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Prepared for the Inter-American Development Bank by:

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GENDER CONTRIBUTION TO THE INNOVATION-PRODUCTIVITY RELATIONSHIP IN THE WAKE OF COVID-19

Evidence for the Caribbean

Ezequiel Tacsir
Mariano Pereira

Content

Abstract*

This study presents new findings on the impact of the COVID-19 pandemic on productivity and innovation for Caribbean firms, with particular focus on the effects on firm gender diversity and workforce composition. Research on the impact of women's participation on firm performance and innovation has so far produced mixed results, though there is some evidence to suggest that for Latin America, larger shares of women in the knowledge creation and innovation process may increase innovative behavior and, as a consequence, lead to greater labor productivity. In the current context, female participation in firms becomes an even more pressing issue, given the early indications of the pandemic's disproportionately negative burden on women's income and jobs in different regions. We found that the gender composition of the personnel has an interesting direct effect on productivity. At the same time, our results show that the expected reductions in female personnel due to the pandemic, have a negative effect in the shares of female participation which, in turn, have the potential to nullify the mentioned productivity channel. This suggests the existence of a minimum threshold of female participation to profit from diversity. Hence, it seems that policy should focus particularly on protecting female jobs, particularly in the wake of dramatic shocks affecting revenues and/or employment.

JEL Codes: O32, J16, D22
Keywords: Caribbean, pandemic, innovation, gender, productivity

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1 Introduction

Research on women's impact on firm performance and innovation has so far produced mixed results. Several studies, using employer-employee or firm-level datasets, have found that women's participation in research and development (R&D) teams increases the probability that a firm will innovate (Díaz, González, and Sáez, 2013; Fernández, 2015; García, Zouaghi, and García, 2017; Østergaard, Timmermans, and Kristinsson, 2011; Teruel, Parra, and Segarra, 2015), and that this, in turn, can have positive effects on firm productivity. Other studies find empirical evidence for the impact of gender diversity on firm productivity as being mostly negative (Parrotta, Pozzoli, and Pytlikova, 2014), although some, (e.g., Garnero, Kampelmann, and Rycx, 2014) find a positive relationship. In this context, only two papers address the issue for Latin American countries but, to date, there are none for the Caribbean context.

At the same time, mounting evidence around the world suggests that women's economic income and jobs could have been more negatively affected by the pandemic than men's (de Paz et al. 2020, and 2021; Center on Gender Equity and Health, 2020; Bundervoet, Dávalos, and Garcia, 2021; Cucagna, and Romero, 2021; Kugler et al., 2021). However, there is only limited evidence (Torres et al., 2021) that points to the differential effect of the pandemic on firms in terms of gender of the firm's owners, shareholders or workforce. Taking this into account, we aim to fill this gap by exploiting the Innovation, Firm Performance, and Gender Firm-level Dataset for the Caribbean (IFPG, 2021) and by adapting the Crepón, Duguet, and Mairesse (1998) model (CDM from now on) to provide evidence on the differential impacts of this external shock in terms of innovation activities and firm productivity for female owned or managed firms. At the same time, we also extend CDM to include, in particular, the gender dimension, in a spirit similar to the approach pursued by Gallego and Gutierrez (2018) to account for the impact on productivity due to the presence of women in different roles at the firm level. In addition, we extend the approach by providing a comparison of the potential effects of the pandemic on productivity through exploiting the expected effects of the pandemic on sales, revenues, and productivity in the Caribbean.

To our knowledge, our research provides the first attempt to jointly address the effects of the pandemic on female owned or managed firms in the Caribbean. Taking this into consideration, our research sheds new light on two issues. First, how does gender composition in the firm workforce and managerial staff contribute to firm productivity.[1] Second, whether there is evidence of any change in the relationship between innovation and productivity, as a result of COVID-19, for firms with different gender composition (either at the managerial/ownership or workforce level).

[1] As will become clearer in the following sections, the lack of detailed information on gender composition at different innovation-related roles, allows us to capture only the direct effect that gender composition within a given firm might have at the productivity level, and not via the innovation outputs.

2

Literature Review and Research Questions

Our research lies at the intersection of three strands of literature, namely: innovation and productivity, gender and impact of the COVID-19 pandemic, and performance of female-owned or managed firms. The literature received, relevant to these converging topics, is summarized below.

Innovation and Productivity

Taking advantage of innovation surveys, Crepon et al. (1998) were the first to empirically integrate the relationship between innovation and productivity in a recursive model. Their findings for France corroborated the positive correlation between firm productivity and higher innovation output, even controlling for the skill composition of labor. They also confirmed that a firm's decision to invest in innovation (R&D) increases with its size, market share, and diversification, and with the demand-pull and technology-push forces.

There is evidence that higher levels of investment in innovation (notably in R&D) lead to a higher propensity to introduce technological innovation in firms in Argentina (Chudnovsky et al., 2006) and Brazil (Raffo, Lhuillery, and Miotti, 2008), but research does not support this relationship for Chile (Benavente, 2006) or Mexico (Perez et al., 2005). One important pitfall of previous research is related to the lack of homogeneous and comparable data across the different countries in the Latin American region, which may be a factor underlying this heterogeneity. Differences in sampling methodologies, questionnaire design, and data processing for the existing innovation surveys, seriously affect the comparability of the results. Crespi and Zuniga (2012) performed the first comparative study to examine the determinants of technological innovation and its impact on firm labor productivity in manufacturing firms across Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama, and Uruguay). This exercise showed that the firms who invested in knowledge were more able to introduce technological advances, and those who innovated exhibited superior labor productivity to those who did not. In line with this comparative evidence, Crespi, Vargas, and Tacsir (2016) performed a similar exercise for the region by exploiting information from the Enterprise Surveys project. These contributions focused exclusively on manufacturing. Crespi, Vargas, and Tacsir (2014) analyzed the effects on labor productivity in services sectors at the firm level, providing comparative evidence for Chile, Colombia, and Uruguay.

Regarding the Caribbean, the available evidence does not show any consistent effects of innovation on productivity. While Mohan et al. (2016), using the LACES dataset, verified that innovative firms in the region exhibited higher labor productivity compared to non-innovative firms, Mohan, Strobl, and Watson (2017), exploiting the PROTEqIN database, found that, although firms spending more on innovation are more likely to introduce a product or process innovation, these innovation expenditures had a positive, but not a significant, impact on labor productivity.

