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GENDER DIVERSITY, INNOVATION, AND OPEN INNOVATION IN THE CARIBBEAN REGION

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IDB

Contents

Abstract

The Caribbean economies are well-ranked in terms of women's participation in the labor market, but less so in terms of innovation, suggesting the relevance of an analysis of gender diversity's impact on innovation. This paper examines how gender diversity in Caribbean firm affects the formation of external partnerships and agreements for innovation, and also how the effects of that diversity on innovative outcomes are influenced by the presence of women in diverse positions within a firm. Using information for 13 Caribbean countries from the Innovation, Firm Productivity and Gender (IFPG) database, this study confirms gender diversity as a factor which both improves the likelihood of innovation, as well as spurring the decision to collaborate with other firms and organizations. However, impacts will depend on the areas within a firm in which women are present. Gender diversity in the total workforce and in production and non-production activities is more effective than when women are present in areas solely related to management. These findings prompt a reflection on policy implications around the definition or improvement of measures oriented to the closing of innovation-related gender gaps.

Keywords: gender diversity, Caribbean region, innovation, open innovation
JEL: O30, O32, O36, O15

1

Introduction

In Caribbean economies, the impact of gender diversity on innovation remains an important issue; these economies rank high in the region in terms of women's participation in the labor market but less so in terms of innovation. However, without the full inclusion of women in the creative process of innovation dynamics within firms there is a lost opportunity in terms of productivity. A more evenly distributed gender balance has the potential to harness skills and individual capabilities, leading to stronger innovation performances that, in turn, boost growth and competitiveness.

Despite general agreement on the relevance and complexity of innovation, as well as on collaboration to innovate, more research is required to assess and understand how knowledge bases can be broadened when considering diversity with respect to age, gender, race, education, or nationality. Over the past decade, this has become a topic of interest in the literature on innovation. Nevertheless, since results of empirical studies have been mixed (Gallego and Gutiérrez Urdaneta, 2018), there is as yet no conclusive evidence of the relationship between gender diversity and innovation performance. Despite this, most studies suggest that a more even gender balance could be key to improving innovation at the firm level (Arun, Joseph and Ul Akram, 2020; Díaz-García, Gonzalez-Moreno and Sáez-Martínez, 2013; Teruel and Segarra-Blasco, 2017; Østergaard et al., 2011).

At the same time, innovation is a complex process that happens through cooperation among different actors—for example, firms, knowledge organizations, governments, and non-government organizations (Chesbrough, 2003; Tello-Gamarra et al., 2018)—especially where economic and institutional conditions are limiting factors, due to insufficient funds and/or lack of scientific, technological, and managerial capabilities, or other causes. A handful of recent studies evaluate the effects of gender diversity on decisions to cooperate with other actors in the innovation system, and the results here are also mixed (Amoroso and Audretsch, 2020).

This paper focuses on two questions previously unexplored in studies on gender diversity's effect on innovation and cooperation to innovate in Caribbean firms. The first is whether the effect of gender diversity on innovation outcomes is dependent on there being women in decision-making positions (such as top management, or in activities related to production as well as non-production). The second seeks to determine to what degree gender diversity

within firms in the Caribbean region helps to form external partnerships and agreements, thereby improving innovative results and consolidating innovation systems.

The Caribbean is a propitious context for examining the impact of gender diversity on innovation and open innovation. Throughout the Latin American and Caribbean (LAC) region, between 1990 and 2018, women's participation in the labor force increased by 25 percent. (World Bank, 2020). Available data shows that the sub-index of the Economic Participation and Opportunity[1] rate in the LAC region is at 64.2 percent, above the global average of 58 percent (World Economic Forum, 2021). In particular, the Caribbean shows a good rate of participation of women in the labor force in different positions within firms (Moore et al., 2017), with some Caribbean countries registering a larger number of women in executive positions compared to other LAC countries (World Bank, 2021; World Economic Forum, 2021).

On the other hand, the unprecedented technological developments over the past century mean that both innovation and research and development (R&D) now play fundamental roles in understanding growth and competitiveness within firms and countries (Fagerberg, 2004; Lundvall, 2010). As Braguinsky et al. (2020) indicate, successive innovations (such as product introductions) in firms have helped build knowledge-capital and shape future product expansion and growth. Innovation and R&D are also main drivers when facing the current challenges of digitalization and environmental sustainability, where LAC economies currently lag behind. In the 2021 Global Innovation Index (GII), there are no countries in the LAC region ranked within the top 50. Regarding Caribbean countries in particular, only Jamaica and Trinidad and Tobago appear in the GII, ranking 74 and 97, respectively (WIPO, 2021). These indicators suggest that LAC firms continue to register a limited capacity to innovate, owing in part to lack of finances for investment in R&D, lack of technological capabilities, and weak institutional support (Padilla-Pérez and Gaudin, 2014; Vélez, 2019).

Literature on the relationship between gender diversity and innovation (as well as open innovation) in the Caribbean is still scarce. The aim of this study is to offer new insights for the design of strategies and policies that can foster a wider participation of women in the innovation performance of firms, since this can be a driver that has wider competitive advantages. Enhancing productivity through innovation is at the top of the agenda in both developed and developing economies. This paper could help Caribbean countries seeking opportunities for stronger and more sustainable post-pandemic growth (IDB, 2021).

The study draws on information on 13 Caribbean countries from the Innovation, Firm Productivity and Gender (IFPG) database. The first section is three-fold: it shows how a more evenly balanced distribution of men and women at different levels of employment impacts Caribbean firms' likelihood to innovate; it compares the different effects of gender diversity; and it corroborates previous findings on the same theme in the Caribbean (Moore, Presbitero and Rabellotti, 2017). The second section of the study analyzes how the effects of gender within different areas of a firm could advance collaboration to innovate, given that innovation in isolation is relatively difficult to achieve in small economies such as the Caribbean.

The main results confirm that gender diversity can indeed lead to innovation and collaboration between Caribbean firms and other organizations, but also that the impact depends

[1] Economic Participation and Opportunity is one of the four key gaps tracked by the Gender Gap Index. This measure is comprised of five indicators: Labor Force Participation Rate, Wage Equality for Similar Work, Estimated Earned Income, Legislators, Senior Officials and Managers, and Professional and Technical Workers.

upon which area within a firm that women are present. Firms with gender diversity throughout the workforce in both production and non-production activities gain more from the presence of women than firms where women are present only in managerial roles, with the greatest effect of gender diversity in production and non-production activities being found in technological innovation. These findings suggest that, in regards to innovation, policies could be implemented to identify or improve measures for closing gender gaps.

2

Background

2.1. Gender Diversity and Innovation

Previous studies on innovation have focused more on technical areas than on human resources. Given that innovation is a key driver for growth in productivity, a great number of studies have analyzed the influence of different factors on the innovation performance of firms, for example, R&D investment, absorptive capacity, and business strategy, among others (Cohen and Levinthal, 1990; Kafouros et al., 2020; Protogerou, Caloghirou and Vonortas, 2017). Meanwhile, factors related to human capital, such as team diversity and gender diversity—variety and equal balance of men and women in the workplace (Campbell and Mínguez-Vera, 2008 ; Østergaard, Timmermans and Kristinsson, 2011)—have gone largely unexplored in the literature on innovation in general and on open innovation in particular (Agnete Also, Ljunggren, and Hytti, 2013; Bogers, Foss, and Lyngsie, 2018; Ljundggren et al., 2010).

Nevertheless, gender issues have captured the interest of both academics and policymakers and there has been a rise over the past decade in the number of studies that consider human resources and demographics for the understanding of innovation processes (Arun, Joseph, and Ul Akram, 2020; Bogers, Foss, and Lyngsie, 2018; Garcia Martinez, Zouaghi, and Garcia Marco, 2017; Gallego and Gutiérrez Urdaneta, 2018). The evidence available suggests that gender diversity can have a positive effect on innovation within a firm in three types of position held by women: (i) shareholders (ownership), (ii) top managerial positions, and (iii) employees (in terms of the overall workforce or where there is diversity in different functional areas).

