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Article

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Impact of covid-19 on labor force participation in Brazil

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Abstract: This study aims to analyze the impact of Covid-19 on the female's labor force participation (LFP) probability in Brazil in 2020. We found through the probit model that females are about 7 percentage points less likely to participate in the labor force than males. Covid-19 and layoffs decrease by about 7 and 30 percentage points the women's LFP probability, respectively. An additional year of schooling increases female's LFP probability by 14 percentage points. These results are statistically significant at 1%. However, Covid-19-gender interaction term coefficient is not significant. We suggest a rich agenda for women's jobs opportunities in developing countries.

Subjects: Economics and Development; Labour Economics; Development Economics

Keywords: economic impact of Covid-19; gender gap; labor force participation; labor market; Brazilian economy

JEL Codes: C38; D13; E29; O12

1. Introduction

It is well known that female labor force participation (LFP) is lower than that of males (Fernández, 2013). That also holds particularly in Brazil. For example, Blau and Kahn (2013) show that the females' participation in the U.S labor force in 2010 was about 75% against about 67% of other countries. The females' LFP in Brazil in 2020 was about 43%. Why do females participate less in the labor market than males, especially when facing an economic crisis? The prevailing literature shows that, as some sectors, such as services and rentals sectors, are female-employment intensive, an economic crisis that disproportionately reduces employment in these sectors tends to impact the females' LFP negatively and increases the gender gap in employment (Farré et al., 2020). Likewise, scholars also argue that the females' LFP is lower than their male counterparts because they may spend more time with home tasks than males (Gallen, 2018). Thus, the extra care responsibilities arising from the closure of schools due to the Covid-19 pandemic may fall excessively on working mothers than on working fathers (Alon et al., 2020). This paper aims to provide micro-level evidence of Covid-19 impacts on gender gap LFP probability in Brazil.

There is a growing literature on the causes of gender differential in economic outcomes. Past studies have documented that there is gender gap in outcomes such as women wages (Blau & Kahn, 2017; Mahajan, 2017), competition bias (Lowes, 2021), labor force participation (Genre et al., 2010; Grigoli et al., 2018; Juhn & Potter, 2006), and policies (Murtin et al., 2014). Recently, economist have shown that economics crisis can also explain some gaps in outcomes across gender (Alon et al., 2020; Davis & von Wachter, 2011; Stefania, 2019). However, there is no study carried out for Brazil aiming at analyzing the impact of Covid-19 on LFP probability across gender.

We used data from Covid-19 National Household Sample Survey in Brazil (Pnad-Covid19). Although Covid-19 is present worldwide, Brazil has one of the highest incidence rates of Covid-19 diseases per inhabitant. The first case of the SARS Covid-19 virus was registered on 26 February 2020, and the country currently accumulates more than 33 million cases and about 677 thousand deaths (World Health Organization, WHO, 2020). As a result, Brazil has respectively established itself in third and second place among the countries with the most cases and deaths by Covid-19. Vaccines against the Covid-19 virus started on 17 January 2021, and currently about 79% and 45% of the population have already taken the first and second doses of the vaccine, respectively (Saude, 2022).

Although the number of accumulated cases of Covid-19 is higher in states such as São Paulo and Minas Gerais, the proportion of deaths from Covid-19 (either as a proportion of accumulated cases or of the total population) is higher in poor states, such as Amazonas and Maranhao.

Kapitsinis (2021) conducted a cross-country study to explain the causes of Covid-19. For Brazil, two factors may explain these results, the pre-pandemic health policy, and the local and federal governments mitigating actions during the pandemic. First, except for Rio de Janeiro, states with a higher fatality rate (the number of deaths divided by the number of cases in absolute value) of Covid-19 generally have lower per capita income and a historically higher mortality rate than states with a higher fatality rate. Access to the health system in poor states is usually through the *Sistema Único de Saúde* (SUS); however, the precariousness of the hospital infrastructure and the shortage of doctors is still evident. Although actions have been taken, such as the *Programa Mais Médicos* (see http://maismedicos.gov.br/) to alleviate the health system crisis associated with the lack of professionals, many severe restrictions still exist. Thus, the economic condition of the population combined with the provision of health services made the population of poor Brazilian states significantly weakened during the pandemic.