Gender Effects of the COVID-19 Pandemic

Received evidence, based on earlier infectious disease outbreaks, anticipated the high likelihood of gender-differentiated impacts of COVID-19 on economic outcomes such as employment or income (de Paz et al., 2020 and 2021). In particular, these gender-differentiated impacts were anticipated since the sectors and occupations that employ a disproportionate share of women were among the hardest hit by the lock-down measures, (e.g., tourism and hospitality, retail, etcetera).[2] A growing body of new data and early analysis confirms that women globally have shouldered a larger share of the negative economic impacts of COVID-19 than men (e.g., Center on Gender Equity and Health, 2020; Bundervoet, Dávalos, and Garcia, 2021; Cucagna and Romero, 2021; Kugler et al., 2021). Significantly more women than men have lost their jobs during the early stages of the pandemic. This trend has been documented for many countries through several recent global, regional, and country-level studies (Kugler et al. 2021; Bundervoet, Dávalos, and Garcia, 2021; World Bank Enterprise Surveys, 2020; Cucagna and Romero, 2021)

Gender differences in the impacts of COVID-19 are observed not only for employment, but also for businesses ownership and leadership. An interest in gender ownership seems warranted, given the pre-pandemic literature establishing gender as an important determinant of business performance, with female-owned or -managed firms typically registering lower levels of labor and total factor productivity than male-owned or managed firms (see Torres et al, 2021, for an extensive review on the matter).[3] Even when there are well-documented pre-existing constraints, the consensus is that the pandemic has exacerbated them. The Enterprise Survey data (harmonized dashboard) shows that in 12 out of 18 countries, businesses with a female top manager were more likely to close (at least temporarily) due to the COVID-19 outbreak than businesses with a male top manager. Moreover,

[2] The impact on tourism is of particular relevance to the Caribbean.

[3] These unconditional gaps typically narrow when controlling for sector and firm size because women business owners often operate in sectors where profit margins are comparatively lower and have fewer employees than their male counterparts. At the same time, several cross-country studies have documented that women-led businesses are more profitable and larger when they are in male-dominated sectors (Campos et al., 2018 and 2019). However, firm characteristics do not explain the entirety of the gap in productivity, sales revenues, and profits.

in 11 out of 18 countries, women-led enterprises reported shorter survival durations than men-led enterprises. The study by Torres et al. (2021), based on the World Bank analysis of Business Pulse Survey and Enterprise Survey data from 52 countries, also shows gender-differentiated impacts on businesses. Women-led businesses were, on average, more likely to be closed six weeks or more after the peak crisis than men-led businesses (15.5 versus 14.1 percent), a small but statistically significant difference.

Further disaggregation shows that gender gaps are even larger among micro-businesses and businesses in the hospitality industry, which supports the notion that the observed gender differences are at least partly linked to the concentration of male and female entrepreneurs in different segments of the economy. Arguably, while gender gaps in enterprise performance are well documented, there is far less conclusive evidence on how these gaps evolve during times of economic crisis. In this sense, evidence might suggest that access to finance might be an important channel in the difference between firms. In particular, a few studies—such as Ahmed, Muzi, and Ueda (2020) for women-led firms in Europe and Central Asia; Cesaroni, Lotti, and Mistrulli (2013) for Italy; Thébaud and Sharkey (2016) and Palvia, Vähämaa, and Vähämaa (2015) for the United States—argue that gender gaps in enterprise performance and access to finance worsened in the aftermath of the 2008 global financial crisis. Overall, women-owned firms faced a more pronounced credit contraction when liquidity was tight and were more likely to experience difficulties in acquiring funding when lending tightened. The study also found that women-led businesses are less likely to have received some form of public support, even though they have been harder hit in some domains. Similarly, Future of Business Survey and Facebook et al. (2020) showed that globally, female-owned businesses were seven percentage points more likely to close down than male-owned businesses at the peak of the pandemic. Female-owned firms were also concentrated in consumer-facing sectors (services, hospitality, retail trade) where the demand shock was hitting the hardest.

Gender and Firm Performance in the Caribbean

Dohnert, Maffioli, and Crespi (2017) provide an exhaustive analysis of the differential impact of gender for small Caribbean states. Moore, Presbitero, and Rabellotti, (2017) found that while firms owned by females were as productive as male-owned ones, firms managed by females were not. They concluded that there is a gender gap in firm performance for female-managed firms, even after controlling for country and sector characteristics and for a large set of firm-level variables that drive productivity. However, the authors also found that differences in firm size, age, and access to finance across gender, explained a significant part of the productivity gap of female-managed firms. These results are consistent with those of Mohan, Strobl, and Watson (2017), who found that female-managed firms are especially deterred by barriers to innovation. Bernini, Figal Garone, and Maffioli (2017) showed that female-owned or -managed firms participated less in innovation programs.[4] Therefore, an

[4] Related to the effect of COVID on public support, Torres et al. (2021) report that women-led firms have received little public support—both in the raw unconditional data and conditional on the firm size and sector, with the exception of medium sized firms. These findings are consistent with a recent study on the impacts of COVID-19 on firms in South Asia, where women-led firms were also found to have less public support (Brucal et al., 2021). One potential reason could be that women entrepreneurs have fewer and weaker social network ties than male entrepreneurs; see Kim (2019) for information on the United States. This may disadvantage them in terms of accessing information on government support programs.

innovation policy would be better aimed at these firms and their specific needs and could thus help reduce potential gender discrimination.

Although not focusing on the Caribbean, Gutierrez and Gallego (2018) and Lage de Sousa et al. (2020) approach gender diversity in Colombia and Brazil, respectively. There is a dearth of evidence on the topic for the Caribbean. Gutierrez and Gallego (2018) studied the topic in manufacturing firms in Colombia and their main results indicate that firms with a larger share of women in the knowledge creation and innovation process could increase their innovative behavior and consequently exhibit greater labor productivity. An increase of six percentage points in the share of women in STI would increase the innovative behavior of firms by two percentage points. In addition, they found evidence of a differentiated effect of gender diversity by type of innovation. Specifically, women's participation has a greater effect on technological innovation than on organizational innovation. Finally, gender diversity drives firm productivity, even after controlling for the effect of innovation on the production process.

In a similar vein, Lage de Sousa et al. (2020) focuses on the innovation and productivity impacts of workforce (not only gender) diversity in Brazil. Their results suggest that even though there are costs, the benefits of workforce diversity offset those costs in most innovation outcomes. Generally, outcomes for gender diversity indicate that marketing innovation presents robust positive evidence, which means that more gender-diverse firms tend to introduce different marketing strategies over time. For other innovation measures, product innovation also seems to be positively related to gender diversity, although less robust than marketing innovation. It is important to note that an existing correlation between product and process innovations might have led to non-significant outcomes with process innovation. These outcomes suggest that diversity may be more suitable for promoting intangible values (such as brand) than tangible ones (new product).

3 Data and Descriptive Statistics

The innovation, firm performance, and gender firm-level dataset for the Caribbean (IFPG, 2021) includes information at the firm-level across different topic areas. In addition to collecting the information traditionally available in innovation surveys, the dataset devotes particular attention to the gender composition of both the workforce and the managerial/ownership of the firm.[5] Given the context in which the data was collected, it includes an interesting body of information related to the expectations of the respondents in terms of their revenue, sales, and overall dynamics affected by the pandemic.

Specifically, and by using this database, we have generated a broad set of indicators that can be grouped around three dimensions. The first group of variables covers different aspects of the structural characteristics of Caribbean firms, such as age, origin of capital, exporting status, and size, among other variables usually reported in the literature. A second set of variables captures the participation of women and gender diversity within the company, for which we measure the share of women in the total workforce and their distribution in the different areas that make up the company. Finally, a third set of variables captures the innovative and productive performance of firms, using indicators such as intensity of spending on innovation activities, innovation output, and firm productivity. Table 1 provides a detailed description of the variables used in this study.

Table 2. Summary Statistics of the Variables Included presents descriptive statistics for variables and observations used in the remainder of the article. On average, the database is composed of mature companies that have been in the market for over 25 years. 23 percent of companies reported having an international quality certification, 35 percent had placed their products

[5] IFPG also provides information on capital stock and other variables required to provide sound productivity estimates.

