GENDER DIVERSITY OF WORKFORCE AT FIRMS AND INNOVATION PERFORMANCE: EVIDENCE FROM FIRM-LEVEL DATA IN SPAIN

Master's Thesis

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Motivation

- The growing participation of women in the labour force revealed the importance of gender diversity in the workplace.
- This paper **aims** to examine whether **increased gender diversity** at firms fosters **product** and **process** innovation.
- Furthermore, the investigation of the relationship between **gender diversity** and **open innovation,** which refers to employing both internal and external sources, is a **key novelty.**
- The empirical analysis is conducted on the firm-level panel data, **PITEC**, from **Spain** during 2004-2016 using **propensity score matching** technique.
- We find that firms with less than 10% **increase in share of women** in the total workforce are **more likely** to engage in product, process, and open innovation.
- However, over a 3-year period a **negative association** has been observed after a 10% increase in share of women and open innovation, as well as a negative relationship between decreased gender diversity and open innovation.

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Literature Review

- Theoretical Considerations
- Empirical Findings

Theoretical considerations

- **Innovation** is the introduction of a new or improved product or process, implementation of a new marketing or organizational method (OECD & Statistical Office of the European Communities, 2005).
- The initial premise of the **open innovation** stems from the notion that a firm needs to use both internal and external factors to innovate and remain competitive (Chesbrough, 2003; Dahlander& Gann, 2010; Laursen & Salter, 2006).
- **Value-in-diversity approach**: gender diversity positively affects innovation performance by providing different creative ideas, broader perspective and competence base, which yields social and informational benefits (Ostergaard et al., 2011; Xie et al., 2020).
- **Social identity theory:** in the existence of gender diversity, formation of groups with similar interests causing social exclusion can lead to conflicts and decrease in team performance (Díaz-García et al. 2013; Tsui et al., 1992).
- Since innovation takes place in knowledge-based working environments where individuals execute challenging tasks and different points of views, fresh perspectives are highly valued, conflicts may not be an obstacle (Xie et al., 2020).

Empirical findings

- **Gender diversity and innovation**

Author	Result
Xie et al., 2020	Positive relationship between gender diversity(R&D) and innovation efficiency in Chinese firms
Ostergaard et al., 2011	Positive impact of the gender diversity on the likelihood of innovation in Danish companies

- **Gender diversity in corporate boards**

Author	Result
Griffin et al., 2021	Greater female presence in boards has positive association with the number of patents and innovation efficiency in 45 countries
Ritter-Hayashi et al., 2019	Positive effect of having female representation in top management on innovation in developing countries
Joecks et al., 2013	U-shaped correlation between gender diversity on boardroom and firm performance: reaching critical mass 30% of female share is beneficial using German dataset

Empirical findings

- **Gender diversity in Spanish firms**

Author	Result
Teruel & Segarra-Blasco, 2017	Gender diversity in R&D teams has dual effect on patent capacity: a negative effect on the Spanish patents and a positive effect on internationally registered patents.
Díaz-García et al., 2013	Gender diversity in R&D teams is positively linked to radical innovation, but not with incremental innovation

- **Gender diversity and open innovation**

Author	Result
Laursen & Salter, 2006	Firms open to external search are more innovative, possibility of a curvilinear relationship in the UK firms
Adams et al., 2023	Significant positive relationship between the increased percentage of women on corporate boards and open innovation in emerging countries

Data and methodology

- Data
- Descriptive Statistics
- Methodology

Data

- Panel of Technological Innovation (PITEC) data from Spanish Innovation in Companies surveys
- Includes more than 12,000 firms
- Yearly data gathered between 2003 and 2016 (have limited it to 2004-2016)
- Consists of 171,511 firm-year observations (have limited it to 128,572)

Explanatory variable:

- Increase in the share of women (binary) - 3 treatment groups with chosen threshold
- Increase in Blau index for gender diversity (binary) - 3 treatment groups with chosen threshold

Dependent variables:

- Product, process, external knowledge sourcing, collaboration, and open innovation (binary)

Control variables:

- The number of total employees (and in R&D), Internal R&D and External R&D, Incremental and Radical innovation, group membership, foreign ownership, public fundings, exports, lack of qualified staff and so on.

Descriptive Statistics

If **56.4%** of firms on average had increase in the share of women in **total workforce**, only **13.2%** of firms had an increase in the proportion of women compared with the prior year in **R&D**. This can show the persistency of the low representation of women.

On average, **81.2%** of firms use **external knowledge** sourcing to implement innovation activities. As open innovation refers to utilizing both internal R&D and external source of information, **59%** of companies engage in **open innovation**.

There is significant correlation between open innovation and increase in proportion of women.