The second element that explains the high rate of deaths from Covid-19 in Brazil concerns the lack of coordination of mitigating measures by state and federal governments at the beginning of the pandemic. Brazil is one of the last countries to recognize this disease as a pandemic; consequently, one of the last countries to take lockdown measures (the first was on 20 April 2020), and the mandatory use of masks was up to state governments. In addition, given that states had the autonomy to acquire vaccines or finance research for their discovery, wealthier states such as São Paulo were ahead of many other states in acquiring doses through international partnerships.

One of the striking features of the Brazilian labor market is the existence of gender inequality traps in several dimensions (see, for example, Martins, 2015). It is expected these inequalities to be greater in times of crisis. Brazil has high inequality in access to employment by socioeconomic cohort. Therefore, it is a natural place to study the effect of Covid-19 on gender economic outcomes.

We use the probit model to estimate the LFP probability where individual labor supply decision is conditional on wealth, education level, and specific factors such as age, level of local development, time off the job market, Etc. We find several key results. In line with a large literature that documents that females participate less in the labor force than males, particularly during the economic crisis (Alon et al., 2020; Stefania, 2019), we find that females are about 7 percentage points less likely to choose to participate in the labor force than males during Covid-19 crisis in Brazil, despite being in same living arrangement. An additional year of schooling increases the females' LFP probability by 14 percentage points. With Covid-19 cases in a family, the females' LFP probability decreases by about three percentage points than males' one. Moreover, females are less likely to participate in the workforce due to layoffs associated with Covid-19. These results are statistically significant at conventional levels.

This paper is structured as follows. Section 2 provides a brief literature review. Section 3 presents the empirical strategies. Section 4 analyzes the results. Section 4 concludes.

2. Brief review of related empirical literature

An extensive literature has documented that female labor participation is affected by economic crisis (e.g., Davis & von Wachter, 2011; Doepke et al., 2015; Doepke & Kindermann, 2019; Ekberg et al., 2013; Yokoyama et al., 2021). For instance, Albanesi (2019) finds evidence that growing female participation may be responsible for a significant fraction of the reduced cyclicality of aggregate hours during great moderation. Hyland et al. (2020) use the World Bank's newly Women, Business and Law database to show how laws affect females' opportunities to participate in the workforce across countries and suggest that the governments should ensure females job retention during an economic crisis as it takes significant time to reintegrate females into the labor force once they are out of work.

Interest in LFP during the economic crisis has grown due to work by Davis and von Wachter (2011), who studied the effect of the business cycle on gender LFP in the United States. Their paper makes a significant contribution by demonstrating that females participate less than males because of the product's shock. They argue that differences in sectorial products impact females and males differently. This result has been replicated by Alon et al. (2020) to analyze the impact of Covid-19 across gender in the United States.

Since the work of Davis and von Wachter (2011), many empirical studies have measured LFP to document how income shock impacts various gender outcomes. Studies emerge on the economic impacts of Covid-19, particularly in developed countries. For example, Farré et al. (2020) studied the effect of lockdown on gender inequality in paid and unpaid jobs in Spain. They found evidence that females were slightly more likely to lose their job than males during the lockdown, and those who remained employed were more likely to work from home. In turn, Sevilla and Smith (2020) find evidence that there is a gender childcare gap across UK families, as females have spent most of their working hours with childcare.

We can also find cross-country evidence of the impact of Covid-19 on gender inequality. For example, Adams-Prassl et al. (2020), in their study for Germany, the UK, and US., analyzed the reduction in job earnings of different workers due to decreased work hours and job losses. As they show the impacts of the Covid-19 crisis to be large and unequal within and across countries, they prove that females and less educated workers are more affected by the crisis.

This paper builds on and contributes to these past studies in several ways. First, to test whether economic crisis affects female's LFP, we use data before and during the Covid-19 crisis. Thus, we can analyze LFP across gender due to the pandemic or other factors.

Second, as we take one of the most complete and structured household surveys on Covid-19, this study is a quasi-experiment of the Covid-19 impact at household level in middle-income countries. Finally, as mentioned, no studies on the gender effects of Covid-19 exist in the case of Brazil. These findings will be significant for policy to mitigate the impacts of the Covid-19 crisis on females in developing countries.