To date there is no overall agreement as to gender diversity's impact on innovation, although most studies show that female participation in the workplace increases a firm's capacity to innovate, due to women's different perspectives, perceptions, and skill sets (Díaz-García, González-Moreno, and Sáez-Martínez, 2013; Garcia-Martínez, Zouaghi, and Garcia Marco, 2017; Romero-Martínez, Montoro Sánchez, and Garavito Hernández, 2017; Østergaard et al., 2011). Existing literature shows there can be a substantial impact on several aspects of innovation where women are in executive positions, such as firm owner, CEO, or part of top manager teams (TMTs). The upper echelon theory (Hambrick, 2007) supports this argument

and suggests that a team's composition (especially in TMTs) determines a firm's strategy, because differing cognitive frames among decision-makers diversify perceptions and thus provide different frames for strategic choices.

One of the reasons why women in executive positions positively impact innovation is because they are more focused on R&D activities than their male counterparts (Miller and Del Carmen Triana, 2009) and their attitude is relatively open to new ideas (Santos, Marques, and Ratten, 2019). Furthermore, women tend to conduct stringent monitoring and gather more detailed information about a firm's environment (Galbreath, 2011), thereby reducing asymmetric information and problems related to R&D agency (Tong and Zhang, 2021; Chen al., 2021). They also gain more knowledge of the market, leading to better-informed decisions (Carter, Simkins, and Simpson, 2003). In addition, female directors are more likely to foster a structure that encourages innovation, cooperation, and information exchange, which are essential for the success of R&D (Chen et al., 2021).

Further studies confirm the positive impact of women in top positions on a firm's innovative behavior and performance (Arun et al., 2020; Dohse et al., 2019; Moore et al., 2017; Ritter-Hayashi et al., 2019). A TMT with a relatively even gender balance garners a higher innovation performance. (Ain et al., 2021; Ritter-Hayashi et al., 2019; Ruiz-Jiménez et al., 2016; Torchia et al., 2018; Xie et al., 2020). Diversity within a TMT generates new ideas and favors the allocation of resources and research opportunities for further investment in R&D actions that can have successful results in terms of innovation (Miller and Del Carmen Triana, 2009; Loukil and Yousfi, 2015; Miller and Del Carmen Triana, 2009; Mukarram et al., 2018).

Studies that focus on gender diversity in the total workforce, rather than solely in TMTs, within small teams (like TMTs), may be less effective (Østergaard et al., 2011), since the innovation process involves interactions among various employees at different levels of the firm (Kline and Rosenberg, 1986; Lundvall, 1992). Therefore, it is more appropriate to take a broader view of the skills and knowledge within the firm when analyzing the effects of employee diversity on the firm's innovative performance (Østergaard et al., 2011).

Gender diversity in the workforce can enhance the innovative capability of an enterprise and is particularly useful for introducing processes, marketing, and organizational innovations in large firms, which, in turn, can improve their own innovativeness (Teruel and Segarra-Blasco, 2017; Ritter-Hayashi et al., 2019). The impact of gender diversity may also differ according to the type of innovation, since each type calls for the development of different resources and skills (Gallego and Gutiérrez Urdaneta, 2018; Teruel and Segarra-Blasco, 2017). For example, technological innovation (new or improved products and processes) often requires increased creativity, investment, adoption of risk, and the development of complex operations. Such innovations could benefit from women's ability to resolve conflicts, generate new ideas, and carry out complex tasks related to R&D (Díaz-García et al., 2013; Xie et al., 2021). Where non-technological innovation (organizational and market-related) is concerned, women, who are considered to be more "people-oriented" (Torchia et al., 2018), may be better at monitoring the environment and identifying customer needs, thus generating a positive impact on marketing innovation as well as helping to implement changes in organization.

2.2. Gender Diversity and Open Innovation

Many firms choose to collaborate with other actors (customers, suppliers, universities, and research centers, among others) to share the costs and risks of an innovation process, or as

a way of procuring resources and capacities which they do not have internally. This strategy is commonly referred to as open innovation (Chesbrough, 2006). Existing literature provides evidence for the positive impact of open innovation, where a combination of internal and external knowledge and technology can help firms improve the innovation process (Belderbos et al., 2004; Bayona-Saez et al., 2017; Cheng and Huizingh, 2014; Laursen and Salter, 2006; Pasciaroni and Barbero, 2020; Van Beers and Zand, 2014). Among the determinant factors key to understanding R&D cooperation, the most relevant are firm size and intensity of innovation (Fritsch and Lukas, 2001). However, scant attention has been paid to diversity of human capital in collaborative activities (Ali et al., 2020; Bogers et al., 2018). Although most research on open innovation still overlooks this aspect (Gassmann et al., 2010), many studies assess the way human capital can impact the use of external knowledge (Bogers et al., 2018) and the role that individuals can play in a firm's degree of openness (Bogers et al., 2018; Ahn et al., 2017). Nevertheless, there are still few assessments on the effects of gender diversity. That gender diversity in different areas of a firm improves the likelihood of engaging in collaborative innovation processes is confirmed by evidence showing how entrepreneurial companies led by women have a greater capacity to absorb knowledge acquired from research institutions and partners in the value chain (Amoroso and Audretsch, 2020).

2.3. The Context: Women's Participation in Labor Forces in the Caribbean Region

In the Caribbean region, there is a higher-than-average participation of women (between 15 and 64 years) in different levels of the labor force, when compared with data for the overall LAC region (see Figure 1). This is especially the case for the Bahamas, Barbados, and Jamaica. The former shows the highest (76.5 percent) while Suriname is ranked lowest (44 percent). Barbados and Jamaica rank higher than many other Latin American countries, including Guatemala (42.5 percent) and some of the largest countries in the region, such as Mexico, Brazil, Chile, Argentina, and Colombia, where women's participation ranges between 49.1 and 61.9 percent (World Bank, 2021; World Economic Forum, 2021).

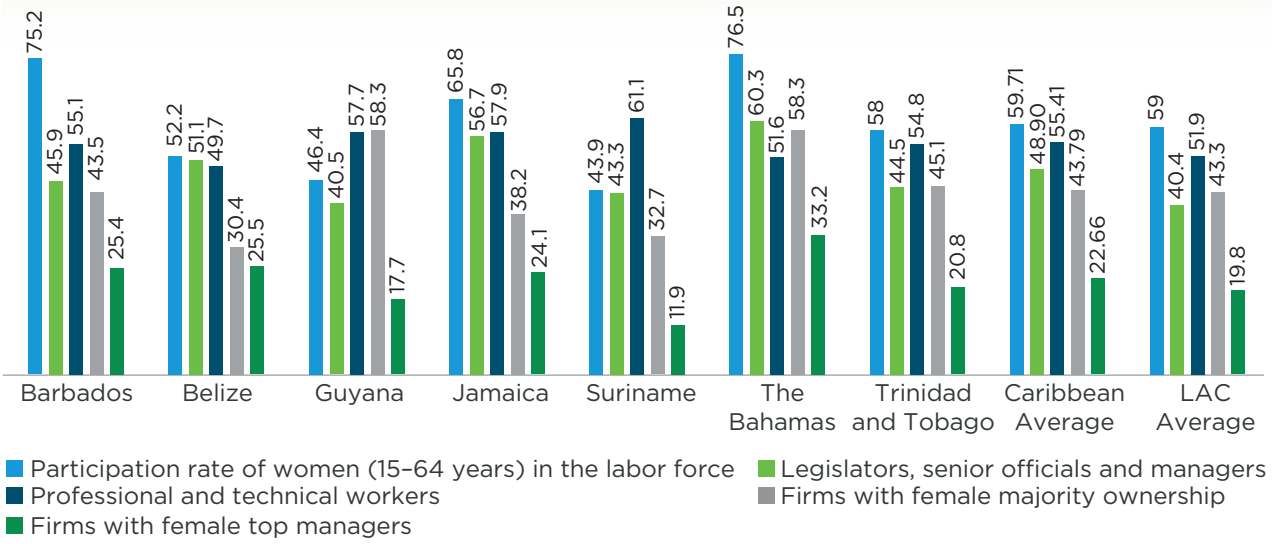
Compared to other economies in the region, the Caribbean countries also perform well regarding women in senior positions. On average, nearly 49 percent of senior officials are women (World Bank, 2021; World Economic Forum, 2021), while in Jamaica, Belize, and the Bahamas this indicator ranges between 51.1 and 60.35 percent. Among Latin American countries, the situation is similar in Colombia (53.4 percent) and Honduras (50.9 percent) but much lower in Bolivia and Chile (at 29.2 percent).