Descriptive Statistics

Variables	*Observations*	*Mean*	*Standard deviation*
Number of total employees (ln)	128572	4.139	1.728
Number of total employees in R&D (ln)	128572	0.912	1.256
Share of women employees	128572	0.325	0.250
Share of women employees in R&D	128572	0.128	0.232
Increase in share of women	75298	0.564	0.496
Increase in share of women in R&D	97783	0.132	0.359
Blau index	128572	0.313	0.158
Blau index in R&D	128572	0.115	0.185
Increase in Blau index	75119	0.557	0.497
Group membership	128572	0.410	0.492
Internal R&D	128572	0.479	0.500
External R&D	128572	0.226	0.418
External knowledge sourcing	94286	0.812	0.391
Cooperation	94287	0.369	0.483
Incremental innovation	128572	0.354	0.478
Radical innovation	128572	0.268	0.443
Product innovation	128572	0.463	0.499
Process innovation	128572	0.473	0.499
Open innovation	94286	0.592	0.491
Neither	94286	0.128	0.334
Foreign ownership	128572	0.142	0.349
Public funding	116420	0.147	0.354
Exports	128572	0.417	0.493
Lack of employees	128572	0.369	0.483
Sales per person	128572	11.681	1.165
Number of external knowledge sources	128572	2.528	2.862
Machine	128572	0.170	0.376
External knowledge acquisition	128572	0.029	0.167
Trainings	128572	0.130	0.336
Market research	128572	0.173	0.378
Design	128572	0.072	0.258

Note. NA values are excluded.
Source: authors' calculations from PITEC

Descriptive Statistics

We also present the average values for **manufacturing** and **service industry** firms.

In total, a bigger share of the firms belongs to the **manufacturing** industry **(50.46%).** Firms operating in the **service** industry (**41.79%** of total) are more gender-diverse than manufacturing ones as Blau index indicates.

However, on average, **manufacturing** firms are **involved in innovation** practices, such as product, process, open, radical, incremental innovation, **more** than service firms.

Table 3
Descriptive statistics for industries

	Manufacturing industry			Service industry		
Variables	Obs.	Mean	Std. dev	Obs.	Mean	Std. dev
Number of total employees (ln)	64880	4.026	1.399	53733	4.243	2.042
Number of total employees in R&D (ln)	64880	1.043	1.234	53733	0.783	1.270
Share of women employees	64880	0.262	0.213	53733	0.428	0.265
Share of women employees in R&D	64880	0.145	0.245	53733	0.114	0.221
Increase in share of women	38548	0.542	0.498	30780	0.594	0.491
Increase in share of women in R&D	48940	0.166	0.372	41220	0.139	0.346
Blau index	64880	0.296	0.154	53733	0.350	0.156
Blau index in R&D	64880	0.128	0.188	53733	0.104	0.182
Increase in Blau index	38608	0.539	0.498	30554	0.582	0.493
Group membership	64880	0.400	0.490	53733	0.415	0.493
Internal R&D	64880	0.574	0.494	53733	0.383	0.486
External R&D	64880	0.273	0.445	53733	0.173	0.378
External knowledge sourcing	52941	0.834	0.372	35004	0.787	0.410
Cooperation	52941	0.347	0.476	35005	0.394	0.489
Incremental innovation	64880	0.443	0.497	53733	0.274	0.446
Radical innovation	64880	0.318	0.466	53733	0.226	0.418
Product innovation	64880	0.563	0.496	53733	0.377	0.485
Process innovation	64880	0.549	0.498	53733	0.392	0.488
Open innovation	52941	0.641	0.480	35004	0.531	0.499
Neither	52941	0.103	0.305	35004	0.156	0.363
Foreign ownership	64880	0.159	0.366	53733	0.132	0.339
Public funding	57363	0.144	0.351	49778	0.152	0.359
Exports	64880	0.616	0.486	53733	0.219	0.414
Lack of employees	64880	0.411	0.492	53733	0.324	0.468
Sales per person (ln)	64880	11.965	0.879	53733	11.312	1.345
Number of external knowledge sources	64880	2.862	2.828	53733	2.197	2.855
Machine	64880	0.197	0.398	53733	0.145	0.352
External knowledge acquisition	64880	0.028	0.166	53733	0.030	0.170
Trainings	64880	0.136	0.343	53733	0.130	0.336
Market research	64880	0.215	0.411	53733	0.137	0.344
Design	64880	0.090	0.286	53733	0.055	0.228

Notes. NA values are excluded.
Source: authors' calculations from PITEC

Descriptive Statistics

By keeping the **control group unchanged,** we perform the **t-test** for 3 different treatment groups: **more than 0%** change in share of women, between **0 and 10%** increase in share women, **more than 10%** increase in share of women.

The proportion of firms utilizing open innovation is **not statistically different** for firms that have any positive change in the proportion of women in their total workforce.