3. Empirical strategy

This section presents the econometric model and data used for estimation. We adopt three strategies to examine the impacts of Covid-19 on gender labor force participation probability. We start by specifying the following previous studies (e.g., Baker et al., 2022; Lowes, 2021) parsimonious probit:

$$lfp_{i,t} = \alpha_0 + \gamma_1 female_{i,t} + X_{it}\beta + \varepsilon_{it} \tag{1}$$

where $LP_{i,t}$ is an indicator equal to 1 if individual i at time t participates into labor force, and 0 otherwise, and X_{it} is a vector of covariates for individual i (age, age squared, years of education,

time out of the job market, etc.), which we set following Mincerian specification (e.g., Armand et al., 2020; Ashraf et al., 2020).

Let X_{it} containing individual-specific covariates, such as years of education and age, as well as the time (associated to layoffs) out of work (i.e., $X_{it}\beta = \beta_1 educ_{it} + \beta_2 age_{it} + \beta_3 age2_{it} + \beta_4 T_t$), we expect $lfp_t{}'$ to be positive for each additional year of education, and having a non-monotonic relationship with individual age, indicating that the LFP probability is positive with age, but then it declines as the individual gets older. Furthermore, the individual loses valuable experience as he or she is out for a long period in a skill related role. The individual therefore must find it difficult to be hired again as there are infinite workers with similar profiles. As a result, $\beta_1, \beta_2 > 0$, while $\beta_3, \beta_4 < 0$.

Second, we estimate the impacts of Covid-19 as:

$$lfp_{i,c,t} = \alpha_0 + \gamma_1 female_{i,c,t} + \gamma_2 Covid_{i,c,t} + X_{it}\beta + \varepsilon_{i,c,t} \tag{2}$$

where $Covid_{i,c,t}$ is an indicator equal to 1 if individual *i* at time t claims having income negatively impacted by Covid-19, and 0 otherwise. This is a proxy for exogenous income shock capturing the economic crisis effect on gender (Mohapatra, 2021). The rationale is that the economic crisis, such as that caused by Covid-19, affects gender outcomes because it impacts income (Cerra & Saxena, 2008).

Finally, we include the interaction term Covid-19 and gender estimating the following equation:

$$lfp_{i,c,t} = \alpha_0 + \gamma_1 female_{i,c,t} + \gamma_2 Covid_{i,c,t} + \gamma_3 Covid * female_{i,c,t} + X_{it}\beta + \varepsilon_{i,c,t} \tag{3}$$

where i contains Covid and female interaction term.

The order condition for convex functions yields: $\frac{\partial lfp_t}{\partial female_t}, \frac{\partial lfp_t}{\partial Covid_t}, \frac{\partial lfp_t}{Covid * female_t} < 0$, *i at time t*, and stochastic form results that $\gamma_1 < 0$, which suggests that female may participate worse on labor force, $\gamma_2 < 0$, whereby Covid-19 has negative impact on the LFP probability, $\gamma_3 < 0$, whereby female and Covid-19 interaction term impact negatively LFP probability, respectively.

3.1. Data and source

We use the Pnad-Covid19 database of the Brazilian Institute of Geography and Statistics (IBGE), round November 2020. As this is a complete survey on the household situation during the Covid-19 crisis, we focus on the labor market module. We have matched this module with the IBGE's pre-Covid-19 household survey (2019 Pnad continuous) to monitor the individual who left the labor market due to the pandemic and who left or returned to the labor market for some different reason.

The combination of high-frequency and disaggregated data offers considerable advantages: We can estimate the impacts of Covid-19 on LFP probability far more precisely and stratify (by age, gender, schooling, health, Etc.) and get rich specifications allowing for heterogeneity in Covid-19 crisis effects across critical dimensions, such as LFP and nonlinearities. We can also monitor each situation that may lead an individual to drop out of the labor market, except for the Covid-19 pandemic.

Table 1 summarizes the descriptive statistics of the variables by emerged databases and by Pnad-Covid19 and Pnad continuous separately. Individuals are young aged. Males are under 36, and females are under 38 ages. The proportion of employed males is more significant than that of employed females; this difference is more significant in the Pnad-Covid19 database, where we observe 60.57% of employed males against 39.43% of employed females. In general, females are less skilled and earn less than males.

