Can Digitization Help Close the Gender Gap? An Examination of Brazil's Labor Market[*†]

(Preliminary - please do not circulate without permission)

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Abstract

What is the impact of ICT availability on gender in the labor market? Using high-frequency data from Brazil, we investigate the effect of fixed broadband on labor outcomes by using Covid-19 as the exogenous shock that found sticky ICT contracts in the short-run. We document that high-skilled women benefit more than men when ICT resources are in place through higher employment and lower unemployment levels, both in teleworkable and non-teleworkable positions. By classifying workers according to their potential to work-from-home (WFH), we identify that the impact is higher for this category of workers, with positive spillovers also generated for those who are not able to telework but live in connected municipalities. The outcomes of this paper emphasize the role of digitization as a potential instrument to reduce employment asymmetries between workers, including by narrowing the gender gap in the labor market.

Keywords: Information and Communication Technologies, fixed broadband, gender economics, labour market.

JEL Codes: J16, J21, J31,O33, O38.

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1 Introduction

Working from home (WFH) has become a common practice among multiple countries after the pandemic of Covid-19. In the United States, the proportion of employees who primarily worked from home went from 2.4% in 2010 (Mateyka et al. (2012)) to almost 59% nearly two years after the pandemic (Parker et al. (2022)). In Canada, the official statistics point out an increase in WFH practices from 7% to almost 40% between the 2016 Census and March 2020 (StatCan (2023))[1]. But one of the key pre-requisites for enabling telework is the readiness of the ICT infrastructure (OECD (2020b)), which is very unequal in the world.

Take Brazil, for example. At the onset of the pandemic of Covid-19, only about half of the country had a minimum coverage of high-speed internet, as measured by the number of contracts of fixed broadband per 100 people. In 2020, the country was a mirror of the world in terms of similar trajectories of expansion and density of contracts. Unsurprisingly, only 11% of the workforce was able to telework right after Covid-19 (IBGE (2020)), even if the potential to do so was estimated to be twice as much (Goes et al. (2020)).

With the exogenous shock of the pandemic and the isolation measures that were adopted to avoid the spread of the virus of Covid-19, an opportunity arises to answer how much internet resources can contribute to employment outcomes, including its role in closing or narrowing the gender gap. This is because contracts were not easily adjusted in the short run, for two primary reasons. First, the fixed broadband infrastructure (say, the arrival of cable or optic fibre close to where individuals live) cannot be installed overnight, particularly in developing countries. Second, new internet contracts imply changes in household budget constraints, which is harder to adjust during economic crises. In other words, no anticipatory behaviour was expected given the uncertainty of the aggregate shock of the pandemic (Imai and Kim (2019)).

Given this scenario, this work aims to answer the following research questions. First, does the availability of fixed broadband (or "high-speed internet") help protect workers from being fired[2]? Second, does it boost new hirings in connected municipalities compared to markets where the same resources are not available? Third, do internet resources affect wage levels, either upward or downward? Fourth, can we observe differences between men and women on the labour outcomes?

To conduct the analysis, we assemble a comprehensive panel at the municipality level of formally registered employees, and we merge it with granulated data on the availability of fixed broadband. By assumption, only those that had access to high-speed internet and occupied

[1] In this work, we use the terms work-from-home (WFH) and remote work interchangeably. Following the terminology of the International Labour Organisation (ILO) ILO (2020), telework is employed to denote workers that are doing some type of remote work using ICT resources.

[2] High-speed internet and fixed broadband are used interchangeably in this text (FCC, 2014).

positions that could be typically performed at home were able to smoothly transition from the workplace to their homes while performing their tasks. To identify the channels of the impact of internet access on the labor market, we adapt an index first developed in the United States for whether workers can work remotely (Dingel and Neiman (2020)).

In addition to being a world benchmark in terms of internet connectivity, Brazil offers an interesting case study to examine the impact of ICTs on protecting employment and wages for a number of reasons. First, the rich dataset on labor at the individual level allows for the unique observation of workers at the absence of technology by a thorough description of their profile (age, gender, race, industry, occupation, etc.). Second, at the outbreak of the pandemic in the country (March 2020), only about half of the almost 6,000 municipalities had high-speed internet above the minimum threshold in density of contracts. Third, there has been a significant heterogeneity on the impact of Covid-19 among workers, given the deep structural differences in local economies (Goes et al. (2020)). Again, this feature is a reflection of what happened worldwide (ILO (2022)). Finally, the country suffered a loss in working hours of 14.7% due to the pandemic in 2020,which stands about halfway of the maximum loss experienced by any country in the first year of the crisis (ILOSTAT (2023)).