TABLE 1 ● VARIABLES EMPLOYED IN THIS STUDY

Variable	Description
Characteristics of Firm	
Exporter	Binary variable that takes value 1 if an exporter. Dated at the beginning of the innovation period,
Foreign-owned	Binary variable that takes value 1 if foreign capital > 10%. Dated at the beginning of the innovation period,
Public support	Binary variable that takes value 1 if access to program support for innovation. Dated at the beginning of the innovation period,
R&D_Department	Binary variable that takes value 1 if R&D group. Dated at the beginning of the innovation period,
Legal_status	Set of binary variables that indicates firm's current legal status: i) shareholding company, ii) Sole proprietorship, and iii) Partnership and limited partnership. Dated at the beginning of the innovation period,
Firm's_age	Years since begin operations. Dated at the beginning of the innovation period,
Qual_certif	Binary variable that takes value 1 if has an internationally recognized quality certification. Dated at the beginning of the innovation period,
K_L	Stock of capital divided by FT employee
Size	Set of dummy variables that indicates if firm's size is: i) Micro (0 to 4 employees), ii) small (4 to 10 employees), iii) medium (11 to 100 employees) or iv) large (more than 100 employees)
Sector	Set of dummy variables that indicates if firm's sector is: i) agriculture, mining, and quarrying, ii) manufacturing, iii) electricity, gas and water, iv) construction, v) retail and wholesale, vi) services and vii) arts and entertainment.
Female Participation or Gender Diversification	
Female_sd	Standard deviation coefficient of female participation among the different units within the firm
Share_female	Ratio of female workers to total workforce
CV	Coefficient of variation of female participation among the different units within the firm (constructed based on the survey data)
Innovative and Productive Characteristics of Firm	
Inno	Binary variable that takes value 1 if perform innovation activities
l_AI_L	Innovation expenditure by FT-employee
Inno_prod/serv	Binary variable that takes value 1 if product or service innovation
Inno_proc	Binary variable that takes value 1 if process innovation
l_VAB_L	Gross value added measured as revenues minus costs of goods sold (COGS by full-time employees (in log)

Source: Authors' elaboration based on IFPG (2021).

TABLE 2 ● SUMMARY STATISTICS OF THE VARIABLES INCLUDED

	N	mean	sd	min	max
=1 if exporter'	1,654	0.354	0.478	0	1
=1 if foreign capital > 10%	1,654	0.154	0.361	0	1
=1 if access to program support for innovation	1,654	0.019	0.135	0	1
=1 if R&D group	1,654	0.038	0.191	0	1
Current legal status	1,654	1.647	0.478	1	2
Years since begin operations	1,654	26.270	20.150	0	234
=1 if have a quality certification	1,654	0.231	0.422	0	1
Innovation Expenditure by FT-employee	1,654	7.854	1.856	3.583	13.21
=1 if product or service innovation	1,654	0.245	0.430	0	1
=1 if process innovation	1,654	0.231	0.422	0	1
=1 if perform innovation activities	1,654	0.458	0.498	0	1
K_L	1,654	834220	4578000	0	1.22E+08
Gross value added by FT-employees (in log)	1,654	10.130	2.028	2.996	17.430
Size: micro	1,654	0.298	0.458	0	1
Size: small	1,654	0.476	0.500	0	1
Size: medium	1,654	0.134	0.341	0	1
Size: large	1,654	0.092	0.289	0	1
Sector: agriculture, mining, and quarrying	1,654	0.014	0.117	0	1
Sector: manufacturing	1,654	0.410	0.492	0	1
Sector: electricity, gas, and water	1,654	0.003	0.055	0	1
Sector: construction	1,654	0.063	0.244	0	1
Sector: retail and wholesale	1,654	0.213	0.409	0	1
Sector: services	1,654	0.293	0.455	0	1
Sector: arts and entertainment	1,654	0.004	0.065	0	1

Source: Authors' elaboration based on IFPG (2021).

or services on international markets, and 15 percent were foreign owned. Finally, more than two thirds of the database is made up of micro or small companies (up to 10 employees), and more than 90% of the base is made up of companies in manufacturing, services, and commerce. Regarding innovative performance, almost half of the companies reported making innovation efforts and investing an average of US$ 7,854 per employee. A small fraction of these companies accessed a public support program for innovation, and only four percent reported having a dedicated R&D department. Finally, the average firm in the database reported a capital stock per employee of US$834,220, and a gross value added of US$10,130 per worker.

Methodology

4

Identification strategy: CDM Model

To deal with the problem of selectivity bias and endogeneity in the functions of innovation and productivity, we will employ the CDM model. Let $i = 1, \ldots, N$ index firms, the Equation (1) accounts for firms' innovative efforts, IE_i^*:

$$IE_i^* = z_i\beta + e_i \tag{1}$$

where IE_i^* is an unobserved latent variable, z_i is a vector of determinants of innovation effort, β is a vector of parameters of interest, and e_i is an error term. We proxy firms' innovative effort IE_i^* by their (log) expenditures on R&D activities per worker denoted by IE_i only if firms make (and report) such expenditures.[6] Thus, we can only directly estimate equation (1) at the risk of selection bias (Griffith et al. 2006). Instead, we assume the following selection equation describing whether the firm decides to do (and/or report) innovation investment or not:

$$ID_i = \begin{cases} 1 \text{ if } ID_i^* = w_i\alpha + \varepsilon_i > c \\ 0 \text{ if } ID_i^* = w_i\alpha + \varepsilon_i \leq c \end{cases} \tag{2}$$

where ID_i is a binary endogenous variable for an innovation decision that is equal to zero for firms that do not invest in innovation, and one, for firms investing in innovation activities; ID_i^* is a corresponding latent variable such that firms decide to do (and/or report) innovation investment if it is above a certain threshold level c, and where w is a vector of variables explaining the innovation investment decision, α is a vector of parameters of interest, and ε is an error term. Conditional on firm *i* performing innovation activities, we can observe the budget invested in innovation (IE_i) activities, and write:

$$IE_i = \begin{cases} IE_i^* = z_i\beta + e_i \text{ if } ID_i = 1 \\ 0 \text{ if } ID_i = 0 \end{cases} \tag{3}$$

[6] In the original CDM model the dependent variable is knowledge capital. It should be noted that by using knowledge investment there is a chance that any adjustment cost might contaminate the true relationship between expenditures on innovation, outputs, and productivity.

Assuming the error terms e_i and ε_i are bivariate normal with zero mean, variances $\sigma_\varepsilon^2 = 1$ and σ_e^2 and correlation coefficient ρ_e, we estimate the system of equations (2) and (3) as a Heckman model by maximum likelihood. The next equation (4) in the CDM model is the knowledge or innovation production function:

$$TI_i = IE_i^* \gamma + x_i \delta + u_i \tag{4}$$

where TI_i is knowledge outputs by technological innovation (such as the introduction of a new product or process at the firm level), and where the latent innovation effort, IE_i^*, enters as an explanatory variable, x_i is a vector of other determinants of knowledge production, γ and δ are vectors of parameters of interest, and u_i is an error term. The last equation (5) relates innovation to productivity. Firms produce output using a technology represented by a Cobb–Douglas function with labor, capital, raw materials, and knowledge as inputs as follows:

$$y_i = \pi_i k_i + \pi_2 m_i + \pi_3 TI_i + v_i \tag{5}$$

where output y_i is labor productivity (log of gross value added per worker), k_i is the log of physical capital per worker (measured by physical investment per worker) and TI_i is an explanatory variable that refers to the impact of technological innovation on productivity levels.