Table 1. Descriptive statistics

Matched databases

Variable	Observations	Mean	Std. Deviation	Min	Max.	Mean Men	Mean Women
lfp	349,306	0.088	0.284	0	1	0.084	0.093
Age	309,411	36.6419	21.709	0	111	35.602	37.602
Employed	251,711	0.382	0.486	0	1	0.480*	0.294*
Weekly income	106,036	2220.478	2384.814	120	50,000	2231.27	2211.30
Years education	309,411	10.988	4.217	0	18	10.813	11.149
Pnad-Covid19							
Age	299,718	38.2895	17.269	1	89	39.234	37.533
Employed	198,523	0.2428	0.42916	0	1	0.307*	0.190*
Weekly income	91,200	2613.639	2884.999	500	15,000	3117.727	2187.102
Years education	299,718	11.858	3.2661	0	18	11.359	12.257
Pnad Continuous							
Age	349,306	36.21276	21.9206	0	111	35.238	37.139
Employed	287,817	0.383570	0.486256	0	1	0.481*	0.499*
Weekly income	188,821	2224.090	2379.402	120	50,000	2230.987	2218.081
Years education	349,306	10.915	4.2612	0	18	10.761	11.060

Source: The authors. Pnad-Covid19 HS, round November 2020, Pnad continuous, round November 2019.

Note: *Lfp* is an index equal to 1 if individual left labor market but return, and 0 otherwise. It is an indicator of the labor force participation probability. *Age* is the individual current age; *Employed* is the total number of individuals who have a job in the week prior the interview. Weekly income is the income obtained from the job the individual held in the week prior the interview; *Years Education* is the number of years of education the individual has completed. *Emerged database participants: 49.50% employed males against 40.5% employed females. Pnad-Covid19: 56.30% employed males against 43.70% of employed females; Pnad-Continuous: 60.57% employed males against 39.43% of employed females.

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4. Results

We present the results in the data columns regarding the effect of gender, gender, and Covid-19, and the interaction between gender and Covid-19 on the LFP probability. We gradually add more control variables as we move through the columns. It is worth noting that, since we have competing models, diagnostic test was required to choose the one that best fits the data. Different tests can be applied to select the model (Hansen & Yu, 2001); however, we use the Bayesian Information Criterion (BIC), which is the most recommended for handheld models (Leeb, 2009).[1] We found that models 1–3 are more adherent to the data.[2]

Table 2 reports the baseline for probit regressions. First, for equation 1, females are about seven percentage points less likely to participate in the labor market than men in Brazil, holding other factors at their business-as-usual levels. This result is statistically significant at 5% for an asymptotic sample.

As this find aligns with the statistics on the labor market in Brazil, it is also consistent with the previous works on gender impacting economic outcomes (e.g., Alessandra & Veldkamp, 2011; Azmat & Ferrer, 2017; Babcock et al., 2017; Ou & Pan, 2021). For example, Lowes (2021) finds evidence that gender difference matters for competition outcomes. Her generous findings are 21 percentage points against our conservative seven percentage points.

Second, in regression with females and education being explanatory variables, the effect of gender difference on LFP probability decreases and reaches about 13 percentage points in favor of males. In comparison, an additional year of schooling increases females' LFP probability by 14 percentage points. This result is due to the underlying effects of the return of education on gender outcomes. Since the seminal work by Becker (1962), which showed the importance of human capital investment, several subsequent studies have provided evidence that education matters (e.g., Cameron & Taber, 2004; Carneiro et al., 2010). In work on grade choice, Heckman et al. (2016) show evidence that ability bias is a significant component of observed educational differentials, which reflect in the skill differentials across individuals. Skills are essential for plotting an individual's economic outcomes over the life cycle, including which profession to choose and the possible gains. We observe that these gains increase females' participation probability in the labor market. This finding is statistically significant at the usual levels.

Table 2. Probit regression by gender

Variable	(1)	(2)	(3)	(4)
Female	−0.073 (0.031)**	−0.1284 (0.032)***	−0.127 (0.032)***	−0.154 (0.104)
Years education		0.141 (0.0083)***	0.140 (0.008)***	0.1407 (0.008)***
Covid			−0.027 (0.010)***	−0.0364 (0.032)
Covidfemale				0.0056 (0.020)
Constant	−0.813 (0.051)***	−1.304 (0.060)***	−1.163 (0.079)***	−1.121 (0.169)***
Observations	349,306	349,306	349,306	349,306
Prob > chi2	0.00	0.00	0.00	0.00
BIC	234,104.426	256,211.244	258,480.125	286,930.142

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors. Matched databases.

Third, we add the effect of Covid-19 on the gender LFP outcomes. The estimated parameter for Covid-19 is negative and statistically significant even at 1%. It indicates that, with a reported case of Covid-19 symptoms in a living arrangement, females are about three percentage points less likely to participate in the labor market than males. As a result, the economic crisis affects household labor supply decisions in favor of males.

