms have relatively lower densities for low Blau index values and higher densities for high Blau index values, reflecting higher gender diversity on average. Hence, our index of gender diversity shows a different distribution according to firm size, with gender diversity increasing in firm size.

Table 2. Statistical summary. 2007-2012.				
	Mean	**Standard deviation**	**Min.**	**Max.**
Type of innovation				
Product(dummy)	0.5716	0.4948	0	1
Process(dummy)	0.5668	0.4955	0	1
Marketing(dummy)	0.3098	0.4624	0	1
Organization(dummy)	0.4474	0.4972	0	1
Blau index	0.3145	0.1503	0	0.5
Innovation investment				
External R&D investment per employee	1099.45	8025.05	1×10^{-7}	502123.5
Internal R&D investment per employee	5766.30	26801.23	1×10^{-7}	2966199
Training investment per employee	36.49	275.37	1×10^{-7}	18823.73
R&D cooperation (dummy)	0.2990	0.4578	0	1
Firm's explanatory variables				
Firm size	211.63	934.31	1	38756
Firm age	28.61	22.23	1	256
Export activity(dummy)	0.4986	0.5000	0	1
Group(dummy)	0.3875	0.4872	0	1
High-tech and KIS firms(dummy)	0.4609	0.4985	0	1
Observations of all firms	26,960			

Source: own elaboration.

Equations (1) to (4) include a set of control variables that affect the innovation production function. In addition to our index of gender diversity, the first set of variables includes a firm's characteristics such as firm size, firm age and its quadratic value. A second set of variables includes those factors that affect the innovative capacity of the firm, such as the external and internal R&D intensity;[6] the total expenditure on R&D training activities by an employee; and a dummy identifying whether a firm cooperates with other firms. A third set of explanatory variables captures the environment in which the firm operates, such as a dummy identifying if the firm exports[7], a dummy identifying if a firm belongs to a group, and a dummy identifying if the firm is active in a high-tech or KIS sector. Table

[6] As Cohen and Levinthal (1990) show, the total expenditure on R&D improves the absorptive capacity of firms, thus affecting their ability to innovate.

[7] International markets increase competition, but they also enlarge access to more sources of information and knowledge that increase the probability of innovating.

2 shows the main summary statistics.[8] Finally, all the explanatory variables are lagged in order to avoid causality bias.

4. Empirical Results

4.1 General results

Table 3 presents the results for the whole database considering our index of gender diversity for the total workforce in the firm (Columns (1)-(8)). In order to capture the moderating role of firm size between gender diversity and the innovation output, we include the cross-product between our proxy of gender diversity and firm size (Columns (5)-(8)).

Our results show that gender diversity has a statistically significant positive impact on the probability of introducing process, marketing and organizational innovations (Columns (2)-(4))[9], while the impact is non-significant on the probability of introducing product innovations. Hence, our results confirm Hypothesis (1) since gender diversity exerts a larger impact on the probability of introducing non-technological (marketing and organisation) innovations than technological (product and process) innovations. Thus, we observe that non-technological innovations benefit from more gender diversified work

[8] See Table A.1 for a more detailed description of the variables and Table A.2 in the Appendix for the Pearson correlations.

[9] The results of the impact of gender diversity on innovation without controlling for endogeneity are positive, regardless of whether we take into consideration the employees in the R&D department or the total workforce. These results may be requested from the authors.

environments confirming our hypothesis that this type of innovations are more "people-oriented", which requires work environments with wider perspectives to be developed. We also see that, even controlling for gender diversity, firm size (*size*) exerts a positive impact on the propensity to innovate. In other words, larger firms have more capacity to generate innovations.

When jointly considering the moderating role of firm size between gender diversity and innovation (Columns (5)-(8)), we find that the cross-product between gender diversity and firm size (*gender′* × *size*) shows a positive impact on innovation, although it is only significant on the probability of introducing product and marketing innovations. Hence, for larger firms gender diversity exerts a larger positive impact on the probability of innovating than for smaller firms.