With respect to participation of women in professional and technical jobs, the wider LAC region shows an overall value of 51.9 percent, with an above-average rate of 55 percent in the Caribbean economies. Five of the seven countries analyzed in Figure 1 present higher values than the LAC overall; among these, Suriname registers the highest value (61.1 percent), followed by Jamaica (57.9 percent). In the overall LAC region, Cuba (38.1 percent) and Bolivia (40.5 percent) show the lowest levels.

In terms of engagement and responsibility, 43.8 percent of Caribbean firms have a female majority in their ownership team, which is close to the LAC average (43.3 percent). On the other hand, the participation of women in a firm's corporate governance is still very limited: under 20 percent of firms have women in top managerial positions (19.8 percent). The situation in the Caribbean is similar, with women in the highest management positions in only 22.6 percent of firms. The disparity across countries is greater for

FIGURE 1

RELATIVE PARTICIPATION OF WOMEN IN THE LABOR FORCE AND IN MANAGEMENT POSITIONS IN CARIBBEAN COUNTRIES (IN PERCENTAGES)



Source: Authors' elaboration with data from the World Economic Forum (2021).

this indicator: in the Bahamas, women are in top managerial positions in over one-third of firms; Barbados and Belize both reach 25 percent, while in Suriname the figure is under 12 percent.

Overall, the data supports the argument that female participation in ownership and management of firms throughout the Caribbean region is higher, on average, than the rest of the world (Moore et al., 2017). However, in the literature there are no comparative studies on the effects of gender diversity in different areas or positions held by women in firms. Also, empirical evidence is inconclusive concerning the impact of gender on open innovation and, more importantly, neither of these topics have been explored for the Caribbean.

3

Methodology

3.1. Data

To analyze the relationship between gender diversity and innovation performance in firms in the Caribbean region, the present study uses the Innovation, Firm Productivity, and Gender (IFPG) database, funded by the Compete Caribbean Partnership Facility (CCPF) and its donors: the Inter-American Development Bank (IDB), United Kingdom's Foreign and Commonwealth Development Office, Caribbean Development Bank, and the Government of Canada. Within the IDB, the Competitiveness, Technology, and Innovation Division (IFD/CTI), Caribbean Country Department (CCB), and IDB–Invest Strategy and Development Department (DSP) coordinated and supervised the data collection. The overall aim is to generate up-to-date and internationally comparable data on the private sector for the region on issues such as productivity, innovation, gender, and the impact of the COVID-19 pandemic. The IDB conducted the survey in 2020, which collates information from 1,979 firms located in 13 Caribbean countries.[2]

3.2. Method

The first part of the analysis uses two models to conduct econometric estimations. The first model, a probit model, (Eq.1) evaluates the gender diversity effect on innovation in general (INNOVA):

$$\Pr [INNOVA_i = 1 \mid \chi_i] = \Phi(\chi_i B_1 + \gamma B_2 + \varepsilon_i) \qquad \text{(Eq. 1)}$$

The second model evaluates the gender diversity effect, differentiating technological and non-technological innovation (Eq. 2, 3). In this case it is assumed that decisions to carry out technological and non-technological innovation are not independent, and that both are affected by common factors. To analyze the propensity to innovate, biprobit regression models are estimated for all firms in the sample, adopting the following general form:

[2] Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Guyana, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Suriname, the Bahamas, and Trinidad and Tobago.

$$y_1^* = \chi\beta_1 + \gamma\beta_2 + \varepsilon_1 \quad \text{(Eq. 2)}$$

$$y_1 = \begin{cases} 1 \; if \; y_1^* > 0 \\ 0 \; if \; y_1^* \leq 0 \end{cases}$$

$$y_2^* = \chi\beta_2 + \gamma\beta_2 + \varepsilon_2 \quad \text{(Eq. 3)}$$

$$y_1 = \begin{cases} 1 \; if \; y_2^* > 0 \\ 0 \; if \; y_2^* \leq 0 \end{cases}$$

where y_1^* and y_2^* are the unobserved latent variables, which in this case represent technological innovation (INNTEC) or non-technological innovation (INNnoTEC), respectively. Of the three equations, β_1 represents measures of gender diversity, β_2 represents a set of control variables, and ε_1 and ε_2 are correlated error terms.

Regarding the variables introduced in the models, the dependent variable in both cases indicates whether the firm is innovative (INNOVA in Eq.1) and also the possible types of innovation (INNTEC and INNnoTEC in Eq. 2, 3, see the list of variable definitions in Annex F). All three are binary variables: INNOVA takes the value of 1 if firms achieved some type of innovation (product, process, organizational, or market innovation) between 2017 and 2020, and 0 if otherwise. INNTEC takes the value of 1 if firms achieved some product or process innovation between 2017 and 2020, and 0 if otherwise. INNnoTEC takes the value of 1 if firms registered organizational or market innovation during the same time period and 0 if otherwise.

The main independent variable is the presence of gender diversity in the firm. The choice was made to use the following three measures of gender diversity:

- Total workforce gender diversity (TWF gd): This variable includes all firm employees. In line with studies that observe categorical attributes (age, nationality, gender, education, etc.) for team diversity, the Blau Index of Heterogeneity (1977) is used, as in previous studies on gender diversity and innovation (Teruel and Segarra-Blasco, 2017; Xie et al., 2020):

$$D = 1 - \sum_{i=1}^{k} Pi^2,$$

where k represents the total number of categories of a variable. Here only two categories are possible (male and female), and Pi is the proportion of employees who fall into category k. The minimum value of D = 0 occurs when all employees fall within the same category and there is no variety (e.g., all employees are men). The greater the distribution across categories, the higher the diversity index value; the highest value (D = 0.5) would indicate equality in the distribution.

- Management team gender diversity (MT_gd): The Blau Index is used to define gender diversity in employees in management or in roles leadership, strategy, improvement, and growth of the firm.
- Skilled production and non-production workers (OtherAC_gd): As with the two previous measures, the Blau Index is used to define gender diversity among employees who are directly active in the production process or at a supervisory level (production), or in professional, support, and administrative roles, and sales employees and others (non-production) where management is considered to be a skilled activity.

In terms of control variables, first R&D investment (Inv_R&D) is measured as the mean investment in research and development activities over total employees in the previous three years. Second, the age of the firm (Age) is measured by the log number of years from its founding. Third, exports are factored in as a variable of international trade (Export). This is a dummy variable that takes the value 1 if the firm exports, and 0 if otherwise. Fourth, the variable if the firm is part of a company group (Group) —a dummy variable that takes the value 1 if firms belong to a larger company, and 0 if otherwise. Fifth, a dummy variable (Use_IP) takes the value of 1 if the firm has any mechanism in place to protect its intel-

lectual property in the observation period and 0 if otherwise. The last three control variables refer to the sector (Sector), country (Country), and size (Size) of a firm, the latter based on number of employees. Six dummies are included to cover variation using Castellacci's sector taxonomy for each sector.[3] A dummy variable is created with the value 1 if the firm is active in that specific sector and 0 if otherwise. For evaluating countries, 13 dummy variables were created taking the value 1 if a firm is located in a specific country. Finally, four dummies capture different size effects. Size as a continuous variable is not used, because the diversity measures are very depend on the size of the firm, and the high correlation between these two measures can generate multicollinearity problems; the use of dummy variables allows measurement of the impact of diversity on the likelihood to innovate or cooperate within a group of similarly sized firms (Østergaard et al., 2011). Four groups were created with this objective: (Size1, with fewer than 10 employees; Size2, from 11 to 49 employees; Size3, from 50 to 249 employees; and Size4, over 250 employees).

Another consideration is that previous studies on gender diversity and innovation indicate a possible endogeneity problem in this relationship (Teruel and Segarra-Blasco, 2017; Gallego and Gutierrez, 2018). Concerns about endogeneity are related to omitted unobservable firm characteristics. For example, managers worried about innovation and gender diversity might increase the hiring of women in their firms (Gallego and Gutierrez, 2018), and therefore gender diversity could be an endogenous variable relative to the dependent variable, hence correlated with $\varepsilon_{i,}$ (Teruel and Segarra-Blasco, 2017). To address possible endogeneity, a control function correction method is used (Blundell and Powell, 2003); thus in the first stage the following Equation (4) is estimated:

$$\text{gender\_ diversity} = xB_{1+}{}_{\text{ɤ}}B_2 + \varepsilon_1 \qquad \text{(Eq. 4)}$$

where gender_diversity refers to possible measures at the firm level, as defined above. B_1 is the instrumental variable for TWF_gd, MT_gd and OtherAC_gd, each calculated as the mean of its respective Blau index result over sectors of two digits, as executed by Teruel and Segarra-Blasco (2017). B_2 represents control variables of Size_con (log total employees), Age, Export, Group, and Sector effects based on Castellacci's taxonomy, as well as Country; in all estimations robust standard errors are used. Table 1 presents the results of the first stage and Table 2 the results of exclusionary testing, checking the validity of the instruments. Each instrument tests for general innovation, technological and non-technological innovation, and analyzes cooperation in innovation. Instruments do not have an effect on measures for innovation and cooperation. The predicted values of gender diversity (gender_diversity_hat) are introduced in Equations (1), (2) and (3).