Finally, in specification 3, we did not find any statistically relevant results when we added gender and the Covid-19 interaction term. In this case, only an additional year of education has a positive and statistically significant impact on LFP probability.

The results of regressions with age and age squared as explanatory variables are reported in Table 3. In this specification, we observe that the LFP probability increases with age and then decreases, which is consistent with the fact that the individual without job stability may find it more challenging to fit into the job market as she or he gets older. The effect of age on the LFP probability is positive and statistically significant at conventional levels for Equations 1 and 3 specifications. In Equation 2, however, the quadratic term of age is negative as expected but not statistically significant.

The essential difference between estimates reported in Table 3 concerning the baseline results in Table 2 is that the magnitudes of the coefficients are now more significant. We observe that females are about 11 percentage points less likely to participate in the labor market than males, ceteris paribus (Column 1), and about 13 percentage points in the rest of the specifications (Columns 2 to 4).

Instead of age, we estimate equations 1–3 using the individual's self-reported result about the layoffs period, which may reflect the loss of a valuable experience (Table 4). We call it the time variable. The time variable contributes to reducing LFP probability. As Covid-19 removes more females than males from work, as discussed in section 2, females' LFPs may be negatively affected by the loss of experience associated with the amount of time they are out of the workforce. This result of time on gender LFP, also significant even at 1%, ranges from 36 to 32 percentage points in favor of males.

4.1. Extension and discussions

An interesting point in the analysis of gender outcomes is that many of the gender gap explaining factors may suffer from mixed effects. For instance, it is commonly argued that error selection bias

Table 3. Probit regression by gender and age

Variable	(1)	(2)	(3)	(4)
Female	− 0.1107 (0.0340)**	−0.1364 (0.03418)***	−0.1352 (0.0342)***	−0.16435 (0.1107)
Years education		0.07158 (0.0097)***	0.0710 (0.009)***	0.0710 (0.000)***
Covid			−0.0373 (0.010)***	−0.0464 (0.034)
Covidfemale				0.00591 (0.021)
Age	−0.110 (0.005)***	0.1164 (0.006)***	0.1160 (0.005)***	0.1160 (0.005)***
Age2	−0.0014 (0.0007)***	−.00131 (0.0007)***	−0.0013 (0.0007)	−0.0013 (0.0007)***
Constant	−3.044 (0.113)***	−3.2109 (0.1200)***	−3.03 (0.131)***	−2.991 (0.206)***
Observations	349,306	349,306	349,306	349,306
Prob > chi2	0.00	0.00	0.00	0.00

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors. Matched databases.

Table 4. Probit regression by gender and time

Variable	(1)	(2)	(3)	(4)
Female	0.0169 (0.0335)	−0.055 (0.033)*	−0.055 0.033)***	−0.0780 (0.1081)
Years education		0.08050 (0.009)***	0.079 (0.009)***	0.0798 (0.009)***
Covid			−0.0215 (0.0103)***	−0.0285 (0.0334)
Covidfemale				0.00461 (0.02078)
Time	−0.3676 (0.0153)***	−0.322 (0.0162)***	−0.3219 (0.0162)***	−0.3219 (0.0162)***
Constant	0.28523 (0.070)***	−0.1269 (0.0863)	−0.022 (0.1000)***	0.0126 (0.1861)***
Observations	349,306	349,306	349,306	349,306
Prob > chi2	0.00	0.00	0.00	0.00

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors. Matched databases.

can eclipse inference (see, Heckman, 1979). It might be revealed much more than expected when data are detached in the group instead of in aggregate form (e.g., Jann, 2008) or when the structure of the error term is known. This extension is an attempt to cope with such concerns by presenting contrafactual estimations as a robustness check. We analyze results across gender using data before and after Covid-19. We made a slight modification to the model of equation 1.