As such, with respect to the impact of gender diversity on the probability of innovation, our results partially confirm Hypothesis (2), since firm size seems to play a moderating role between gender diversity and (product and marketing) innovation.

Concerning other explanatory variables, external R&D (*extRD*) and internal R&D (*intRD*) investment show a positive impact, regardless of the type of innovation. Cooperation activity in innovation (*coop*) also shows a significant and positive impact on the probability of innovating. This is likely due to an increased access to additional sources of information. Our results are in line with previous empirical results where cooperation in innovation also affects firm innovation (Segarra-Blasco and Arauzo-Carod, 2008; Simonen and McCann, 2008; Chun and Mun, 2012). Finally, firms that invest in training (*training*) are far more likely to innovate.

Regarding the impact of firm characteristics, firm age and its quadratic value (*age*) are only significant for the introduction of product and organizational innovations. In particular, for product innovation firm age shows a positive sign and its quadratic value a negative sign. Conversely, for organizational innovations firm age shows a negative sign and its quadratic value a positive sign. In this regard, our results are in line with Sørensen and Stuart (2000) and Coad et al. (2013). Export activity (*exp*) shows a positive impact on the propensity to innovate. Regarding firms belonging to a group, these firms show a lower probability of introducing product and marketing innovations. This may suggest a trapping effect, whereby company headquarters decide strategically where to invest their financial resources in order to focus the efforts of the different firms. Consequently, the capacity to decide on what efforts are focused on innovation projects is lower for firms belonging to groups.

Table 3. Multivariate probit results explaining types of innovation								
	Product	Process	Marketing	Organization	Product	Process	Marketing	Organization
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
gender'	-0.100	0.364**	2.143***	0.587***	-2.047***	0.067	-0.109	0.152
	(0.152)	(0.146)	(0.145)	(0.140)	(0.395)	(0.383)	(0.383)	(0.380)
gender'×size					0.452***	0.067	0.514***	0.099
					(0.085)	(0.083)	(0.081)	(0.081)
extRD	0.005***	0.004***	0.004***	0.007***	0.005***	0.004***	0.004***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
intRD	0.045***	0.026***	0.023***	0.022***	0.045***	0.026***	0.024***	0.022***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
training	0.021***	0.031***	0.018***	0.025***	0.021***	0.031***	0.018***	0.025***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
coop	0.327***	0.352***	0.157***	0.252***	0.326***	0.351***	0.155***	0.251***
	(0.021)	(0.021)	(0.018)	(0.019)	(0.022)	(0.021)	(0.010)	(0.019)
size	0.080***	0.148***	0.036***	0.153***	-0.065**	0.126***	-0.133***	0.121***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.028)	(0.028)	(0.028)	(0.027)
age	0.262***	-0.021	-0.032	-0.365***	0.270***	-0.019	-0.022	-0.362***
	(0.075)	(0.070)	(0.071)	(0.068)	(0.075)	(0.070)	(0.071)	(0.068)
ageQuad	-0.043***	0.006	0.006	0.058***	-0.044***	0.005	0.004	0.058***
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)
exp	0.189***	0.039**	0.106***	0.052***	0.201***	0.041**	0.119***	0.055***
	(0.020)	(0.019)	(0.019)	(0.018)	(0.020)	(0.019)	(0.019)	(0.019)
group	-0.036*	0.004	-0.101***	-0.005	-0.033	0.005	-0.097***	-0.004
	(0.021)	(0.020)	(0.020)	(0.019)	(0.021)	(0.020)	(0.020)	(0.019)
ρ21		0.301***	(0.011)			0.300***	(0.011)	
ρ31		0.349***	(0.011)			0.348***	(0.011)	
ρ41		0.240***	(0.010)			0.240***	(0.010)	
ρ32		0.340***	(0.011)			0.340***	(0.011)	
ρ42		0.427***	(0.011)			0.427***	(0.011)	
ρ43		0.641***	(0.011)			0.641***	(0.011)	
Constant	-0.817***	-0.597***	-1.215***	-0.048	-0.238	-0.509***	-0.529***	0.082
	(0.136)	(0.129)	(0.130)	(0.125)	(0.175)	(0.168)	(0.170)	(0.166)
$\chi 2$ (joint significance)		7089.25*				7074.00*		
Wald $\chi 2$		14587.91*				14631.85*		
LogLikelihood		-57106.42				-57076.05		
Observations				26,956				