In all equations, we will control for unobserved industry characteristics by including a full set of Sector code dummies. In addition, we will control for idiosyncratic characteristics of each national innovation system by including a full set of country dummies. We also propose to control for firm size in all equations except the R&D investment equation (2), since R&D investment intensity is already implicitly scaled for firm size. As this recursive model does not allow for feedback effects between equations, we will implement a three-step estimation routine. First, we estimate the generalized Tobit model (equations 2 and 3). Second, we estimate the innovation function as a probit equation using the predicted value of (log) innovation expenditure as the main explanatory variable, instead of reported innovation efforts, thus correcting for potential endogeneity in the knowledge production equation. Lastly, we estimate the productivity equation using the predicted values from the second step to take care of the endogeneity of TI_i in equation 5. In line with previous studies, we do not only use technological innovation as a dependent variable, but also estimate separate versions of equation 4 for each type of innovation (technological and non-technological innovation[7]). This allows us to explore whether there are different returns for each different class of innovation investment.

Finally, taking advantage of the structural framework provided by the CDM model, our research produces two contributions. First, we present an integrated view of the role of women in innovation and production within the firm. Second, we provide evidence related to the impact of COVID-19 on both innovation and productivity.

To assess whether women's participation contributes to a firm's propensity to innovate, and whether gender diversity directly contributes to productivity, we follow the work of Gallego and Gutiérrez Urdaneta (2018).[8] As previously

[7] Technological innovation (or TPP) includes innovation in product, processes, and services. Non-technological innovation agglutinates whether the firm has implemented an organizational, commercial, logistic, and/or payment-related innovation.

[8] At this point, it should be clear to the reader that gender diversity and female participation are interesting concepts that should be differentiated. Even when two different firms might have zero diversity, the levels of female participation could be radically different. In fact, one of these firms could only employ, while the other, employ only women. It should be noted that the descriptive data shows that there are no extreme cases of firms in terms of female participation in our dataset.

mentioned, the CDM model has three stages in order to deal with the sample selection and endogeneity problems on innovation efforts and outcomes. We built upon the same structure by including a set of covariates related to participation and distribution of women in the different units at the firm in the third stage.

$$y_i = \pi_i k_i + \pi_2 m_i + \pi_3 TI_i + \pi_3 \mathit{Gender}_i + v_i \qquad (6)$$

We approach gender diversity by using three different measurements: 1) the ratio of women to total employees in the firm, 2) the coefficient of variation (CV), and 3) the standard deviation coefficient (SD) of the distribution of women across different areas of the firm. The CV is defined as follows:

$$CV = \frac{\sqrt{\frac{\Sigma_i^n (D_i - D_{mean})}{n}}}{D_{mean}}$$

where D is the number of female (male) employees who work in the same area. To do so, we exploit the fact that IPFG splits the overall workforce into i) skilled production and non-production workers, ii) unskilled production and non-production workers and iii) management workers. Hence, we account for n=6 different groups and three types of occupations for each gender. Finally, and based on the above information, our measurement of gender dispersion is the standard deviation index that follows the traditional calculation.

To assess the impact of COVID-19 we exploit the firm's expected impact on employment, sales, and innovation due to the pandemic. We estimate the CDM model using variables that include the firms' expected impact and compare these with the baseline estimates of the CDM model, based on the financials referring to the fiscal year prior to the pandemic.

5 Results

CDM Model: Traditional Set Up

Table 3 shows the results on the parameters of equations (2) and (3) employing a Heckman model. The second column shows the probit estimation of the investment decision on innovation activities (IE>0). The first item of note is the positive correlation between firm size and the decision to invest. This is one of the most consistent findings in the literature: firm size is relevant for investment in innovation. One way of interpreting this finding is that there are some fixed costs, particularly related to R&D and fixed assets investments (e.g., labs), involved in introducing innovations, which larger firms can spread out over more units of output. The dummy variables exporter and foreign owned do not seem to be very relevant to the decision to invest in innovation activities. The dummy patent, which takes value 1 when the firm applied for a patent, is a proxy of past innovation efforts from firms. Even though this is an imperfect proxy, given that only a few firms apply for patents, it clearly correlates with the past decision to invest in innovation activities. To have an established R&D group in place and access to public support for innovation, positively effects the likelihood of investing in innovation and its intensity.

As discussed in the methodology section, the following step is to analyze the role of innovation expenditures in the production of technological and non-technological innovations. We do so by introducing the prediction of the investment in innovation activities from the previous step as an input of the innovation production function. Columns (1)-(2) and (3)-(4) show the results for technological and non-technological innovation in an OLS and IV setting, respectively, by means of a biprobit. Overall, the predicted expenditures are highly significant in the tech and non-tech innovation equations, although the coefficients are larger in the case of technological innovation.

With respect to the other control variables, and focusing our results in the IV setting, we

TABLE 3 ● FIRST STAGE: SELECTION EQUATION FOR INNOVATION DECISION AND INNOVATION INTENSITY EQUATION

	IE / L (in log)	P(IE>0)
Cost obstacles to IA		-0.463***
		(0.154)
Market obstacles to IA		0.057
		(0.096)
Knowledge obstacles to IA		0.118
		(0.114)
Institutional obstacles to IA		0.378**
		(0.187)
Size (FT employee, ln)		0.412***
		(0.053)
=1 if R&D group	1.427***	0.755***
	(0.311)	(0.160)
=1 if access to program support for innovation	1.913***	1.084***
	(0.629)	(0.361)
=1 if obtain patent	1.717***	0.901***
	(0.410)	(0.326)
Years since begin operations	-0.004	-0.001
	(0.004)	(0.001)
=1 if exporter'	0.171	0.100
	(0.181)	(0.103)
=1 if foreign capital > 10%	0.230	-0.008
	(0.167)	(0.100)
=1 if have a quality certification	0.216	0.048
	(0.157)	(0.089)
Constant	6.675***	-1.312***
	(1.128)	(0.292)
Observations	**1,654**	**1,654**
Log like	-2280	-2280
Athrho	1.958***	
	(0.285)	
lnsigma	0.840***	
	(0.125)	

Source: Authors' elaboration based on IFPG (2021).
Notes: i) All parameters were estimated using a Heckman model, ii) All equations include a set of dummy variables indicating sector of activity and current legal status, iii) Robust standard errors clustered at country-sector level, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