In the second part of the analysis, to evaluate gender diversity's impact on cooperation in innovation, probit regression models were carried out using the following Equation (4):

$$\Pr[COOP_i = 1 \mid \chi_i] = \Phi(\chi_i B_1 + \text{ɤ} B_2 + \varepsilon_i) \qquad \text{(Eq. 5)}$$

In Equation (5), the dependent variable is cooperation (COOP), a binary variable taking the value 1 if the firm has developed any type

[3] Castellacci (2020) proposes a new taxonomy of sectorial innovation patterns that includes both manufacturing and service sectors. This is composed of four large sectorial groups, each with two sub-groups: 1. Advanced knowledge providers—knowledge-based services (KBS) and specialized manufacturing supplier (SMS); 2. Mass production goods—science-based manufacturing (SBM) and scale-intensive manufacturing (SIM); 3. Support infrastructure services—network infrastructure services (NIS) and physical infrastructure services (PIS); and 4. Personal goods and services—supplier-dominated manufacturing (SDM) and provider-dominated services (PDoS). Considering the sample structure, this classification is used to control the sectorial effect. To learn more about this taxonomy, see Castellacci (2020). Annex A contains a description of the sectors included in each sub-group.

TABLE 1
FIRST STAGE TO OBTAIN GENDER DIVERSITY VARIABLE PREDICTIONS

Dependent variable	TWF_gd	MT_gd	OtherAC_gd
meanTWF_gd	1.038*** (0.144)		
meanMT_gd		1.722*** (0.372)	
meanOtherAC_gd			1.426*** (0.220)
Size_con	0.067*** (0.005)	0.168** (0.011)	0.151*** (0.007)
Age	(-0.006 (0.006)	(-0.016 (0.018)	(-0.033** (0.011)
Export	(-0.011 (0.009)	(-0.0004 (0.026)	(-0.002 (0.015)
Group	0.026* (0.011)	0.074* (0.033)	0.010 (0.019)
Cons	(-0.1767** (0.059)	(-0.8833 ** (0.1357)	(-0.4867*** (0.0794)
Obs	1979	1979	1.891
Log pseudolikelihood	(-81.7428	(-1313.8301	(-810.0749
R-squared	0.7028	0.1326	0.2627

Notes: Estimations for all models were calculated using a Tobit model. All regressions include dummies controlling for country and Castellacci sector in two digits. Coefficient values are reported. Robust standard errors are in parentheses.
ɬ p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

TABLE 2
TEST OF EXCLUSIONARY RESTRICTION

	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC
meanTWF_gd	0.767 (1.022)	0.840 (1.056)	1.81 (1.096)						
meanMT_gd				0.085 (0.938)	0.782 (0.959)	1.023 (1.09)			
meanOtherAC_gd							-0.035 (0.927)	0.465 (0.958)	0.516 (1.06)
Constant	-0.247 (0.368)	-0.640** (0.380)	-1.260*** (0.396)	-0.301 (0.275)	-0.550* (0.275)	-0.925** (0.319)	-0.005 (.2620)	-0.472ɬ (0.267)	-0.806** (0.297)
Obs	1979	1.979		1979	1.979		1979	1.979	
Log pseudolikelihood	-1215.5076	-1964.4279		-1215.7785	-1965.1217		-1215.7816	-1965.5096	

Notes: All regressions include dummies controlling for country and Castellacci´s sector. Coefficient values are reported. Robust standard errors are in parentheses. ɬ p>0.10 * p<0.05; ** p<0.01; *** p<0.001

of innovation in cooperation with other firms or organizations, and 0 if otherwise. B_2 represents our main independent variable, which is gender diversity. In this case, the same control variables are used as for Eq. 1, 2, and 3. The relationship between diversity and openness can face endogeneity problems due to unobserved variables and reverse causation between the two measures. This implies that firms may increase their human capital diversity to be able to better engage in open innovation (Bogers et al., 2018); hence, the models are tested with the same predicted values of gender diversity obtained via Eq. 4.

4

Results

4.1. Descriptive

Notably, only 11 percent of Caribbean firms are managed by groups with an equal distribution of men and women. Belize has the highest number of firms with equal gender distribution in management activities (22 percent), followed by St Vincent and the Grenadines (19 percent). In 55 percent of Caribbean firms, management of firms is in the hands of one gender only. Barbados (86 percent) and Trinidad and Tobago (65 percent) are the countries with the highest number of firms with no gender diversity in management teams. In 34 percent of firms, management is shared between both genders, but one gender is predominant (see Figure 2).

On the other hand, 54 percent of firms in the Caribbean show some (not total) gender diversity in the groups of employees in production and non-production activities, implying that these are composed of representatives of both genders, though where one gender predominates. In 42 percent of firms in the sample, groups are composed of representatives of one gender only. Just 4 percent of these firms show a perfect gender diversity balance in their groups of production and non-production activities. Belize is the Caribbean country with the highest percentage of firms with gender diversity in this group (16 percent), while Trinidad and Tobago and Barbados register the lowest values (1 percent).

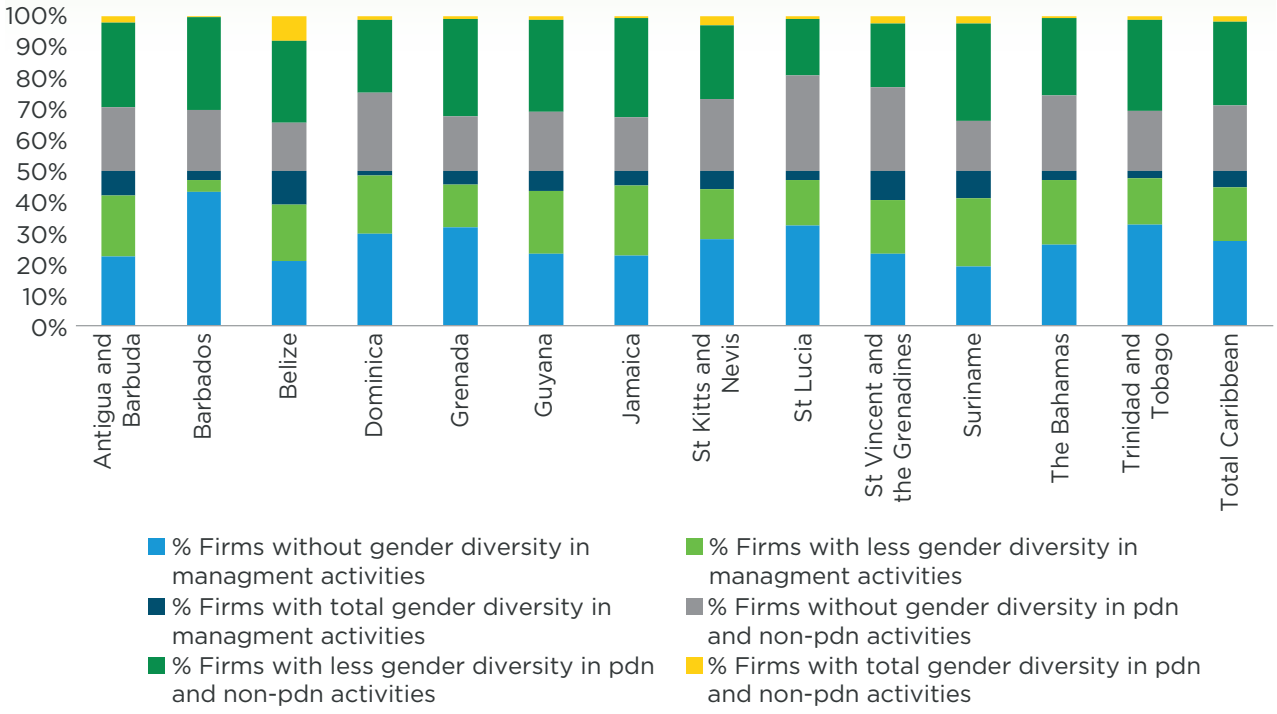
In view of gender diversity of the total workforce, Figure 3 shows that firms in all sectors are situated in the upper levels of the Blau Index. However, the total is disaggregated into the roles of production and non-production activities, and a concentration is observed in the low and medium levels. For management activities, there is greater concentration in the lower levels of the Blau Index and a smaller concentration at the higher values. This description would support the hypothesis that it is more difficult for women to advance to higher positions in firms.