For firms with increase between 0 and 10%, incorporating open innovation **increases** compared to the ones with no change in the share of women.

However, utilizing open innovation activities **decreases** when companies increase their share of women more than 10%.

These results suggest a **nonlinear relationship** between open innovation and increase in share of women.

Table 6

Mean t-test. The comparison between companies with no change and an increase between and 10% in increase in share of women

	Increase between 0 and 10%			
	Group 0 Mean (SD)	*Group 1 Mean (SD)*	*Difference*	*Significance*
Group membership	0.38 (0.49)	0.47 (0.50)	-0.09	***
Internal R&D	0.46 (0.50)	0.50 (0.50)	-0.03	***
External R&D	0.21 (0.40)	0.24 (0.43)	-0.04	***
External knowledge sourcing	0.83 (0.37)	0.86 (0.35)	-0.02	***
Cooperation	0.38 (0.48)	0.41 (0.49)	-0.03	***
Incremental innovation	0.34 (0.47)	0.38 (0.49)	-0.04	***
Radical innovation	0.26 (0.44)	0.29 (0.45)	-0.03	***
Product innovation	0.44 (0.50)	0.49 (0.50)	-0.05	***
Process innovation	0.45 (0.50)	0.51 (0.50)	-0.07	***
Open innovation	0.61 (0.49)	0.63 (0.48)	-0.02	***
Neither	0.11 (0.31)	0.10 (0.30)	0.01	***
Foreign ownership	0.14 (0.35)	0.17 (0.37)	-0.03	***
Public funding	0.14 90.35)	0.16 (0.37)	-0.02	***
Exports	0.40 (0.49)	0.45 (0.49)	-0.06	***
Lack of employees	0.37 (0.48)	0.37 (0.48)	0.00	NS
Sales per person	11.68 (1.20)	11.79 (1.09)	-0.11	***
Number of external knowledge sources	2.47 (2.86)	2.75 (2.90)	-0.28	***
Machine	0.15 (0.35)	0.17 (0.38)	-0.03	***
External knowledge acquisition	0.02 (0.14)	0.03 (0.16)	-0.01	***
Trainings	0.10 (0.30)	0.12 (0.33)	-0.02	***
Market research	0.16 (0.37)	0.18 (0.38)	-0.02	***
Design	0.06 (0.23)	0.06 (0.24)	-0.01	***
Number of observations	32,826	32,448		

Notes. Welch Two Sample t-test; NA values are excluded. Standard errors are presented in parentheses.
Source: authors' calculations from PITEC

Descriptive Statistics

Carrying out the means test based on **increase in Blau** index variable with 3 treatment groups: companies with a **positive change** in their Blau index, with an increase in Blau between **0 and 0.1**, increase **more than 0.1**.

There is **no significant change** in open innovation activities in the case of the first treatment group.

The share of companies that engaged open innovation to their working process is **higher** for companies that increased their Blau index between 0 and 0.1 compared to last year.

More than 0.1 increase in gender diversity indicator is associated with **decreasing** level of open innovation.

Thus, the result is **in line** with previous findings implying the existence of an **inverted U-shaped** relationship for open innovation.

Table 9

Mean t-test. The comparison between companies with no change and an increase between 0 and 0.1 in their Blau index

	Increase between 0 and 0.1			
	Group 0 Mean (SD)	*Group 1 Mean (SD)*	*Difference*	*Significance*
Group membership	0.38 (0.49)	0.47 (0.50)	-0.09	***
Internal R&D	0.46 (0.50)	0.50 (0.50)	-0.04	***
External R&D	0.21 (0.40)	0.24 (0.43)	-0.04	***
External knowledge sourcing	0.83 (0.37)	0.86 (0.36)	-0.02	***
Cooperation	0.38 (0.48)	0.41 (0.49)	-0.03	***
Incremental innovation	0.34 (0.47)	0.38 (0.49)	-0.04	***
Radical innovation	0.25 (0.44)	0.29 (0.45)	-0.03	***
Product innovation	0.44 (0.50)	0.49 (0.50)	-0.05	***
Process innovation	0.45 (0.50)	0.52 (0.50)	-0.07	***
Open innovation	0.61 (0.49)	0.63 (0.48)	-0.02	***
Neither	0.11 (0.31)	0.10 (0.30)	0.01	***
Foreign ownership	0.14 (0.35)	0.17 (0.37)	-0.03	***
Public funding	0.14 (0.35)	0.16 (0.37)	-0.02	***
Exports	0.40 (0.49)	0.45 (0.50)	-0.05	***
Lack of employees	0.37 (0.48)	0.37 (0.48)	0.00	NS
Sales per person	11.68 (1.20)	11.78 (1.11)	-0.10	***
Number of external knowledge sources	2.46 (2.86)	2.77 (2.92)	-0.30	***
Machine	0.15 (0.35)	0.17 (0.38)	-0.02	***
External knowledge acquisition	0.02 (0.14)	0.02 (0.15)	0.00	***
Trainings	0.10 (0.30)	0.13 (0.33)	-0.02	***
Market research	0.16 (0.37)	0.18 (0.38)	-0.02	***
Design	0.06 (0.23)	0.06 (0.24)	-0.01	***
Number of observations	33,270	33,936		