TABLE 4 ● SECOND STAGE: TECHNOLOGICAL AND NON-TECHNOLOGICAL INNOVATION

	Naive		IV	
	Tech innovation	Non-tech innovation	Tech innovation	Non-tech innovation
Years since begin operations	0.001	0.002	0.003	0.002
	(0.003)	(0.003)	(0.002)	(0.002)
=1 if exporter'	-0.263*	-0.105	-0.158	-0.051
	(0.112)	(0.120)	(0.118)	(0.123)
=1 if foreign capital > 10%	0.182	0.423**	0.021	0.322**
	(0.192)	(0.157)	(0.122)	(0.124)
=1 if have a quality certification	0.256+	-0.103	0.040	-0.111
	(0.143)	(0.161)	(0.104)	(0.132)
Size (FT employee, ln)	0.145*	0.228**	0.363**	0.360**
	(0.072)	(0.059)	(0.064)	(0.062)
AI expenditure (in ln)	**0.021**	**0.055+**		
	(0.040)	**(0.031)**		
AI expenditure (linear prediction, in ln)			**0.559****	**0.211***
			(0.107)	**(0.099)**
Constant	0.514	-1.465*	-5.387**	-3.588**
	(0.585)	(0.729)	(0.715)	(0.784)
Observations	737	737	1,654	1,654
Log like	-901	-901	-1450	-1450
Athrho	0.008		0.541**	
	(0.056)		(0.061)	

Source: Authors' elaboration based on IFPG (2021).
Note: i) All parameters were estimated using a Biprobit model, ii) All equations include a set of dummy variables indicating sector of activity and current legal status, iii) Robust standard errors clustered at country-sector level, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

observe that size continues to be a very relevant variable. In this stage, being an exporter, and age, have a positive effect on obtaining a TPP innovation (but not a non-technological innovation). At this point it should be noted that the predicted expenditure already contains the indirect effect of different control variables of the previous equations. This could explain the negative sign of some variables, such as legal status. Again, quality certification remains non-significant.

Next, we estimate four versions of the labor productivity equation with an alternative breakdown of firms, according to the innovation bundles they have introduced. Column (1) reports the results for all types of firms, differentiating by the type of innovation introduced. Column (2) estimates the effect on productivity of obtaining both types of innovation. Column (3) reports on the productivity effect of TPP innovation in the absence of a non-tech innovation. Finally, column (4) reports on the

TABLE 5 ● MARGINAL EFFECTS FOR TECHNOLOGICAL AND NON-TECHNOLOGICAL INNOVATION

	P(tech inno=1 and non-tech inno=1)	P(tech inno=1 and non-tech inno=0)	P(tech inno=0 and non-tech inno=1)
Years since begin operations	0.000	0.001	-0.000
	(0.000)	(0.001)	(0.000)
=1 if exporter'	-0.014	-0.040	0.003
	(0.019)	(0.025)	(0.008)
=1 if foreign capital > 10%	0.034+	-0.027	0.032**
	(0.019)	(0.029)	(0.010)
=1 if have a quality certification	-0.009	0.023	-0.013
	(0.016)	(0.029)	(0.012)
Size (FT employees, in ln)	0.057**	0.067**	0.017**
	(0.008)	(0.016)	(0.005)
Linear prediction	**0.052****	**0.139****	**-0.008**
	(0.015)	**(0.028)**	**(0.010)**
Observations	1,654	1,654	1,654

Source: Authors' elaboration based on IFPG (2021).

TABLE 6 ● THIRD STAGE: PRODUCTIVITY EQUATION

	Gross value added by FT employees (in log)			
	I	II	III	IV
Size (FT employee, ln)	0.088***	0.088***	0.140***	0.152***
	(0.034)	(0.031)	(0.024)	(0.019)
K/L ratio (in ln)	0.095***	0.095***	0.096***	0.096***
	(0.015)	(0.014)	(0.011)	(0.018)
Years since begin operations	-0.000	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
P(tech inno=1 and non-tech inno=1)	0.722**	0.707**		
	(0.334)	(0.351)		
P(tech inno=1 and non-tech inno=0)	-0.042		0.158	
	(0.339)		(0.265)	
P(tech inno=0 and non-tech inno=1)	0.091			-0.227
	(0.886)			(0.966)
Constant	12.496***	12.495***	12.362***	12.364***
	(0.357)	(0.290)	(0.268)	(0.327)
Observations	1,583	1,583	1,583	1,583
R-squared	0.835	0.835	0.834	0.834

Source: Authors' elaboration based on IFPG (2021).
Note: i) All parameters were estimated using OLS, ii) All equations include sector and size fixed effects, iii) Bootstrapped standard errors in parentheses, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

productivity effect of introducing solely a non-technological innovation. In these different regressions we are using the predicted probability of introducing technological, non-technological or both (from the Biprobit estimation in the versions presented in Table 4). First, size and capital endowment have a positive effect, irrespective of the innovation output considered. Secondly, only those firms that introduced TPP and non-TPP innovations jointly, experience a positive effect on their productivity levels. This suggests an important complementarity between these different types of innovation.

CDM Model: Female Contribution to Innovation and Productivity

As stated earlier, gender might have different channels that affect innovation and, either directly or indirectly, the firm´s productivity. To be as thorough as possible, in this section we implement two additions. First, we included a dummy variable that accounts for female ownership in the second stage of our empirical strategy. Second, and more importantly, given that the IFPG 2021 dataset allows us to explore -as in Gutierrez and Gallego (2018)—an extension of the CDM model, and further study the contribution of women to firms' productivity changes due to innovation, we included different indicators to proxy both female participation and gender diversity in the productivity equation. We hypothesize that greater gender diversity, or participation of women in the labor force, leads to a larger pool of productive capabilities that manifests itself in higher productivity. To study that, we estimated an augmented Cobb-Douglas production function that includes common inputs, capital, labor, and human capital, plus a measure of gender diversity in the overall firm and the predicted innovation results obtained in stage 2. In terms of the first extension, Table 7 reports the estimates after including a variable regarding whether or not a firm is female owned. Overall, the results and coefficients are similar to those reported in Table 3, in which size plays an important role in both types of innovation, and foreign capital affects non-TPP innovation. The estimated coefficients for the linear prediction of innovation expenditure intensity are identical.

Table 8 shows the estimated parameters of equation 6. The first two columns include indicators of gender diversity (i.e., the standard deviation of female participation in the firm and its coefficient of variation) and the last column is an indicator of the participation of women within the firm (the share of female workers in the labor force).Two results are worthy of notice. First, the comparison with the estimated parameters in Table 6. The only difference between these two tables are the covariates related to gender diversity. Therefore, any difference provides evidence of the correlation between gender diversity (or female participation) and innovative performance. The comparison suggests that the impact of introducing a non-technological innovation on productivity was overestimated in Table 6, since it is lower than the same parameter estimated in Table 7. That is, the probability of introducing a non-technological innovation is positively correlated with the participation of women within the firm. This result contrasts with that of Gallego and Gutierrez (2018), who found that women's participation has a greater effect on technological innovation than on organizational innovation. The characteristics of the labor market in the Caribbean brings us to an understanding of this finding. The participation of women is not only very low but is also concentrated in the management area (see Figure 1). This suggests that promoting greater gender diversity within the Caribbean labor market—at

TABLE 7 ● TECHNOLOGICAL AND NON-TECHNOLOGICAL INNOVATION: FEMALE CONTRIBUTION

	IV	
	Tech innovation	Non-tech innovation
Years since begin operations	0.003	0.002
	(0.002)	(0.002)
=1 if exporter'	-0.164	-0.050
	(0.119)	(0.123)
=1 if foreign capital > 10%	0.025	0.321**
	(0.121)	(0.123)
=1 if have a quality certification	0.035	-0.110
	(0.104)	(0.133)
Size (FT employee, ln)	0.365**	0.360**
	(0.064)	(0.062)
AI expenditure (linear prediction, in ln)	0.559**	0.211*
	(0.107)	(0.099)
= 1 if female ownership	**0.118**	**-0.024**
	(0.075)	**(0.111)**
Constant	-5.413**	-3.587**
	(0.716)	(0.787)
Observations	1,654	1,654
Log like	-1449	-1449
Athrho	0.543**	
	(0.062)	

Source: Authors' elaboration based on IFPG (2021).
Notes: i) All parameters were estimated using a Biprobit model, ii) All equations include a set of dummy variables indicating sector of activity and current legal status, iii) Robust standard errors clustered at country-sector level, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

least in terms of incorporating women in the productive area—could promote better innovative performance within companies. More research is needed to strengthen this finding and policy recommendation.