Let

$$\int_0^1 lfp_1{}^M = \int_0^n \delta^M X_1{}^M + v_1{}^M \tag{4}$$

$$\int_0^1 lfp_2{}^F = \int_0^n \delta^F X_2{}^F + v_2{}^F \tag{5}$$

represent equations for group 1 of M males and for the group 2 of F females in discrete form, where lfp_i and X_i are defined as before; $\oint$ is an operator tracking variable values, whose lower and upper bounds are indicated by 0 and 1 for lfp_i, and 0 and n observations for X_i; and v_i is an error term. As $E(v_i) = 0$, if both lfp_i and X_i are differentiables, gender gap can be written, as follows:

$$\widehat{lfp_i^G} = \theta_i f^G\left(\widehat{X_i^G}\right) \tag{6}$$

where $\widehat{lfp_i}$ is the difference in the LFP across males and females, i.e., in terms of group 2; G = f,m indexes females and males, respectively; θ_i are transformations of δ_i; $\widehat{X}_i$ is the average difference of the control variables for the two groups. We stochastically represent Equation 6 as:

$$\widehat{lfp_{it}} = \theta_i f(Education, Covid, \gamma_c, \vartheta_a) + w_{it} \tag{7}$$

where γ_c is the fixed effects controlling for local time invariant characteristics, such as the economic development level. We treat the development of the country in terms of observed income gains. That is justified since income has been pointed out as a necessary condition of individual freedom of choice and may positively impact women's economic outcomes. In addition,

we can observe the different scales of gains in Pnad-Covid19, which inform the living standard of households in Brazil. We take the upper and lower gauge to refer to the term developing and developed hereinafter, respectively. ϑ_a is the time dummy controlling for the time period an individual has been absent from labor force, and w_{it} is the transformation of v_i.

The gender LFP probability differences explained by determinants of labor force participation (worker's education, Covid-19 cases, layoffs time) are reported in Table 5. Columns from 1 to 3 are estimates only with Pnad-Covid19 data and from 3 to 6 with pre-Covid data. In each column, "overall" informs about the difference in the results across males and females.We start the analysis with Covid-19 data. In Columns 1 and 2, we can observe that schooling, Covid-19, and layoffs are essential to explain the LFP probability of females and men. The labor force participation probability increases with additional years of schooling but decreases with reported cases of Covid-19 and time off work. This relationship is statistically significant at conventional levels for both males and females. The LFP gap for the group of males increases by 0.32 percentage points for each additional year of schooling and decreases by −0.09 and −0.43 percentage points for revealed cases of Covid-19 and additional years off from the labor force, respectively. That value is even more expressive for females, with 0.32 percentage points for additional years of schooling, −0.013 and −0.87 for revealed Covid-19 cases, and additional years out of the labor force, respectively.

The predicted probabilities are about eight percentage points for a group of males and about nine percentage points for a group of females, which results in a − 0.85 percentage points difference in the probability of participation across males and females. About 1.2 percentage points of gender difference is explained by the individuals' initial endowments, −0.13 percentage points for changes in the structure of labor participation, and −0.06 due to the interaction term.

Table 5. Gender difference in LFP probability

Variable	Pnad-19 data			Pre Covid Pnad continuous data		
	1	2	3	4	5	6
	Male	Female	Overall	Male	Female	Overall
Education	0.0032 (0.0001)***	0.0031 (0.0001)***		0.0035 (0.0001)***	0.0072 (0.001)***	
Covid-19	−0.0009 (0.0004)**	−0.0013 (0.0004)***		−0.0013 (0.0003)***	−0.0053 (0.004)**	
Time	−0.0428 (0.0006)***	−0.087 (0.0007)***		−0.0605 (0.0005)***	−0.102 (0.004)***	
Group 1			0.0844 (0.00067)***			0.086 (0.0004)***
Group2			0.0930 (0.00068)***			0.177 (0.004)***
Difference			−0.0085 (0.00096)***			−0.090 (0.004)***
Endowments			0.0122 (0.00032)***			−0.0058 (0.001)***
Coefficients			−0.0139 (0.00094)***			−0.086 (0.004)***
Interaction			−0.0068 (0.0023)***			0.0019 (0.0009)***
Constant	0.198 (0.003)***	0.372 (0.0041)***		0.2646 (0.0028)***	0.471 (0.023)***	
R-squared	0.030	0.080		0.0502	0.0937	
Observations	167,712	181,594	349,306	340,858	8,448	349,306

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors.

Using pre-Covid-19 data, we observe that the estimates of the LFP probability determinants are more intense than during the covid-19 period; they increase sensibly in size for variables with positive results and decrease more for variables with negative results. Moreover, Covid-19′s impact on gender results is also statistically significant, which suggests some robustness in the results of the previous subsection.

We have controlled by age and local development level (Table A1, Table C1 and Table D1 in Appendix). By age, we have found almost identical outcomes as before. Covid-19 generates a gender gap in labor force participation favoring males (Table A1). However, we did not find statistically significant coefficients in the context of poor parents (Table B1) but in the settings where parents gain an average income (Table C1).