Robust standard errors in parentheses.
Time dummy variables included.
Estimation results are corrected for endogeneity of gender diversity.
*** p<0.01, ** p<0.05, * p<0.1

To summarize, our results show that gender diversity has a larger impact on the probability of introducing non-technological innovations (H1 confirmed). Moreover, for two types of innovation (product and marketing), the impact of gender diversity on innovation is moderated by firm size (H2 partially confirmed).

4.2 Results by size-class

Given the different effect that firm size exerts on the relationship between gender diversity and innovation, we delve deeper into this relationship. Table 4 contains the estimation results differentiating among four different firm size classes: less than 10 employees, from 10 to 49 employees, from 50 to 249 employees and 250 employees or more. The estimated impact of gender diversity on the probability of innovating (columns (1)-(4)) varies according with the size class.

Gender diversity shows a non-significant impact on the probability of innovating for the smallest firms (< 10 employees), with the exception of the negative impact on the probability of introducing product innovations. When considering the effect of gender diversity for small and medium-sized firms (10-249 employees), in general gender-diverse work environments exert a positive and significant impact on the probability of creating non-technological innovations. However, the most outstanding result is the fact that for larger firms, gender diversity presents a statistically significant positive impact on the probability of creating non-technological innovations *and* product innovations.

Our results are in line with our previous theoretical arguments. First, creativity and innovation require different employee skills; therefore larger firms may have a more nearly optimal mixture between individual characteristics. Second, we must also consider that large firms may have a greater capacity to offer an environment in which gender-diverse teams improve their capacity to be more creative, thanks to a better match between employee skills and tasks. Third, larger firms may have specific procedures in place to manage more diversified environments and have capacity to monitor the work processes of diversified teams within the firm.

Our results highlight that large firms seem to be able to capture the advantages of having more gender diverse environments to a much greater extent than do smaller firms.

Table 4. Multivariate probit for gender diversity in the total workforce controlling for endogeneity. Firm size classification.

	Product	Process	Marketing	Organization
	(1)	**(2)**	**(3)**	**(4)**
Less than 10 employees				
gender'	-1.864***	-0.684	-0.250	-0.243
	(0.576)	(0.557)	(0.606)	(0.568)
size	0.142***	0.0190	0.0500	0.204***
	(0.0512)	(0.0498)	(0.0547)	(0.0524)
	ρ21	0.280***	ρ32	0.421***
		(0.034)		(0.037)
	ρ31	0.421***	ρ42	0.407***
		(0.039)		(0.034)
	ρ41	0.226***	ρ43	0.730***
		(0.035)		(0.040)
χ2 (joint significance)		707.85*		
Wald χ2		1349.09*		
LogLikelihood		-4939.07		
Observations		2,728		
From 10 to 49 employees				
gender'	-0.703***	-0.008	1.698***	0.667***
	(0.254)	(0.238)	(0.246)	(0.236)
size	0.115***	0.165***	-0.0451	0.0929***
	(0.029)	(0.027)	(0.028)	(0.027)
	ρ21	0.298***	ρ32	0.354***
		(0.016)		(0.017)
	ρ31	0.324***	ρ42	0.439***
		(0.017)		(0.016)
	ρ41	0.236***	ρ43	0.659***
		(0.016)		(0.018)
χ2 (joint significance)		2976.47*		
Wald χ2		5471.31*		
LogLikelihood		-23443.29		
Observations		10,924		
From 50 to 249 employees				
gender'	-0.0483	0.744***	1.623***	0.194
	(0.257)	(0.250)	(0.246)	(0.236)
size	-0.018	0.129***	-0.0241	0.127***
	(0.032)	(0.031)	(0.031)	(0.030)
	ρ21	0.231***	ρ32	0.317***
		(0.019)		(0.019)
	ρ31	0.322***	ρ42	0.411***
		(0.019)		(0.018)
	ρ41	0.208***	ρ43	0.607***
		(0.018)		(0.019)
χ2 (joint significance)		2077.63*		
Wald χ2		3842.16*		
LogLikelihood		-19269.83		
Observations		8,778		
250 or more employees				