The second result for discussion is related to women's' contribution to productivity. We analyze the role of gender diversity within the firm (columns 1 and 2) separately from the role of greater participation of women in the firm (column 3). Regardless of the indicator used, greater gender diversity is not associated with higher levels of productivity. On the other hand, the evidence indicates that greater participation of women in the company, regardless of the area in which they work, is associated with better productive performance, even after controlling for innovation. In fact, the results show that for each percentage point increase in female participation in the company, the productivity of Caribbean companies increases by 4.5 percent. Said plainly, women's participation has a direct effect on firms´ productivity, and not via innovation activities or outputs.

Contrary to our expectations and to some of the received literature, gender diversity

TABLE 8 ● PRODUCTIVITY EQUATION: FEMALE CONTRIBUTION

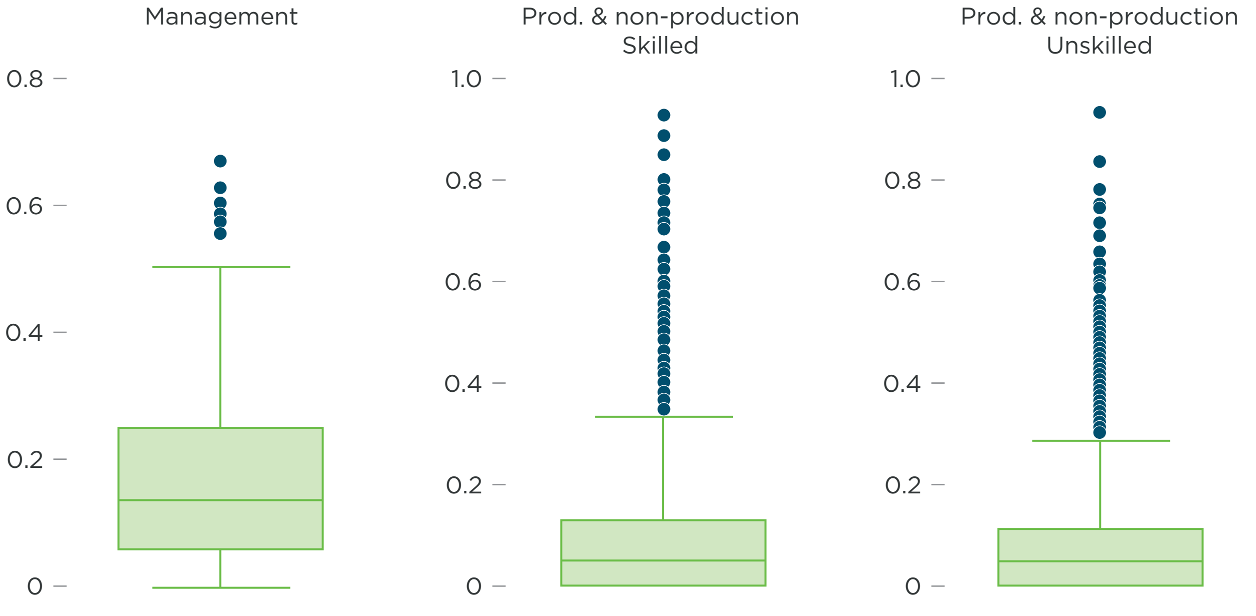
	Gross value added by FT employees (in ln)			
	I	II	III	IV
Size (FT employee, ln)	0.088**	0.079**	0.087**	0.086**
	(0.040)	(0.038)	(0.037)	(0.033)
K/L ratio (in ln)	0.095***	0.094***	0.095***	0.095***
	(0.013)	(0.012)	(0.013)	(0.012)
Years since begin operations	-0.000	-0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
P(tech inno=1 and non-tech inno=1)	0.722**	0.646**	0.731***	0.709***
	(0.368)	(0.301)	(0.282)	(0.252)
P(tech inno=1 and non-tech inno=0)	-0.042	0.050	-0.053	-0.087
	(0.372)	(0.310)	(0.396)	(0.252)
P(tech inno=0 and non-tech inno=1)	0.091	0.328	0.008	-0.012
	(1.007)	(0.927)	(1.281)	(1.057)
Gender disp.: standard deviation index		0.001		
		(0.002)		
Gender disp.: coefficient of variation			-0.041	
			(0.055)	
Gender disp.: female participation				0.177*
				(0.100)
Constant	12.496***	12.506***	12.549***	12.494***
	(0.284)	(0.224)	(0.249)	(0.275)
Observations	1,583	1,583	1,583	1,583
R-squared	0.835	0.835	0.835	0.835

Source: Authors' elaboration based on IFPG (2021).
Notes: i) All parameters were estimated using OLS, ii) All equations include sector and size fixed effects, iii) Bootstrapped standard errors in parentheses, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

within the firm does not imply higher productivity levels at the firm level. The answer seems to lie in the characteristics of women's positioning in the Caribbean labor market, and in particular, their distribution within the different areas of the firm. In exploring gender diversity, the IPFG dataset enabled us to divide the overall workforce into i) skilled production and non-production workers, ii) unskilled production and non-production workers, and iii) management workers.

Figure 1 illustrates the horizontal segregation that characterizes women's positioning in the labor market: there is hardly any participation in the productive areas, disregarding the skill level, of the company, and participation is concentrated in the management area. Women occupy positions linked to employee management, direction, strategy, improvement, and growth of the company, but not in the production process, sales, or administrative tasks.

FIGURE 1 ● FEMALE PARTICIPATION



Source: Authors' elaboration based on IPFG (2021).

CDM Model: Impact of COVID-19 on Female Contribution to Productivity

Even when IFPG was conducted in the wake of the pandemic, it included several questions focused on the respondents´ expectations relating to key variables, such as employment, sales, and firm gender composition. In this section, we exploit that information to compare an already real scenario with a projected scenario.