Notes. Welch Two Sample t-test; NA values are excluded. Standard errors are presented in parentheses.
Source: authors' calculations from PITEC

Descriptive Statistics

We also checked the difference in means test for the **decrease in share of women** and **decrease in gender diversity** indicator.

There is **no significant difference** in applying open innovation practices between the two groups namely, groups with no change and decrease in share of women.

However, on average, **smaller** number of firms apply open innovation in the group with decrease in Blau index.

Table 12

Mean t-test. The comparison between companies with no change and a negative change in thei share of women

	Decrease in share of women			
	Group 0 Mean (SD)	*Group 1 Mean (SD)*	*Difference*	*Significance*
Group membership	0.38 (0.49)	0.45 (0.50)	-0.07	***
Internal R&D	0.46 (0.50)	0.47 (0.50)	-0.01	NS
External R&D	0.21 (0.40)	0.23 (0.42)	-0.02	***
External knowledge sourcing	0.83 (0.37)	0.85 (0.36)	-0.01	***
Cooperation	0.38 (0.48)	0.39 (0.49)	-0.01	***
Incremental innovation	0.34 (0.47)	0.37 (0.48)	-0.03	***
Radical innovation	0.25 (0.44)	0.28 (0.45)	-0.02	***
Product innovation	0.44 (0.50)	0.48 (0.50)	-0.04	***
Process innovation	0.45 (0.50)	0.50 (0.50)	-0.05	***
Open innovation	0.61 (0.49)	0.60 (0.49)	0.01	NS
Neither	0.11 (0.31)	0.11 (0.31)	0.00	NS
Foreign ownership	0.14 (0.35)	0.16 (0.37)	-0.02	***
Public funding	0.14 (0.35)	0.15 (0.36)	-0.01	***
Exports	0.40 (0.49)	0.43 (0.49)	-0.03	***
Lack of employees	0.37 (0.48)	0.37 (0.48)	0.00	NS
Sales per person	11.68 (1.20)	11.72 (1.12)	-0.04	***
Number of external knowledge sources	2.46 (2.86)	2.64 (2.91)	-0.17	***
Machine	0.15 (0.35)	0.16 (0.37)	-0.01	***
External knowledge acquisition	0.02 (0.14)	0.02 (0.14)	0.00	NS
Trainings	0.10 (0.30)	0.12 (0.32)	-0.01	***
Market research	0.16 (0.37)	0.17 (0.38)	-0.01	**
Design	0.06 (0.23)	0.06 (0.23)	0.00	**
Number of observations	33,270	47,666		

Notes. Welch Two Sample t-test; NA values are excluded. Standard errors are presented in parentheses.
Source: authors' calculations from PITEC

Methodology

We will use propensity score matching technique (PSM) (Rosenbaum & Rubin, 1983). This method helps us to take into account number of firm characteristics like size, sector, group ownership, and include performances of the corresponding and past years.

The steps of PSM method:

- propensity score estimation

  Probit estimation equation: $y_{it} = \beta_0 + \beta_1 x_{1,i(t-3)} + \beta_2 x_{2,i(t-3)} + .. + \beta_k x_{k,i(t-3)} + \varepsilon$

- choosing a matching algorithm

  Nearest Neighbour, Caliper and Radius, and Stratification and Interval

- estimating the average treatment effect (ATT)

  $$ATT = E\left(y_{t+3}^{1} - y_{t+3}^{0} \mid D_t = 1\right) = E\left(y_{t+3}^{1} \mid D_t = 1\right) - E\left(y_{t+3}^{0} \mid D_t = 1\right)$$

- checking the matching quality and conducting a sensitivity analysis.

Results

- Propensity Score matching
- Results of PSM
- Discussion
- Conclusion

Propensity score estimation

We created 4 regression models considering the set of control variables for each four outcomes.

Looking at statistically significant coefficient estimates, when setting the treatment group with more than 0% increase in share of women, we can see that firms that are part of a group of companies are more likely to increase share of women in all models.

For the second treatment group with an increase between 0% and 10%, a positive relationship is revealed in all models for firms with higher sales productivity per employee at 95% confidence level. There is more likelihood of increasing gender diversity if the firm undertakes exporting activities.