Regarding innovation, some type of innovation had taken place in the previous three years in 39 percent of firms (Table 3). Antigua and Barbuda and Suriname have the highest proportion of innovative firms in the region. Of the type of innovation, in all Caribbean countries technological innovation (INNTEC) dominates over non-technological innovation (INNnoTEC), with most firms having undertaken the former.

With regards to cooperation in innovation, 12 percent of firms in the sample had developed innovations in cooperation with other firms or

FIGURE 2

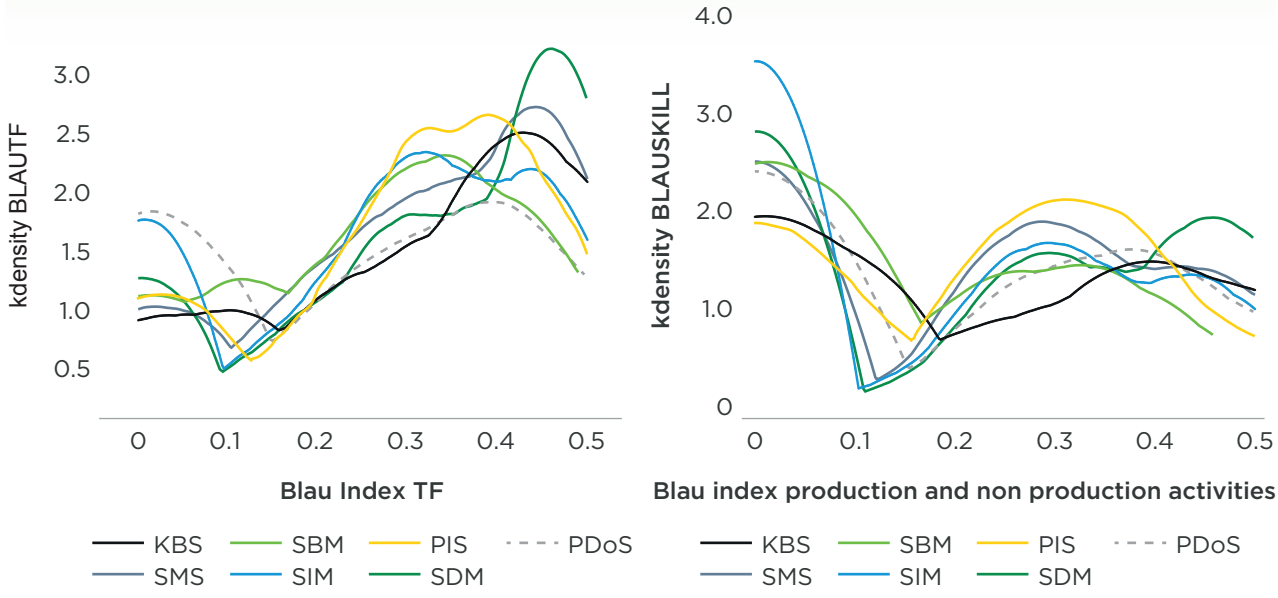
LEVELS OF GENDER DIVERSITY IN MANAGEMENT, PRODUCTION (PDN) AND NON-PRODUCTION (NON-PDN) ACTIVITIES, BY COUNTRY



Source: Authors' elaboration with data from IFPG.

FIGURE 3

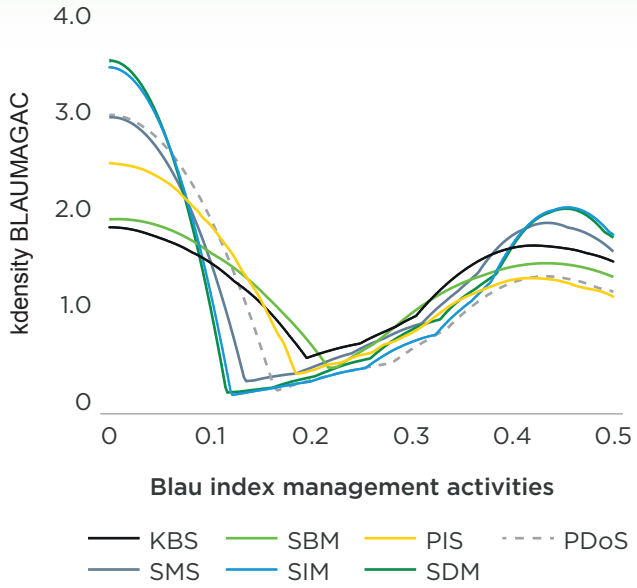
KERNEL DENSITIES OF THE BLAU INDEX OF THE TOTAL WORKFORCE, PRODUCTION AND NON-PRODUCTION ACTIVITIES AND MANAGEMENT ACTIVITIES, BY CASTELLACCI SECTOR



(continued on next page)

FIGURE 3 *(continued)*

KERNEL DENSITIES OF THE BLAU INDEX OF THE TOTAL WORKFORCE, PRODUCTION AND NON-PRODUCTION ACTIVITIES AND MANAGEMENT ACTIVITIES, BY CASTELLACCI SECTOR



Source: Authors' elaboration with data from IFPG.

TABLE 3

SAMPLE COMPOSITION BY COUNTRY AND INNOVATION BEHAVIOR

Country	Total firms	Innovative firms	Innovative firms (%)	INNTEC (%)	INNnoTEC (%)	Cooperative firms (%)
Antigua and Barbuda	150	92	61	95	58	17
Barbados	170	20	12	75	55	4
Belize	157	27	17	85	30	0
Dominica	137	34	25	79	53	7
Grenada	124	60	48	93	52	15
Guyana	155	67	43	84	52	11
Jamaica	172	77	45	83	45	13
St Kitts and Nevis	130	33	25	82	58	8
St Lucia	152	55	36	85	45	11
St Vincent and the Grenadines	133	59	44	90	41	14
Suriname	162	96	59	89	61	17
The Bahamas	157	80	51	79	60	24
Trinidad and Tobago	180	73	41	86	53	13
Observations	1979	773	39	34	21	12

Source: Authors' elaboration with data from IFPG.

TABLE 4
SAMPLE COMPOSITION, BY CASTELLACCI TAXONOMY

Sector category	Sub/sectors	Total firms	Innovative firms	Innovative firms (%)	INNTEC	INNnoTEC
Advanced knowledge providers	Knowledge-based services (KBS)	62	26	42%	19	11
	Specialized manufacturing supplier (SMS)	34	16	47%	13	9
Mass production of goods	Science-based manufacturing (SBM)	61	20	33%	19	8
	Scale-intensive manufacturing (SIM)	111	37	33%	30	18
Support infrastructure services	Physical infrastructure services (PIS)	327	157	48%	140	87
Personal goods and services	Supplier-dominated manufacturing (SDM)	641	234	37%	196	123
	Provider-dominated services (PdoS)	743	283	38%	249	149
		1,979	773	39%	666	405

Source: Authors' elaboration based on Castellacci (2020) and with data from IFPG.

organizations in the previous three years. In the economies of Bahamas, Suriname, and Antigua and Barbuda, firms have been more willing to cooperate with partners; meanwhile, no firms had cooperated in the previous three years in Belize, while in Barbados 4 percent had.

Table 4 shows that most firms in Caribbean countries are in sub-sectors with relatively limited capacity to develop new knowledge: PDoS, SDM, and PIS. These three sub-sectors represent 86.4 percent of firms included in the sample. Those sectors with greater abilities to develop new products and processes are SBM and SIM, which represents only 8.7 percent of firms, while sectors characterized by high technological capacity and a significant ability to create and manage more complex technologies (KBS and SMS) represent only 4.9 percent. PIS (which includes areas such as electricity, water, gas, construction, and wholesale) is the subsector with most innovative firms (48 percent), followed by SMS (which encompasses manufacturing of electrical equipment, machinery, and other equipment).