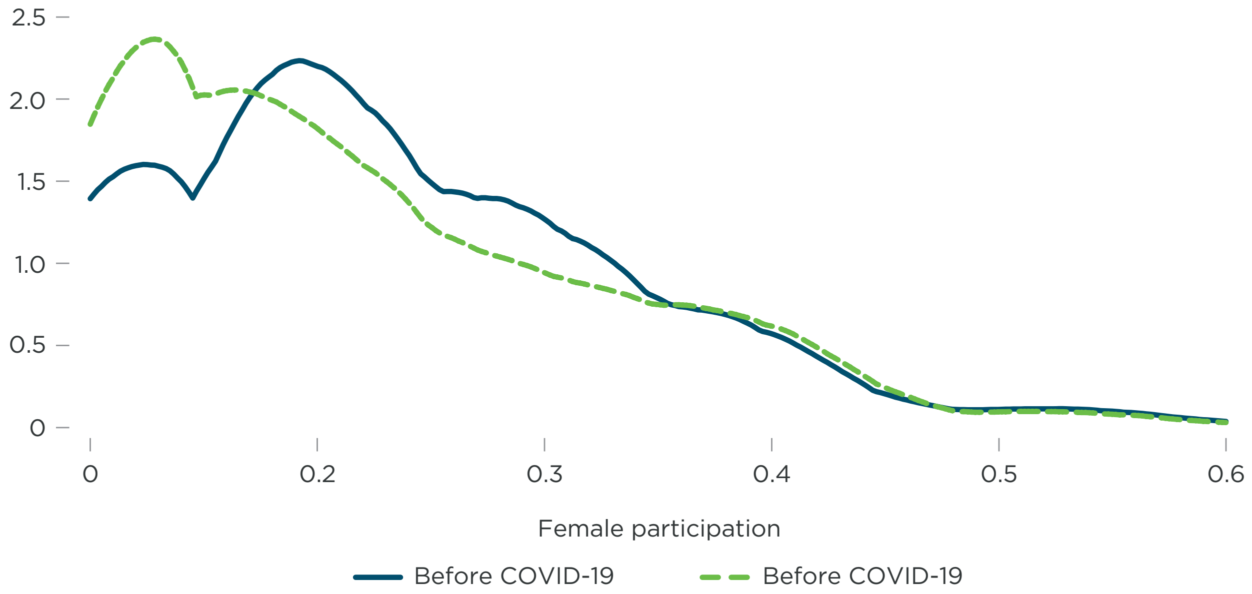
As has been previously established, female participation has a positive direct effect on a firm's productivity. Hence, in line with the gloomy predictions of the pandemic having a disproportionate effect on female employment, it is worth analyzing what firms were anticipating in terms of female employment and what might be the overall productivity effects of such a scenario. Figure 2 and Table 9 illustrate the expectations regarding female participation in overall employment.

Even when most of the firms did not expect major changes in their overall employment levels (Table 11 of the annex), most of the sectors (see Table 9 below) anticipated a reduction in female participation which suggests that, despite the sign and/or magnitude of the overall employment adjustment, this is more acute in the case of women.[9]

Table 10 presents the results of the Productivity equation for the different innovation outputs for the past scenario, as compared to the expected one. The scenario shaped by the pandemic shows that size and capital–labor ratios are the main factors determining firms' productivity levels. Similarly, combining different innovation types has a positive effect on productivity. Interestingly, female participation is expected to no longer have a positive effect on productivity. Although there are no clear explanations, we might assume that there is a threshold effect for where female participation has a positive effect in terms of productivity.

[9] The exception is in construction here, and given the role played by women, it is explained by a more important expectation of reducing the number of employees devoted to the actual construction tasks and maintaining a similar administrative structure.

FIGURE 2 ● EXPECTED IMPACT OF THE COVID-19 PANDEMIC ON FEMALE PARTICIPATION



Source: Authors' elaboration based on IPFG (2021).

TABLE 9 ● EXPECTED IMPACT OF THE COVID-19 PANDEMIC ON FEMALE PARTICIPATION

	N	mean	sd	min	max
			Agriculture, mining, and quarrying		
Female participation	24	18.6%	19.8%	0.0%	72.7%
Female participation expected after COVID-19	24	17.8%	20.3%	0.0%	63.2%
			Manufacturing		
Female participation	690	23.9%	20.0%	0.0%	96.0%
Female participation expected after COVID-19	690	21.1%	19.8%	0.0%	96.0%
			Construction		
Female participation	95	20.9%	14.5%	0.0%	60.0%
Female participation expected after COVID-19	95	22.0%	17.4%	0.0%	66.8%
			Retail and wholesale		
Female participation	350	28.6%	21.1%	0.0%	100.0%
Female participation expected after COVID-19	350	24.7%	21.3%	0.0%	92.5%
			Services		
Female participation	487	30.1%	20.7%	0.0%	100.0%
Female participation expected after COVID-19	487	27.7%	22.1%	0.0%	100.0%
			Other		
Female participation	7	36.4%	13.0%	20.0%	50.0%
Female participation expected after COVID-19	7	31.3%	17.8%	6.8%	50.0%

Source: Authors' elaboration based on IFPG (2021).

TABLE 10 ● PRODUCTIVITY EQUATION: FEMALE CONTRIBUTION EXPECTED AFTER COVID-19

	Gross value added by FT employees (in ln)		
	I	II	III
Size (FT employee, ln)	0.086**	0.088**	
	(0.035)	(0.035)	
Size (expected by COVID, FT employee, ln)			0.105***
			(0.037)
K/L ratio (in ln)	0.095***	0.095***	
	(0.013)	(0.016)	
K/L (expected by COVID, in ln)			0.089***
			(0.012)
Years since begin operations	0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
P(tech inno=1 and non-tech inno=1)	0.709*	0.723**	0.656*
	(0.379)	(0.284)	(0.362)
P(tech inno=1 and non-tech inno=0)	-0.087	-0.037	-0.062
	(0.366)	(0.290)	(0.292)
P(tech inno=0 and non-tech inno=1)	-0.012	0.095	0.068
	(0.910)	(0.819)	(1.318)
Female participation	**0.177***		
	(0.094)		
Female participation (expected by COVID)		**-0.013**	**-0.009**
		(0.094)	**(0.095)**
Constant	12.494***	12.497***	12.539***
	(0.237)	(0.266)	(0.269)
Observations	1,583	1,583	1,583
R-squared	0.835	0.835	0.835

Source: Authors' elaboration based on IFPG (2021).
Notes: i) All parameters were estimated using OLS, ii) All equations include sector and size fixed effects, iii) Bootstrapped standard errors in parentheses, iv) Symbols ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

6 Conclusions and Policy Recommendations

Research on the impact of women's participation on firm performance and innovation has so far produced mixed results. At the same time, even when the literature highlights the importance of diversity across the firms as a driver of innovation and productivity, there is a dearth of evidence for Latin America in general, and the Caribbean in particular. To date, the evidence for Latin American countries suggests that firms with a larger share of women in the knowledge creation and innovation process might increase their innovative behavior and, consequently, may exhibit greater labor productivity.

The presence of women in firms becomes an even more interesting topic in a context in which evidence around the world suggests that women's economic outcomes related to income and jobs could be more negatively affected by the pandemic than those of men. Taking this into account, we aim to fill this gap by exploiting the innovation, firm performance, and gender firm-level dataset for the Caribbean (IFPG, 2021), and adapt the Crepón, Duguet, and Mairesse model (1998) to include, in particular, the gender dimension, in a spirit similar to the approach pursued by Gallego and Gutierrez (2018) in order to account for how women's presence in different roles at the firm level impacts productivity. We also extend the approach to provide a comparison of the pandemic's potential effects on productivity, by analyzing the pandemic's expected effects on sales, revenues, and productivity in the Caribbean.