Considering the treatment group of more than 10% increase, acquisition of machinery and equipment for innovation process is negatively associated with the increase in share of women and it is applicable for all models.

b) Treatment group 2

	Model 1	Model 2	Model 3	Model 4
	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)
Group	0.035 (0.026)	0.022 (0.022)	0.022 (0.022)	0.036 (0.026)
Share of women	0.066 (0.056)	0.040 (0.045)	0.040 (0.045)	0.064 (0.056)
Employment	0.054*** (0.009)	0.093*** (0.007)	0.092*** (0.007)	0.053*** (0.009)
Employment in R&D	0.022* (0.013)	-0.002 (0.012)	-0.002 (0.012)	0.022 (0.013)
Internal R&D	-0.096** (0.037)	-0.000 (0.030)	0.002 (0.030)	-0.098** (0.037)
External R&D	0.017 (0.024)	0.016 (0.021)	0.016 (0.021)	0.017 (0.024)
Foreign ownership	-0.037 (0.317)	-0.031 (0.028)	-0.031 (0.028)	-0.038 (0.317)
Cooperation	0.019 (0.024)	0.015 (0.021)	0.013 (0.021)	0.01 (0.024)
External knowledge sourcing	-0.024 (0.03)	-0.015 (0.029)	-0.005 (0.029)	-0.043 (0.03)
Public funding	0.028 (0.028)	0.047 (0.026)	0.047 (0.026)	0.030 (0.028)
Incremental innovation	0.000 (0.021)	-0.013 (0.030)	0.001 (0.019)	-0.029 (0.021)
Radical innovation	-0.012 (0.023)	-0.026 (0.026)	-0.016 (0.026)	-0.034 (0.023)
Exports	0.055** (0.024)	0.074*** (0.020)	0.074*** (0.020)	0.055** (0.024)
Lack of employees	0.040* (0.021)	0.035 (0.018)	0.034 (0.018)	0.040* (0.021)
Sales per person	0.033** (0.013)	0.038*** (0.010)	0.038*** (0.010)	0.032** (0.013)
Number of external knowledge sources	0.000 (0.005)	0.001 (0.004)	0.001 (0.004)	0.000 (0.005)
Machine	-0.026 (0.024)	-0.019 (0.021)	-0.026 (0.022)	-0.037 (0.024)
External knowledge	-0.093* (0.051)	-0.151*** (0.047)	-0.151*** (0.047)	-0.094* (0.051)
Trainings	0.084*** (0.029)	0.076*** (0.026)	0.073*** (0.026)	0.083*** (0.029)
Design	-0.011 (0.036)	-0.006 (0.033)	-0.00 (0.033)	-0.012 (0.036)
Market research	0.039 (0.026)	0.032 (0.023)	0.035 (0.023)	0.036 (0.026)
Product innovation		0.024 (0.038)		0.052 (0.43)
Process innovation			0.030 (0.0211)	0.045 (0.25)
Neither				-0.018 (0.63)
Sector and year dummies	Yes	Yes	Yes	Yes
R^2	0.012	0.018	0.012	0.012
LR-chi^2	246.59	533.71	535.36	251.23
p>chi^2	0.000	0.000	0.000	0.000
No of obs.	15331	21334	21334	15331

Notes. Model 1, 2, 3 and 4 stands for the regression models using set of control variables for each outcome, namely external knowledge sourcing/cooperation, product/process innovation and open innovation, respectively. Significance levels are ***p < 1%, **p < 5%, *p < 10%.
Source: authors' calculations from PITEC

Propensity score estimation

The same logical sequence follows for creating regression models for gender diversity as treatment variable.

For models of both treatment group 1 and 2, firms that engage in export operations, have higher sales per staff are more likely to have higher gender representation.

However, in the treatment group with more than 0.1 increase in Blau index, inverse relationship exists with carrying out exporting activities and it is valid for all models.