4.2. Gender and Innovation Performance

The first part of the econometric analysis is an assessment of the impact that a more balanced presence of men and women has on firm-level innovation performance, and is measured through likelihood to innovate in general terms, or likelihood to implement technological and non-technological innovations. Table 5 shows the results from estimations using predicted measures of gender diversity, first in the total workforce, and second in different positions of the firm, such as management (MT_gd) and production and non-production activities (OtherAc_gd). To avoid collinearity between

these variables, different measures of diversity are included separately.

The results show that all three measures have a significant and positive impact on the likelihood of firms to develop some type of innovation. Gender diversity in the total workforce (TWF_gd) has a positive and significant effect on technological and non-technological innovation, though the effect is less marked in the latter. Gender diversity in management activities (MT_gd) has a significant and positive impact on technological innovation but has no effect on non-technological technological innovation, as is also the case for gender diversity in other activities (Other Ac_gd) (with the greatest impact on technological innovation). These findings confirm that the influence of gender diversity may differ according to the types of innovation, in line with Teruel and Segarra-Blasco (2017) and Gallego and Gutierrez (2018). The reason for this is that each type of innovation is different, which implies that different employee skills are needed for developing innovations (Teruel and Segarra-Blasco, 2017).

With regards the effect of gender diversity in the total workforce, the findings support the hypothesis that heterogeneous teams will have varied knowledge, skills, and thinking styles, which could facilitate better innovation performance (García-Martínez et al., 2017; Østergaard et al., 2011). This argument is especially relevant in the case of technological innovation. When compared with manufacturing, diversity in the total work force is found to be non-significant only in non-technological innovation in the services sector.

To show that the effect of gender diversity on innovation depends on the position held in the firm, a further two types of gender diversity were analyzed. The first type explores gender diversity among workers in charge of activities related to management of employees, leadership, strategy, improvement, and growth of the enterprise (MAG_gd). Here, the findings confirm a high impact of diversity on innovation in general and on technological innovation, but this measure shows no impact on non-technological innovation. When compared by sector, the gender diversity measure is significant and positive for both technological and non-technological innovation in manufacturing, while in the services sector it is significant only for technological innovation (see Annexes B and C).

The above findings are in the mainstream and suggest that when the management team is more balanced between men and women the innovation performance of firms is improved (Ritter-Hayashi et al., 2019; Ruiz Jiménez and Fuentes, 2016; Torchia et al., 2011). This effect is most relevant in technological innovation, in both manufacturing and service sectors. Meanwhile, among the controls, R&D investment is consistently positive and significant. Furthermore, the other relevant indicator is the use of intellectual property mechanisms (IP) in the estimation of innovation in general and in technological innovations, which points to the importance of the latter in the orientation of firms toward a particular type of innovation.

The second type is gender diversity among workers involved in the production process, whether directly or at a supervisory level, as well as those engaged in non-production activities—professional, support, administrative, sales, and others (OtherAC_gd). This measure shows that gender diversity is relevant, both for innovation in general and technological innovation across the entire sample. Moreover, in the manufacturing sector this measure has a significant and positive impact on non-technological innovation, while in the services sector this type of gender diversity is significant only in technological innovation.

The different gender diversity measures lead to the conclusion that, although gender diversity in all areas has a positive effect on innovation performance, gender diversity in the total workforce has a higher impact on a firm's innovative performance than in other areas (such as gender diversity in management

TABLE 5

GENDER DIVERSITY EFFECTS ON THE PROPENSITY OF FIRMS TO INNOVATE

	M1.TWF _gd			M2.MT_gd			M3.Otheract_gd		
	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC
TWF_gd_hat	0.921***	0.919***	0.341ɨ						
	(0.237)	(0.215)	(0.202)						
MT_gd_hat				0.451***	0.485***	0.119			
				0(.117)	(0.108)	(0.100)			
OtherAc_gd _hat							0.600***	0.620***	0.179
							(0.126)	(0.112)	(0.109)
Inv_R&D	4.86E-06***	2.78E-06***	1.52E-06***	4.87E-06***	2.76E-06***	1.52E-06***	4.84E-06***	2.81E-06***	1.52E-06***
	(1.01E-06)	(7.31E-07)	(2.78E-07)	(1.02E-06)	(7.71E-07)	(2.80E-07)	(1.00E-06)	(7.47E-07)	(2.80E-07)
Age	0.0034	-0.007	0.019	0.004	-0.005	0.019	0.016	0.007	0.023ɨ
	(0.014)	(0.012)	(0.012)	(0.014)	(0.012)	(0.012)	(0.015)	(0.013)	(0.012)
Export	0.030	0.010	0.031ɨ	0.021	0.001	0.028ɨ	0.023	0.003	0.028ɨ
	(0.020)	(0.018)	(0.016)	(0.022)	(0.018)	(0.017)	(0.20)	(0.018)	(0.017)
Group	-.007	-0.001	-0.025	-0.019	-0.016	-0.025	0.004	0.010	-0.019
	(0.028)	(0.025)	(0.023)	(0.029)	(0.026)	(0.024)	(0.027)	(0.024)	(0.022)
Use_IP	omited	0.391***	0.238***	omited	0.387***	0.238***	omited	0.387***	0.238***
		(0.033)	(0.022)		(0.033)	(0.022)		(0.0328)	(0.022)
Sector	yes	yes	yes	Yes	yes	yes	yes	Yes	yes
Country	yes	yes	yes	Yes	yes	yes	yes	Yes	yes
Size	yes	yes	yes	Yes	yes	yes	yes	Yes	yes
Obser	1801	1979		1801	1979		1801	1979	
Log pseudolikelihood	-888.79504	-1668.2397		-888.40223	-1666.447		-885.15366	-1663.1133	

Notes: Marginal effects of explanatory variables on the propensity to innovate are reported. Robust standard errors in parentheses, ɨ p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

teams). Moreover, the contribution of gender diversity in production and non-production activities should be noted, since it supports the idea that, even though the decision to innovate is commonly taken at the highest levels, innovation is a process distributed throughout all areas of a firm. Therefore, characteristics associated with women that improve the likelihood to innovate will be important at all levels.

4.3. Gender Diversity on Cooperation to Innovate

The results shown in Table 6 reveal that gender diversity in the total workforce and in production and non-production activities has a positive and significant effect on the likelihood of cooperation to innovate. On the other hand, the presence of females in the management teams of these firms is not a significant factor for enhancing open innovation in the Caribbean.

According to the literature, gender diversity at executive levels within firms has a more significant impact on a firm's decision to cooperate with external partners. However, the findings for Caribbean firms show that gender diversity in the total workforce has a greater marginal effect on a firm's openness to cooperate. It is also especially relevant that gender diversity in production and non-production areas

TABLE 6
GENDER DIVERSITY EFFECTS ON COOPERATION TO INNOVATE

	COOPERATION		
TWF_gd_hat	0.455* (0.179)		
MT_gd_hat		0.083 (0.086)	
Other Ac_gd _hat			0.211* (0.091)
Inv_R&D	3.42E-07 (2.26E-07)	3.58E-07¹ (2.16E-07)	3.61E-07¹ (2.15E-07)
Age	0.011 (0.010)	0.010 (0.010)	0.015 (0.010)
Export	0. 040** (0.014)	0. 036** (0.014)	0. 036** (0.014)
Group	-0.025 (0.020)	-0.017 (0.020)	-0.016 (0.019)
Use_ IP	0.095*** (0.02)	0.098*** (0.020)	0.096*** (0.020)
Sector	yes	yes	yes
Country	yes	yes	yes
Size	yes	yes	yes
Obs	1979	1979	1979
Log pseudolikelihood	-599.7397	-602.7931	-600.8309

Notes: Marginal effects of explanatory variables on the propensity to cooperate are reported. Robust standard errors in parentheses,
¹ p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

can improve the likelihood of cooperating with external agents with an end to innovating.

These findings attest to the importance of human capital in collaborative activities (Ahn et al., 2017; Bogers et al., 2018). Furthermore, although structural factors such as the age of a firm or its being part of a larger group are not significant, the export variable is indeed significant in the three models, as is investment in R&D in two of the three models—two factors which could reinforce the profile of those firms more willing to establish external partnerships. Also, it has been revealed that intellectual property mechanisms are significant elements in the likelihood of firms to cooperate with other agents.