gender'	1.409***	0.489	4.120***	0.961***
	(0.339)	(0.326)	(0.308)	(0.302)
size	0.097***	0.079***	0.148***	0.133***
	(0.031)	(0.030)	(0.026)	(0.028)
	ρ21	0.417***	ρ32	0.360***
		(0.028)		(0.027)
	ρ31	0.402***	ρ42	0.483***
		(0.028)		(0.027)
	ρ41	0.319***	ρ43	0.652***
		(0.026)		(0.029)
χ2 (joint significance)		1319.50*		
Wald χ2		2587.14*		
LogLikelihood		-8905.52		
Observations		4,526		

Robust standard errors in parentheses.
The estimations include the same control variables as in Table 3.
Time dummy variables included.
Estimation results are corrected for endogeneity of gender diversity.
*** p<0.01, ** p<0.05, * p<0.1

Hence, our results show partial support for the positive effect of gender diversity on innovation and, as others have argued, the mere presence of gender diverse teams may not be sufficient. Our evidence shows that small firms are not able to capture the impact of gender diversity because their size polarizes the distribution of gender diversity. As we show in Figure 1, the distribution of the gender diversity index according to firm size is more polarized towards lower values of gender diversity. It seems that small firms have a size which does not allow them to achieve more gender-diverse compositions than their larger counterparts. Hence, small firms not only exhibit more moderate levels of gender diversity, they also have more difficulties in capturing the positive effect of gender diversity on innovation.

5. Conclusions

Gender diversity has been addressed recently as an important factor in generating positive synergies between groups of workers and in increasing innovative performance of firms. A more diverse workforce in terms of age, education or gender may have a positive effect, given that these individual characteristics may complement each other (Lazear, 1999; Berliant and Fujita, 2011; Baer et al., 2013). However, up to now the empirical evidence is still not conclusive (Díaz García et al., 2009).

After controlling for endogeneity, we analyse the relationship between gender diversity and innovation. Our work is in line with Díaz-García et al. (2013) and Fernández-Sastre (2015), but it differs in several ways. Firstly, we consider that firm size moderates the impact of gender diversity on innovation output. Secondly, we analyse the effects of gender diversity on four types of innovations. This approach is essential in order to determine any disparities in the impact of diversity on innovation output. Finally, our econometric methodology controls for the endogeneity that appears between gender diversity and innovation.

Our results show several relevant findings. First, gender diversity has a positive impact on innovation, but this differs according to the type of innovation and according to firm size. We find that the gender diversity of a firm's total workforce exerts a larger positive impact on the probability of introducing non-technological innovations, compared to technological innovations. Second, small firms seem to have greater difficulty in benefiting from the advantages of having a more gender diversified team. Conversely, for larger firms gender diversity exerts a positive impact. To sum up, our results highlight the heterogeneous impact that gender diversity has on the firm's capacity to innovate, with regard to both the type of innovation and firm size.

The link between gender diversity and firm size indicates that large firms are more likely to manage R&D diversified teams and benefit more from the specific skills of female and male researchers when solving problems in the field of R&D. Our empirical evidence highlights that small firms are not able to capture the benefits of gender diversity because their size polarizes the distribution of gender diversity. The size of a small firm does not allow it to achieve a more gender-diverse composition than its larger counterparts. This results in small firms exhibiting more moderate levels of gender diversity and, consequently, they are not able to capture the positive effect of gender diversity on innovation. In addition to the diseconomies of scale, there are diseconomies of specialization due to the fact that small and young firms predominate in sectors such as ICT, R&D activities or services where women play a crucial role, while larger firms predominate in sectors which are gender neutral or male-dominated.