b) Treatment group 2

	Model 1	Model 2	Model 3	Model 4
	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)
Group	0.046* (0.025)	0.043* (0.021)	0.044** (0.022)	0.046* (0.025)
Share of women	0.362*** (0.054)	0.301*** (0.044)	0.301*** (0.044)	0.362*** (0.054)
Employment	0.046*** (0.009)	0.079*** (0.007)	0.079*** (0.007)	0.046*** (0.009)
Employment in R&D	0.020 (0.013)	0.000 (0.012)	0.000 (0.012)	0.021 (0.013)
Internal R&D	-0.085** (0.037)	-0.003 (0.030)	-0.001 (0.030)	-0.086** (0.038)
External R&D	0.022 (0.023)	0.026 (0.020)	0.026 (0.021)	0.022 (0.023)
Foreign ownership	-0.055* (0.031)	-0.049* (0.027)	-0.050* (0.027)	-0.056* (0.031)
Cooperation	0.008 (0.023)	0.011 (0.021)	0.010 (0.021)	0.005 (0.024)
External knowledge sourcing	-0.029 (0.036)	0.011 (0.029)	0.010 (0.029)	-0.040 (0.051)
Public funding	0.027 (0.027)	0.039 (0.025)	0.040 (0.025)	0.029 (0.027)
Incremental innovation	0.00 (0.022)	-0.006 (0.029)	0.006 (0.019)	-0.022 (0.032)
Radical innovation	-0.014 (0.022)	-0.023 (0.025)	-0.014 (0.020)	-0.033 (0.028)
Exports	0.056** (0.023)	0.073* (0.020)	0.073*** (0.020)	0.056** (0.023)
Lack of employees	0.046** (0.021)	0.042** (0.018)	0.041** (0.018)	0.046** (0.021)
Sales per person	0.033*** (0.012)	0.037*** (0.010)	0.037*** (0.010)	0.033*** (0.012)
Number of external knowledge sources	-0.000 (0.005)	-0.000 (0.004)	-0.000 (0.004)	-0.000 (0.005)
Machine	-0.040* (0.024)	-0.023* (0.021)	-0.028 (0.022)	-0.047* (0.025)
External knowledge	-0.092* (0.051)	-0.136*** (0.046)	-0.136*** (0.046)	-0.093* (0.051)
Trainings	0.084*** (0.028)	0.076*** (0.026)	0.075*** (0.026)	0.083*** (0.028)
Design	-0.014 (0.036)	-0.011 (0.032)	-0.012 (0.032)	-0.015 (0.036)
Market research	0.036 (0.025)	0.026 (0.023)	0.028 (0.023)	0.033 (0.025)
Product innovation		0.021 (0.037)		0.045 (0.042)
Process innovation			0.022 (0.021)	0.029 (0.025)
Neither				-0.006 (0.063)
Sector and year dummies	Yes	Yes	Yes	Yes
R^2	0.013	0.01	0.018	0.013
LR-chi^2	285.05	534.03	534.82	287.52
p>chi^2	0.000	0.000	0.000	0.000
No of obs.	15834	21998	21998	15834

Notes. Model 1, 2, 3 and 4 stands for the regression models using set of control variables for each outcome, namely external knowledge sourcing/cooperation, product/process innovation and open innovation, respectively. Significance levels are ***p < 1%, **p < 5%, *p < 10%.
Source: authors' calculations from PITEC

Results of PSM analysis (1)

In the first treatment group, there is **no relationship** between increasing share of women and each of 5 outcomes.

Firms with an increase up to 10% are 1.1% and 1.4% **more likely** to engage in product and process innovation, respectively.

For the third treatment group, more than 10% increase in share of women **decreases** the likelihood to promote open innovation by 1.7% at 10% significance level.

b) Treatment group 2

Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation						
(t+3)	Unmatched	0.472	0.432	0.398	0.007	***
ATT	Matched	0.472	0.461	0.011	0.008	*
Process Innovation						
(t+3)	Unmatched	0.472	0.421	0.051	0.007	***
ATT	Matched	0.472	0.457	0.014	0.008	**
External knowledge sourcing (t+3)	Unmatched	0.851	0.846	0.004	0.006	NS
ATT	Matched	0.851	0.852	-0.001	0.007	NS
Cooperation (t+3)	Unmatched	0.444	0.421	0.023	0.008	***
ATT	Matched	0.444	0.446	-0.002	0.009	NS
Open Innovation (t+3)	Unmatched	0.625	0.617	0.099	0.008	NS
ATT	Matched	0.625	0.620	0.006	0.009	NS

Notes. Propensity score matching results are found based on Table 13b. The number of observations is the same with the regression.
Source: authors' calculations from PITEC

Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation						
(t+3)	Unmatched	0.440	0.432	0.008	0.009	NS
ATT	Matched	0.440	0.433	0.007	0.009	NS
Process Innovation						
(t+3)	Unmatched	0.444	0.421	0.023	0.008	***
ATT	Matched	0.444	0.444	-0.00	0.009	NS
External knowledge sourcing (t+3)	Unmatched	0.840	0.846	-0.006	0.007	NS
ATT	Matched	0.840	0.845	-0.004	0.008	NS
Cooperation (t+3)	Unmatched	0.435	0.421	0.014	0.009	NS
ATT	Matched	0.435	0.448	-0.013	0.010	NS
Open Innovation (t+3)	Unmatched	0.593	0.617	-0.024	0.009	***
ATT	Matched	0.593	0.610	-0.017	0.011	*

Notes. Propensity score matching results are found based on Table 13c. The number of observations is the same with the regression.
Source: authors' calculations from PITEC

Results of PSM analysis (2)

When it comes to gender diversity as a treatment variable, positive change in Blau index **decreases** the likelihood to foster open innovation by 1.1%.