Our results converge with emerging evidence on the impact of Covid-19 on gender outcomes. Farré et al. (2020) show that, even in temporary lockdown, females were more impacted than males in Spain regarding job losses. Sevilla and Smith (2020) find evidence for the U.K that the gender childcare gap raises in favor of males as females are working more at home than males with childcare during Covid-19. That implies that females may face challenges in integrating into the labor force after the pandemic as they have had less time to develop their skill sets than males.

This study also emphasizes local context when analyzing the impact of Covid-19 on gender LFP. This consideration is essential since there are fundamental differences in the gender gap across states in Brazil (Benigno et al., 2021). Even at national level, there are also differences of LFP across a group of workers (Firpo & Pieri, 2018). On the one hand, we found no evidence that the level of local development affects the gender LFP probability if families' earnings mimic the poverty condition. On the other one, when families earn an average income in the setting, the level of development matters.

Brazil is a middle-income country where there is a substantial gap in gender participation in the workforce (Firpo & Pieri, 2018). Moreover, females' employment in Brazil is commonly reported to be more intensive in occupations requiring less skill level, essentially in domestic and retail services. Codazzi et al. (2018) associate this characteristic of female LFP in Brazil with existing social norms, in which some occupations or professions are seen as essentially reserved for females. Such occupations are susceptible to economic shocks which negatively impact women's income (Mohapatra, 2021). The government responses to Covid-19 must consider the possibility of guaranteeing the maintenance of female employment through targeted policies for the female-employment intensive sector. Previous studies have been carried out for developing countries, which limits many comparisons in terms of development indicators. Moreover, past works have focused on countries with robust institutions to incentive females' labor force participation (e.g., Adams-Prassl et al., 2020; Sevilla & Smith, 2020).

However, our results have shown to be consistent, not only with studies focused on the impact of Covid-19 on gender outcomes (e.g., Adams-Prassl et al., 2020; Farré et al., 2020). We have converged with the broadest literature on gender inequality (e.g., Babcock et al., 2017; Ou & Pan, 2021), in which the difference in the observed outcomes is due to the model coefficients, individual attributes, and interaction terms. We have found that differences in the individuals' attributes implied different estimated results.

Thus, governments should promote the improvement of female attributes. Given the heterogeneity of Brazilian states in terms of economic structures (see, Benigno et al., 2021; Medeiros & Souza, 2015), policies and measures to reduce gender gap in LFP should be implemented locally in order to take into account geographic and state-specific effects. As mentioned earlier, the incidence of Covid-19 in terms of cases and deaths differs between states. It should be required a training program for females, but also direct incentives for continuity in the labor market in each

state and social setting. Incentives can be by deducting taxes as firms that each add or kill a female number above a given threshold, depending on the firm's capacity. Incentives can be based on tax deductions for companies that employ the number of women above a certain threshold, depending on the capacity of each organization. As women are also different in their demographic characteristics, mapping the poorest segment of the population will be essential to achieve the expected results. This could be done using, for example, information from government programs such *as Programa da Secretaria Nacional do Cadastro Único*, which identifies and characterizes low-income households in Brazil (Goverment, 2022),

5. Conclusions

This study is based on plentiful statistical data for the most recent course of household living standards and gender labor force participation before and after the Covid-19 pandemic in Brazil. It aims to analyze the significance of Covid-19 in the gender gap predicted labor force participation probability. We use a probit model to reinforce, with new evidence for a developing country, the empirical regularity that gender difference matters, education matters, and economic crisis.

Our results are robust and consistent with past works that analyze the impact of Covid-19 on gender outcomes in developed countries. We hope our findings will serve as the first step toward the discussion on the impact of Covid-19 on females' job opportunities in Brazil. We have shown that females participate less in the labor market than males because they are disadvantaged in many dimensions. The literacy rate of females is lower than that of males. These results suggest that it is necessary to have an agenda for females' employment that contains training programs so that females can cope with economic crises as men do. Since this suggests complementarity, rather than eviction across women and men LFP incentives, the long-term impact is strengthening the country's response to unexpected income shocks, such as the ones brought by the Covid-19 pandemic.

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Notes

1. We found the similar results applying AIC criteria.
2. We compared the statistics in the last column of Table 2 with the information in Table A1 in the Appendix.