The overall results concerning the relationship between gender diversity and open innovation confirm that the presence of women in different positions in a firm improves the capacity to establish cooperation agreements with external partners. Among other factors, this is due to women being open to new ideas and more apt to facilitate communication both internally and externally, as well as more willing to cooperate (Miller and Del Carmen Triana, 2009; Santos et al., 2019; Xie et al., 2020). Furthermore, gender-diverse teams afford easier assimilation of external knowledge into the firm (Bogers et al., 2018).

4.4. Robustness check

To check for robustness of the results on the relationship between gender diversity and innovation performance, as well as on cooperation, the models were run again, leaving out the control variable of investment in R&D. This made it possible to ascertain the net effect of gender diversity on the likelihood to innovate and cooperate without the influence of resources earmarked for R&D activities (clearly associated with innovation). Table 7 confirms the previous findings surrounding the effect of gender diversity on technological and non-technological innovations. Some changes are observed in the marginal effects, and significance is found to persist. Also noteworthy is that a greater presence of women in the total work force may enhance technological and non-technological innovations in firms that use intellectual property mechanisms.

Similar results were found regarding the relationship between gender diversity and cooperation in innovation (Table 6) where estimates were calculated without the control of investment in R&D (Table 8). The export variable is significant in all the models, denoting the relevance of the internationalization of firms, the use of intellectual property mechanisms, and the prevalence of gender diversity in relation to open innovation beyond R&D.

TABLE 7

GENDER DIVERSITY EFFECTS ON THE PROPENSITY OF FIRMS TO INNOVATE. ROBUSTNESS CHECK

	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC
TWF_gd_hat	0.959***	0.950***	0.379†						
	(0.248)	(0.222)	(0.201)						
MAGAC_gd_hat				0.436***	0.508***	0.146			
				0(.124)	(0.110)	(0.102)			
OtherAc_gd _hat							0.593***	0.623***	0.195†
							(0.133)	(0.116)	(0.112)
Age	0.009	-0.003	0.021†	0.010	-0.002	0.021†	0.022	0.010	0.025*
	(0.14)	(0.013)	(0.012)	(0.015)	(0.013)	(0.012)	(0.015)	(0.013)	(0.012)
Export	0.032	0.011	0.030†	0.022	0.002	0.028	0.024	0.003	0.027
	(0.021)	(0.018)	(0.017)	(0.021)	(0.019)	(0.017)	(0.21)	(0.016)	(0.017)
Group	-0.002	0.003	-0.022	-0.011	-0.012	-0.023	0.012	0.015	-0.015
	(0.029)	(0.025)	(0.023)	(0.030)	(0.026)	(0.024)	(0.028)	(0.024)	(0.022)
Use_ IP	omited	0.415***	0.251***	omited	0.410***	0.251***	omited	0.411***	0.251***
		(0.033)	(0.022)		(0.033)	(0.021)		(0.033)	(0.022)
Sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obser	1801	1979		1801	1979		1801	1.979	
Log pseudolikelihood	-937.6792	-1704.2192		-938.1650	-1701.9662		-934.9924	-1699.6663	

Note: Marginal effects of explanatory variables on the propensity to innovate are reported. Robust standard errors in parentheses, † p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

TABLE 8

GENDER DIVERSITY EFFECTS ON COOPERATION TO INNOVATE. ROBUSTNESS CHECK

	COOPERATION		
TWF_gd_hat	0.472** (0.178)		
MAGAC_gd_hat		0.097 (0.086)	
OtherAc_gd _hat			0.218* (0.092)
Age	0.011 (0.010)	0.010 (0.010)	0.015 (0.010)
Export	0. 040** (0.014)	0. 036** (0.014)	0. 036** (0.014)
Group	-0.024 (0.020)	-0.017 (0.020)	-0.015 (0.019)
Use _IP	0.098*** (0.020)	0.101*** (0.020)	0.099*** (0.020)
Sector	yes	Yes	yes
Country	yes	Yes	yes
Size	yes	yes	yes
Obs	1979	1979	1979
Log pseudolikelihood	-600.8610	-603.9905	-602.0589

Note: Marginal effects of explanatory variables on the propensity to cooperate are reported.
Robust standard errors in parentheses, ɬ p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

5

Conclusions and Implications

This study analyzes the role of gender diversity both on the innovation performance of Caribbean firms and establishment of cooperation agreements to innovate. Its findings confirm firstly, that, a more balanced participation of men and women within an enterprise is one of the factors that can improve the likelihood of Caribbean firms to innovate, while the impact of this balance depends on the area in the firm where gender diversity is present. In particular, firms with a more equal gender distribution throughout the total workforce, and in positions related to production and non-production activities, can gain more from the presence of women than those where there is only diversity in the higher positions, such as management. Moreover, gender diversity in firms has been found to affect technological innovation more than non-technological innovation, a scenario common in both manufacturing and service sectors; in the service sector, all diversity measures are found to be non-significant in non-technological innovations. These results are of particular interest for Caribbean countries, given their economic structures and patterns of specialization.

Second, gender diversity is also a significant factor when firms decide to collaborate in innovation with external partners. Over and above the generalized expectation linked to stakeholders, gender balance in the total work force is the indicator that has greatest impact, in particular, increasing the chances of a firm establishing agreements for cooperation to innovate.

However, despite the fact that cooperation is a positive strategy for improving innovation capabilities and overcoming obstacles to innovation, it must be said that, generally speaking, firms in the Caribbean do not have a high propensity for cooperation, especially compared to other LAC countries, such as Colombia, where 35 percent of manufacturing firms cooperate in innovation (Castillo and Gómez, 2021). The findings suggest that enhancing both the use of intellectual property mechanisms and the orientation toward external international markets can contribute positively to higher levels of cooperation. That gender diversity has positive effects on innovation and cooperation to innovate implies that firms stand to gain from increased participation of women in different operational areas.

Gender diversity in the workforce is also relevant when considering the promotion of collab-

oration to innovate with other external agents, and here there is room for progress. Nonetheless, a full review is required, of policy measures and actions which can contribute specifically to enhancing interactions and cooperation—both between firms and among agents such as universities or research centers—that could then forge links within national systems of innovation (in particular, policy support for R&D and innovation projects); also, certain fiscal arrangements could introduce additional criteria regarding gender diversity and partnerships.

The findings discussed above may have important implications for managerial decisions, both within firms and in the sphere of public policy in the Caribbean. Given that gender diversity has a significant effect on innovation performance and cooperation, the authors argue that managers would benefit from adopting a policy of wider participation of women in the total workforce and in innovation activities. This can be made possible through programs directed at employment, consolidation, and promotion of women. According to IFPG data, only 20.5 percent of firms have implemented such programs and only 19 percent implement actions to promote gender equality in the workplace. (Compete Caribbean, 2021)

Since the presence of women in the workforce yields a strong competitive advantage, firms should build a more inclusive culture at the intrafirm level allowing for greater gender integration into all types of activities, especially those related to innovation. In this regard, actions include the use of certain best practices, training, and development of policy measures oriented to the private sector.

To establish gender equality and improve innovation performance—especially the participation of women in economic activities in Caribbean countries—policy actions can help create programs to increase the motivation of firms to specifically increase the proportion of women in the workforce, particularly in sectors traditionally dominated by men.

At the same time, entrepreneurship and capability-building programs could contribute to defining a right direction for policies that would combine innovation and equity. Furthermore, measures to encourage start-ups for women on knowledge-based activities in both manufacturing and services could be implemented, considering the productive capacities of the Caribbean economies. Specifically addressing “born-global” units or taking advantage of global (and regional) value chains can also enhance competitiveness based on innovation. This line of action would not only allow firms to take advantage of gender diversity but also help consolidate a more socially sustainable perspective within the innovation system.