For the second treatment group, there is **no significant linkage** between open innovation and enhanced gender diversity.

In the treatment group with more than 0.1 increase in Blau index, the probability that firms employ external knowledge sourcing, open, product and process innovation **decreases** by 2.9%, 4.9%, 4.2% and 1.6%, correspondingly.

PSM results with Blau index as treatment variable

a) Treatment group 1

Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation (t+3)	Unmatched	0.451	0.432	0.019	0.006	***
ATT	Matched	0.451	0.447	0.004	0.007	NS
Process Innovation (t+3)	Unmatched	0.451	0.420	0.031	0.006	***
ATT	Matched	0.451	0.443	0.008	0.007	NS
External knowledge sourcing (t+3)	Unmatched	0.844	0.846	-0.002	0.006	NS
ATT	Matched	0.844	0.850	-0.006	0.006	NS
Cooperation (t+3)	Unmatched	0.429	0.421	0.009	0.008	NS
ATT	Matched	0.429	0.433	-0.005	0.009	NS
Open Innovation (t+3)	Unmatched	0.610	0.617	-0.007	0.007	NS
ATT	Matched	0.621	0.621	-0.011	0.008	*

Notes. Propensity score matching results are found based on Table 14a. The number of observations is the same with the regression.
Source: authors' calculations from PITEC

c) Treatment group 3

Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation (t+3)	Unmatched	0.346	0.432	-0.086	0.011	***
ATT	Matched	0.346	0.387	-0.042	0.013	***
Process Innovation (t+3)	Unmatched	0.359	0.420	-0.061	0.011	***
ATT	Matched	0.359	0.375	-0.016	0.013	*
External knowledge sourcing (t+3)	Unmatched	0.804	0.846	-0.042	0.011	***
ATT	Matched	0.804	0.833	-0.029	0.013	***
Cooperation (t+3)	Unmatched	0.381	0.420	-0.039	0.014	***
ATT	Matched	0.381	0.473	0.008	0.016	NS
Open Innovation (t+3)	Unmatched	0.514	0.617	-0.102	0.014	***
ATT	Matched	0.514	0.563	-0.049	0.016	***

Notes. Propensity score matching results are found based on Table 14c. The number of observations is the same with the regression.
Source: authors' calculations from PITEC

Results of PSM analysis (3)

We perform propensity score matching for treatment variables with a decrease.

Negative change in share of women employees and in Blau index **decreases** the probability to adapt open innovation by 1.1% and 1.3%, respectively.

PSM results with decrease in share of women as treatment variable

Variable (Dec)	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation (t+3)	Unmatched	0.460	0.432	0.028	0.006	***
ATT	Matched	0.460	0.454	0.006	0.007	NS
Process Innovation (t+3)	Unmatched	0.452	0.421	0.031	0.006	***
ATT	Matched	0.452	0.450	0.002	0.007	NS
External knowledge sourcing (t+3)	Unmatched	0.851	0.846	0.004	0.005	NS
ATT	Matched	0.851	0.858	-0.007	0.006	NS
Cooperation (t+3)	Unmatched	0.426	0.421	0.006	0.007	NS
ATT	Matched	0.426	0.430	-0.003	0.008	NS
Open Innovation (t+3)	Unmatched	0.615	0.617	-0.002	0.007	NS
ATT	Matched	0.615	0.626	-0.011	0.008	*

Notes. The number of observations is 26,617 for product and process innovation, 18,990 for external knowledge sourcing and open innovation.
Source: authors' calculations from PITEC

PSM results with decrease in Blau index

Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Product Innovation (t+3)	Unmatched	0.446	0.432	0.014	0.007	***
ATT	Matched	0.446	0.444	0.002	0.007	NS
Process Innovation (t+3)	Unmatched	0.438	0.420	0.018	0.007	***
ATT	Matched	0.438	0.421	0.011	0.007	*
External knowledge sourcing (t+3)	Unmatched	0.849	0.846	0.003	0.006	NS
ATT	Matched	0.849	0.854	-0.006	0.006	NS
Cooperation (t+3)	Unmatched	0.419	0.420	-0.001	0.007	NS
ATT	Matched	0.419	0.431	-0.012	0.009	*
Open Innovation (t+3)	Unmatched	0.609	0.617	-0.008	0.008	NS
ATT	Matched	0.609	0.622	-0.013	0.009	*

Notes. The number of observations is 16,350 for open innovation, cooperation and external sourcing, 23,229 for product and process innovation.
Source: authors' calculations from PITEC

Results of PSM analysis (4)

We extend our analysis to explore this effect for manufacturing and service industry firms.