Previous theoretical and empirical predictions show opposed impacts of gender-diverse workforce structures on innovation (Alsos et al., 2013). We contribute to the literature by explaining the trade-off between the positive and negative impacts of more gender-diverse working structures and the moderating role of firm size. In that sense, larger firms may have more tools at an organizational level in order to tackle problems with more diverse teams.

Hence, we conclude that the role of gender diversity for firm-level innovation is subject to firm size. From a policy view, there are claims in order to increase the presence of female workers in order to improve firm performance. Recently, advice has been given in order to promote female labour participation in the labour market and, more specifically, in entrepreneurial activity (Bögenhold and Klinglmair, 2015). In this regard, it is useful to consider that an important policy implication of our work is that a minimum scale seems to be required in order for firms to be able to capture the benefits of gender diversity. Still, our results seem to suggest that small firms (from ten employees onwards) may benefit from a more gender diverse workforce. Accordingly, the development of policies that facilitate the human resource management of more gender diverse teams among small firms is important to improve the efficiency of such teams.

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Appendix: Model variables

Table A1. Description of variables

Dependent variables	*product$_{i,t}$*	Dummy equal to 1 if a firm introduced a product innovation in goods or services.
	process$_{i,t}$	Dummy equal to 1 if a firm introduced a process innovation.
	organization$_{i,t}$	Dummy equal to 1 if a firm introduced an organizational innovation.
	marketing$_{i,t}$	Dummy equal to 1 if a firm introduced a marketing innovation.
Independent variables	*size$_{i,t-1}$*	Total number of employees (in logs).
	age$_{i,t-1}$ *ageQuad$_{i,t-1}$*	Firm age and its quadratic value (in logs).
	RDext$_{i,t-1}$	Expenditure on external R&D per employee (in logs).
	RDint$_{i,t-1}$	Expenditure on internal R&D per employee (in logs).
	training$_{i,t-1}$	Training expenditure for innovation activities per employee (in logs).
	coop$_{i,t-1}$	Dummy equal to 1 if a firm cooperates with other companies.
	exp$_{i,t-1}$	Dummy equal to 1 if a firm exports.
	group$_{i,t-1}$	Dummy equal to 1 if a firm is part of a group.
	hightech-kis$_{i,t-1}$	Dummy equal to 1 for firms in high-tech and KIS sectors.
	gender$_{i,t-1}$	Blau index, calculated using male and female proportions of employees.

Table A2. Pearson correlations, 2007-2012.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) product	1														
(2) process	0.36*	1													
(3) marketing	0.32*	0.28*	1												
(4) organization	0.31*	0.38*	0.45*	1											
(5) size	0.13*	0.22*	0.09*	0.21*	1										
(6) age	0.00	0.06*	0.02*	0.03*	0.34*	1									
(7) ageQuad	0.01	0.07*	0.03*	0.05*	0.36*	0.98*	1								
(8) exp	0.19*	0.12*	0.12*	0.10*	0.18*	0.19*	0.19*	1							
(9) group	0.09*	0.12*	0.03*	0.13*	0.50*	0.09*	0.11*	0.13*	1						
(10) RDext	0.26*	0.20*	0.16*	0.22*	0.15*	0.00	0.01	0.14*	0.14*	1					
(11) RDint	0.50*	0.31*	0.27*	0.30*	0.10*	-0.03*	-0.02*	0.22*	0.09*	0.39*	1				
(12) training	0.20*	0.20*	0.17*	0.22*	0.11*	0.00	0.02*	0.04*	0.06*	0.19*	0.22*	1			
(13) coop	0.28*	0.24*	0.17*	0.23*	0.16*	-0.01*	-0.00	0.10*	0.15*	0.39*	0.36*	0.20*	1		
(14) hightech_kis	0.21*	0.00	0.06*	0.08*	-0.11*	-0.14*	-0.14*	0.09*	0.00	0.14*	0.29*	0.10*	0.13*	1	
(15) gender	0.11*	0.08*	0.12*	0.12*	0.11*	-0.01*	-0.01	0.04*	0.06*	0.10*	0.13*	0.09*	0.09*	0.03*	1

Source: Own elaboration from PITEC

** $p<0.05$*