The baseline CDM provides similar results to those found vis-a-vis other countries in the region. Interestingly, productivity seems to be only positively affected by innovation when firms manage to effectively combine technological and non-technological innovation, thereby proving their complementary effect. In what regards women's ownership, our results show that firm ownership has no effect upon the likelihood of obtaining innovation outputs after controlling for the typically exploited variables.

Nevertheless, the composition of the personnel does have an interesting effect. Although—and in contrast to the received literature in the region—diversity has no effect, probably due to low levels of variability within the firm, we found that higher shares of women do have a direct effect on productivity levels that affect the firm's performance (and not via the innovation mechanisms).

In the wake of the pandemic, firms were not anticipating massive reductions in their personnel. However, the reductions were aimed at reducing the share of female participation. Our estimates found that these lower levels of female participation were likely to reduce the productivity effect due to female participation. This suggests that there is a minimum threshold in female participation to generate a positive effect on productivity. Hence, it seems that policy should focus specifically in protecting female jobs, particularly in the wake of dramatic shocks affecting revenues and/or employment.

Evidence provided herein justifies the implementation of policies to facilitate the hiring of women. Promoting greater female participation in the labor force, particularly in those areas that are currently male dominated, is not only justified in terms of equity but also in terms of the development of the Caribbean, given that gender diversity boosts innovation and productivity.

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Annex 1: Expected Impact of COVID-19

FIGURE A1 ● EXPECTED IMPACT OF THE COVID-19 PANDEMIC ON SALES, EMPLOYMENT, AND WAGES

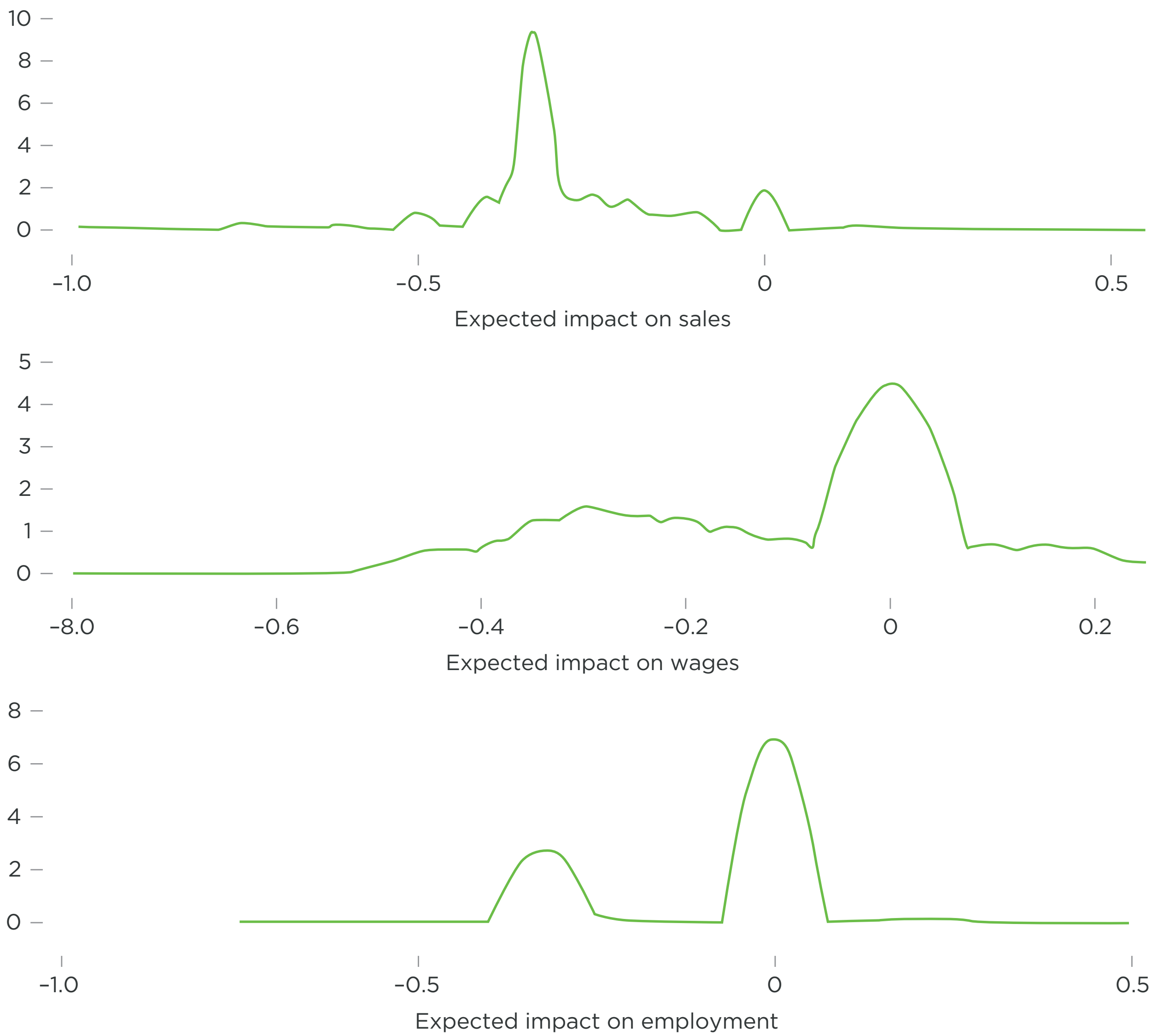

TABLE A1 ● EXPECTED IMPACT OF COVID-19 BY SECTOR

	N	mean	sd	min	max
			Agriculture, mining, and quarrying		
Expected impact on number of employees	23	0.13	0.21	0.00	0.44
Expected impact on wages	23	−0.09	0.17	−0.60	0.15
Expected impact on sales	23	−0.28	0.18	−0.60	0.15
			Manufacturing		
Expected impact on number of employees	680	0.11	0.21	−0.50	0.50
Expected impact on wages	680	−0.11	0.17	−0.60	0.25
Expected impact on sales	680	−0.28	0.15	−0.95	0.55
			Electricity, gas, and water		
Expected impact on number of employees	5	0.00	0.00	0.00	0.00
Expected impact on wages	5	0.04	0.09	0.00	0.20
Expected impact on sales	5	−0.14	0.18	−0.35	0.11
			Construction		
Expected impact on number of employees	105	0.10	0.27	−0.75	0.44
Expected impact on wages	105	−0.08	0.15	−0.45	0.20
Expected impact on sales	105	−0.27	0.14	−0.60	0.11
			Retail and wholesale		
Expected impact on number of employees	353	0.05	0.22	−0.75	0.50
Expected impact on wages	353	−0.09	0.18	−0.45	0.25
Expected impact on sales	353	−0.27	0.14	−0.70	0.30
			Services		
Expected impact on number of employees	486	0.06	0.24	−0.70	0.44
Expected impact on wages	486	−0.10	0.17	−0.80	0.20
Expected impact on sales	486	−0.29	0.20	−0.80	0.50
			Other		
Expected impact on number of employees	7	−0.04	0.09	−0.25	0.00
Expected impact on wages	7	−0.04	0.06	−0.15	0.00
Expected impact on sales	7	−0.24	0.16	−0.50	−0.10

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