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Appendices

Annex A. Castellacci's Taxonomy

Sector category	Description	Sub-sectors	Correspondence with IFPG sectors
Advanced knowledge providers	Characterized by high technological capacity and a significant ability to create and manage complex technological knowledge.	KBS Knowledge-based services	Computers and electronics, ICT, tourism-related ICT, activities of head offices, management consultancy activities; office administration, office support, and other business support activities
		SMS Specialized manufacturing supplier	Manufacturing of electrical equipment, machinery, and other equipment
Mass production of goods	Producing final goods and intermediate products used in other sectors. These are characterized by their ability to develop new products and processes internally.	SBM Science-based manufacturing	Coke and refined products, chemicals and chemical products, pharmaceutical, medicinal, chemical, and botanical products
		SIM Scale-intensive manufacturing	Plastics & rubber and other non-metallic mineral products; basic metals, fabricated metal products (except machinery); vehicles and transportation equipment
Support infrastructure services	Producing mostly intermediate products and services. These have a limited capacity to develop new knowledge internally	PIS Physical infrastructure services	Electricity, gas, steam, and air-conditioning supply; water supply, sewage-waste management and remediation activities, construction, wholesale and transportation, and storage (excluding passenger transportation)
Personal goods and services	These are characterized by lower technological content and a relatively limited capacity to develop new products and processes internally.	SDM Supplier-dominated manufacturing	Agriculture, mining and quarrying, food, beverage, tobacco, textiles, garments and leather products, wood products (except furniture), paper products, printing and recorded media, furniture, and other manufacturing
		PDoS Provider-dominated services	Retail, crafts, souvenirs, vendors, tourism retail, passenger transportation, accommodation, food and beverage service activities, real estate, other services, tour operations, travel agencies, education, health services, cultural activity providers, recreational activity providers, attraction sites, and other personal service activities

Annex B. Gender Diversity Effects on Innovation Performance: Manufacturing Firms

	M1.TWF_gd			M2.MT_gd			M3.Otheract_gd		
	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC
TWF_gd_hat	1.44**	1.21**	1.17**						
	(0.463)	(0.396)	(0.390)						
MT_gd_hat				0.512**	0.472**	0.356*			
				(0.182)	(0.154)	(0.157)			
OtherAC_gd							0.740***	0.591**	0.586**
							(0.216)	(0.184)	(0.185)
Inv_R&D	2.96E-06***	1.63E-06**	1.29E-06***	2.95E-06***	1.56E-06*	1.24E-06***	2.95E-06***	1.61E-06**	1.28E-06***
	(8.40E-07)	5.83E-07)	3.11E-07	(8.32E-07)	(6.01E-07)	(3.19E-07)	(8.34E-07)	(5.84E-07	(3.11E-07)
Age	-0.032	-0.022	-0.012	-0.036	-0.025	-0.015	-0.019	-0.012	-0.001
	(0.022)	(0.018)	(0.018)	(0.022)	(0.018)	(0.018)	(0.023)	(0.019)	(0.019)
Export	0.020	8.17E-06	0.040	0.003	-0.015	0.026	0.005	0.013	0.029
	(0.031)	(0.027)	(0.026)	(0.031)	(0.027)	(0.025)	(0.031)	(0.027)	(0.025)
Group	-0.026	-0.023	-0.059	-0.026	-0.024	-0.051	0.003	0.002	-0.034
	(0.046)	(0.040)	(0.038)	(0.046)	(0.041)	(0.038)	(0.044)	(0.038)	(0.36)
Use_ IP	omited	0.409***	0.193 ***	omited	0.409***	0.195***	omited	0.407***	0.191***
		(0.049)	(0.033)		(0.049)	(0.033)		(0.049)	(0.033)
Sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs	777	851		777	851		777	851	
Logpseudolikelihood	-378.6688	-674.1693		-379.34355	-675.3328		-377.8582	-673.5459	

Note: Marginal effects of explanatory variables on the propensity to innovate are reported. Robust standard errors in parentheses, † p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

Annex C. Gender Diversity Effects on Innovation Performance: Services Firms

	M1.TWF _gd			M2.MT_gd			M3.Otheract_gd		
	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC	INNOVA	INNTEC	INNnoTEC
TWF_gd_hat	0.682*	0.814***	0.014						
	(0.289)	(0.256)	(0.245)						
MT_gd_hat				0.401**	0.485***	-0.014			
				(0.150)	(0.139)	(0.129)			
OtherAc_gd							0.538***	0.666***	-0.017
							(0.159)	(0.138)	(0.1410)
Inv_R&D	9.51E-06***	6.10E-06***	1.82E-06**	9.65E-06***	6.37E-06***	1.82E-06**	9.51E-06***	6.33E-06***	1.82E-06**
	(2.58E-06)	(1.45E-06)	5.62E-07	(2.60E-06)	(1.52E-06)	(5.62E-07)	(2.53E-06)	(1.47E-06	(5.61E-07)
Age	0.024	0.0002	0.045**	0.028	0.004	0.045**	0.036*	0.016	0.044**
	(0.018)	(0.016)	(0.017)	(0.018)	(0.017)	(0.017)	(0.018)	(0.017)	(0.017)
Export	0.056*	0.036	0.036	0.050*	0.030	0.036	0.052*	0.031	0.036
	(0.026)	(0.024)	(0.023)	(0.026)	(0.024)	(0.027)	(0.025)	(0.024)	(0.023)
Group	0.013	0.011	-0.012	-0.002	-0.008	-0.010	0.016	0.013	-0.012
	(0.033)	(0.030)	(0.028)	(0.034)	(0.032)	(0.031)	(0.032)	(0.029)	(0.028)
Use IP	omited	0.328***	0.260***	omited	0.326***	0.261***	omited	0.324***	0.261***
		(0.040)	(0.029)		(0.040)	(0.029)		(0.039)	(0.029)
Sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs	1023	1128		1023	1128		1023	1128	
Logpsuedolikelihood	-461.7450	-924.4535		-460.9608	-922.6167		-458.7004	-918.1270	

Note: Marginal effects of explanatory variables on the propensity to innovate are reported. Robust standard errors in parentheses, † p>0.10 * p<0.05; ** p<0.01; *** p<0.001.

Annex D. List and Definition of Variables

Variable name and abbreviation	Definition
Innovation (INNOVA)	Dummy variable equal to 1 if the firm had a product, process, organizational, or market innovation between 2017 and 2020, and 0 if otherwise.
Technological innovation (INNTEC)	Dummy variable equal to 1 if the firm had a product or process innovation between 2017 and 2020, and 0 if otherwise.
Non-technological innovation (INNnoTEC)	Dummy variable equal to 1 if the firm had an organizational or market innovation between 2017 and 2020, and 0 if otherwise.
Total Work Force gender diversity (TWF_gd)	Continuous variable that measures gender diversity in total work force through the Blau Index Value. This variable includes employees doing management activities, employees involved directly in the production process or at a supervisory level (and whom management considers to be skilled), and employees involved in production processes (but whom management considers to be unskilled).
Management Team gender diversity (MT_gd)	Continuous variable that measures gender diversity management activities through the Blau Index Value. This variable includes employees doing management activities: management of employees and leadership, strategy, improvement, and growth of the enterprise.
Skilled production and non-production workers gender diversity (OtherAC_gd)	Continuous variable that that measures gender diversity in skilled production and non-production workers through the Blau Index Value. This variable only includes employees involved directly in the production process or at a supervisory level and whom management considers to be skilled.
R&D investment (Inv_R&D)	Mean investment in product and process innovation in previous three years over total employees.
Age of the firm (Age)	Logarithm of the number of years from the creation of the firm.
Exports (Export)	Dummy variable equal to 1 if firm exports, and 0 if otherwise.
Part of a company group (Group)	Dummy variable equal to 1 if belongs to a larger company, and 0 if otherwise.
Use_IP	Dummy variable equal to 1 if firms obtained or successfully implemented some mechanism to protect their intellectual property between 2017 and 2020, and 0 if otherwise (including all mechanisms of IFPG: patents, trademarks, industrial design, copyright, denomination of origin, utility model, Non-Disclosure Agreement (NDA) with employees, and Non-Disclosure Agreement (NDA) with clients / suppliers / other outside parties).
Castellaci sector (Sector)	Dummy variable equal to 1 if firms are in determinate sector according Castellaci's taxonomy (see Annex A).
Country	Dummy variable equal to 1 if the firm is located in a determinate country.
Size	Dummy variable to each of four groups (Size1: firms with fewer than 10 employees; Size2: from 11 to 49 employees; Size3: from 50 to 249 employees; Size4: over 250 employees).
Size _con	Logarithm of total employees.

(continued on next page)

(continued)

Variable name and abbreviation	Definition
Cooperation to innovate (COOP)	Dummy variable equal to 1 if the firm has developed any type of innovation together with other firms or organizations.
Mean of gender diversity in total work force (meanTWF_gd)	Mean of TWF_gd over Sector.
Mean of gender diversity in managerial activities (meanMAGAC_gd)	Mean of MAGAC_gd over Sector.
Mean of gender diversity in production and non-production activities (meanOtherAC_gd)	Mean of OtherAC_gd over Sector.

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