Manufacturing firms:

- The probability to apply open innovation **decreases** for manufacturing firms that have more than 0% or more than 10% increase in their proportion of women employees.
- The treatment group with more than 0.1 increase in gender diversity has a significant **negative** association with open innovation.

Service industry firms:

- Firms that increase the share of women more than 10% have 3.1% **less likelihood** to perform open innovation.
- Firms with more than 0.1 increase in Blau index the probability of leveraging open innovation activities **decreases** by 4.5%.

Sensitivity analysis (1)

- We adjust the number of nearest neighbors to match.

In case of increased share of women as treatment variable, the results of matching suggest consistency for pairs ranging from one to seven for first and second treatment groups. For the third treatment group, starting from 2 neighbors the significant **decreasing** relationship continues.

Regarding the increase in Blau index more than 0, the significant negative association with open innovation persists only for 2 and 3 neighbors. Similarly, we still obtain significant **negative** relationship for more than 0.1 positive change in gender diversity after changing the number of neighbors.

- We change the threshold for the increase of women employees and gender diversity indicator.

Estimating propensity scores with 5%, 15% threshold shows that both treatment groups with more than 5% and 15% increase have significant **negative** relationship with open innovation.

Increasing gender diversity between 0 and 0.05 or 0 and 0.2 doesn't change the probability of engaging in open activities. An increase over those threshold levels significantly decreases the likelihood of incorporating open innovation practices to workplace.

Sensitivity analysis (2)

- We repeat the analysis using kernel matching instead of nearest neighbor. Only significant results for open innovation is shown in the third treatment group.

Firms with more than 10% increased share of women and more than 0.1 increase in gender diversity are 1.9% and 5.6% less likely to participate in open innovation.

Kernel for open innovation

a) Increased share of women treatment as treatment variable

Treatment groups	Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Group 1	*Open Innovation* (t+3)	Unmatched	0.609	0.617	-0.008	0.008	NS
	ATT	Matched	0.609	0.618	-0.009	0.008	NS
Group 2	*Open Innovation* (t+3)	Unmatched	0.625	0.617	0.009	0.008	NS
	ATT	Matched	0.625	0.623	0.003	0.008	NS
Group 3	*Open Innovation* (t+3)	Unmatched	0.593	0.617	-0.024	0.009	***
	ATT	Matched	0.593	0.613	-0.020	0.009	***

Notes. The number of observations in Group 1 is 17,138, in Group 2 it is 15,331 and in Group 3 it is 11,712.
Source: authors' calculations from PITEC

b) Increased Blau index as treatment variable

Treatment groups	Variable	Sample	Treated	Controls	Difference (ATT)	Std. Err.	Significance
Group 1	*Open Innovation* (t+3)	Unmatched	0.610	0.617	-0.007	0.007	NS
	ATT	Matched	0.610	0.619	-0.009	0.008	NS
Group 2	*Open Innovation* (t+3)	Unmatched	0.626	0.617	0.009	0.008	NS
	ATT	Matched	0.626	0.625	0.001	0.008	NS
Group 3	*Open Innovation* (t+3)	Unmatched	0.514	0.617	-0.102	0.014	***
	ATT	Matched	0.514	0.570	-0.056	0.015	***

Notes. The number of observations in Group 1 is 17,246, in Group 2 it is 15,834 and in Group 3 it is 8,785.
Source: authors' calculations from PITEC

Discussion

- The difference in means test revealed a more complex non-linear relationship between gender diversity and innovation performance.

- The main implication is that there might be an optimal level of gender diversity that positively affects innovation outcomes. Hence, management should strive for a level of gender diversity that fosters inclusion keeping in mind the tradeoff between the costs and benefits.

- The negative association with decrease in share of women/Blau index confirms the idea that balanced teams are crucial for adopting innovation strategies.

- Focusing on balanced teams rather than maximizing the share of women, creating the environment suitable for active participation of all members, reassessing the corporate culture to integrate women are some examples.

Conclusion

- We find that, on average, firms that increased the share of women employees in yearly basis displays different outcomes than the ones with no increase.
- Companies with increase up to 10% have more likelihood to use product and process innovation. The probability to practice open innovation decreases only with more than 10% increase in the share of women by 1.7% at 10% significance level.
- When it comes to increase in gender diversity in firms as a treatment variable that was assigned based on Blau index, there is a negative linkage with open innovation if we take companies with a positive change in our treatment group. The probability of companies using open innovation decreases by 4.9% for the third treatment group.
- Industry level results indicate that for manufacturing and service sectors the likelihood to openly innovate negatively associate with more than 0% increase in share of women. For third treatment groups, the utilization of open innovation in service industry firms declines more compared to manufacturing companies.
- Our results suggest that the increase in female representation should be balanced. Subsequent research could explore this topic in greater depth by considering alternative combinations of open innovation beyond the R&D and external linkages.

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Thank you!