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Appendix

Table A1. Diagnostic test using BIC criteria

Variable	All	Rural		Urban	
BIC	379,912.02	367,485.531	336,411.931	324,599.774	379,912.02

Source: The authors.

Table B1. LFP probability by gender and age

Variable	Pnad-Covid19 data			Pre Covid Pnad continuous data		
	1	2	3	4	5	6
	Male	Female	Overall	Male	Female	Overall
Education	0.0031 (0.0001)***	0.0030 (0.0001)***		0.0034 (0.0001)***	0.0070 (0.001)***	
Covid-19	−0.0010 (0.0004)**	−0.0013 (0.0004)***		−0.0014 (0.0003)***	−0.0054 (0.002)**	
Time	−0.0428 (0.0006)***	−0.0870 (0.0007)***		−0.0605 (0.0005)***	−0.102 (0.0039)***	
Group 1			0.085 (0.00067)***			0.087 (0.0004)***
Group2			0.093 (0.00068)***			0.179 (0.004)***
Difference			−0.0085 (0.00096)***			−0.0917 (0.004)***
Endowments			0.0125 (0.00032)***			−0.0060 (0.001)***
Coefficients			−0.0141 (0.00095)***			−0.087 (0.004)***
Interaction			−0.0069 (0.0024)***			0.0019 (0.0009)**
Constant	0.200 (0.003)***	0.373 (0.0042)***		0.266 (0.0028)***	0.4759 (0.023)***	
R-squared	0.029	0.079		0.0495	0.0919	
Observations	338,107	81,369	346,476	166,273	180,203	346,476

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors.

Table C1. LFP probability by gender and local development (low income)

Variable	Pnad-Covid19 data			Pre Covid Pnad continuous data		
	1	2	3	4	5	6
	Male	Female	Overall	Male	Female	Overall
Education	0.004 (0.003)	0.0052 (0.0001)		0.0053 (0.0032)	0.022 (0.017)	
Covid-19	−0.0015 (0.010)	−0.0091 (0.012)		−0.0090 (0.0083)	0.0378 (0.041)	
Time	−0.0384 (0.017)**	0.034 (0.026)		0.0034 (0.015)	−0.0934 (0.071)	
Group 1			0.1703 (0 .014)***			0.219 (0.011) ***
Group2			0.274 (0.017) ***			0.2325 (0.067)***
Difference			−0.103 (0.022)***			−0.0127 (0.068)
Endowments			−0.0111 (0.007)			0.0035 (0.022)
Coefficients			−0.107 (0.023)***			−0.0134 (0.068)
Interaction			0.014 (0.008)			−0.0027 (0.022)
Constant	0.253 (0.090)***	0.144 (0.131)		0.196 (0.077)**	0.110 (0.382)	
R-squared	0.0097	0.0045		0.0033	0.0484	
Observations	109,408	60,413	200,372	337,169	143,527	345,527

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors.

Table D1. LFP probability by gender and local development (average income)

Variable	Pnad-Covid19 data			Pre Covid Pnad continuous data		
	1	2	3	4	5	6
	Male	Female	Overall	Male	Female	Overall
Education	0.0034 (0.0001)***	0.0032 (0.0001)***		0.0036 (0.0001)***	0.0072 (0.001)***	
Covid-19	−0.0011 (0.0004)***	−0.00142 (0.0004)***		−0.0015 (0.0003)***	−0.0063 (0.002)***	
Time	−0.043 (0.0006)***	−0.088 (0.0007)***		−0.061 (0.0005)***	−0.1045 (0.003)***	
Group 1			0.084 (0 .006)***			0.086 (0.0004)***
Group2			0.092 (0.0006)***			0.176 (0.004) ***
Difference			−0.0080 (0.0009)***			−0.090 (0.004)
Endowments			0.0118 (0.0003)***			−0.0059 (0.001)
Coefficients			−0.013 (0.0006)***			−0.086 (0.004)
Interaction			−0.006 (0.0002)			0.0018 (0.0009)
Constant	0.200 (0.0038)***	0.375 (0.004) ***		0.267 (0.0028)***	0.484 (0.023) ***	
R-squared	0.0314	0.0827		0.0519	0.0967	
Observations	165,291	83,236	205,527	337,169	132,358	345,527

Source: PNAD-COVID19 HS, round May-November 2020. Authors' estimation in R. * p < 10, ** p < 5, *** and p < 1. () Standard errors.

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