To estimate the effect of the internet availability on employment and wage levels, we use a differences-in-differences (DiD) framework. Following the methodology of previous work (Jung and Lopez-Bazo (2020)), the local market or municipality is considered 'connected' if there are at least five points of access of fixed broadband per 100 people at the onset of Covid-19 in Brazil, in March 2020. The identifying assumption is that, absent the internet, the labor outcomes in treated an untreated municipalities would have followed parallel trends. We conduct the benchmark analysis at the municipality-quarter level, which is consistent with past work for the labor market in Brazil (Fonseca and Van Doornik (2022); Silva et al. (2021)). The identification assumption would be violated if separations and new hirings happened for reasons that are specific to the municipalities where their activities are executed. For instance, an employee would be hired post-pandemic at a certain municipality because of local economic conditions. To make sure that the results are not driven by these differential regional-level dynamics, we control for time-region fixed effects and characteristics.

As a robustness check, we adopt a matched-DiD approach to account for the ex-ante differences between connected and non-connected municipalities, matching them with replacement on pre-Covid-19 shock levels of the quintile of the GDP per capita and the stock of employees per firm. Although this identification strategy does not require that treated and untreated municipalities have similar fixed broadband levels or a common support in the level of covariates across cities when using the matching technique (Fonseca and Matray (2021)), we show that

this parsimonious scheme ensures that both groups of municipalities are similar over a rich array of municipality characteristics. We also show that the results of the main specification and the matched-DiD are qualitatively similar.

The set of empirical results allows us to conclude that high-skilled women were hired more than men in connected municipalities for teleworkable positions, compared to their peers in non-connected cities. These results are particularly important given that women are in about 60% of these occupations. Women are also on an advantageous position when we measure the secondary impact of the internet on their labour outcomes, as they are both separated less and hired more in the positions that are not teleworkable. Globally, we find that workers that occupied teleworkable positions and were living in municipalities with high-speed internet available at the outset of the pandemic were separated at a rate 24% smaller than workers at the municipalities without the same ICT resources[3]. The results are stronger for the most educated and the youngest in the labor force.

The remainder of this paper is organized as follows. Section 2 presents the contributions to the literature of this work. Section 3 introduces the setting. Section 4 discusses the data and the empirical strategy. Section 6 shows the average effect of ICTs on employment and wage levels for Brazil and discusses the validity of the identification assumptions. Section 7 develops robustness checks to confirm the main results. Section 8 discusses the policy implications of the ICT availability on the labor market and offers the final remarks. All appendix material is found after the References Section.

2 Contributions to the Literature

The role of Information and Communication Technologies (ICTs) in the labor market has been debated for more than half a century (see Autor (2015); Mokyr et al. (2015) for a historical perspective). Most progress in the literature examines the impact of ICTs on labor productivity (Cette et al. (2022); Dimelis and Papaioannou (2011)), with a smaller body of work dedicated to understanding how ICTs affect employment (O'Mahony et al. (2008)) and wage (Autor and Acemoglu (2010); Taniguchi and Yamada (2022)).

When the concept of ICTs is narrowed down to internet technologies, again most studies aim at investigating their impact on labor productivity, with the majority of the work concluding that the internet contributes to higher productivity levels (Cambini et al. (2023); Fabling and Grimes (2021); Najarzadeh et al. (2014); Ospino and Ospino (2018)), although heterogeneity plays an important role and exceptions apply (Jung and Lopez-Bazo (2020)). Scanter evidence

[3]ICTs, high-speed internet and fixed broadband are used interchangeably in this text (FCC (2014)).

examines the protection that internet access may offer to workers. Some studies point out that better connectivity through access to fixed broadband may lead to higher participation in the labor force, but this may happen only for certain segments of the population (Dettling (2017)) and under certain circumstances (Katz (2018)). There is also some suggestion that wages may actually decrease right after better connectivity is made available (Bu and Tang (2023)).

On gender, except for the larger literature focused on internet job search (Dammert et al. (2013); Kroft and Pope (2014); Kuhn and Mansour (2014)) and the imbalance of women in occupying ICT jobs (Kurti et al. (2024); Segovia-Perez et al. (2020)), we still have scarce evidence on the effect of technology on women (Dettling (2017); Greenwood et al. (2005); Heckman (1993)).

We aim to contribute to this literature by investigating how the availability of internet resources impacts employment and earnings of the labor force. More specifically, we investigate whether high-speed internet access has the potential to decrease separations and/or increase hirings. Our leading hypothesis is that the availability of internet resources at the moment of an exogenous shock that halted the free movement of individuals led to a distinct pathway for those who could and could not continue working from home, but only for those who had the proper telecommunication infrastructure in place. In addition, this paper tests whether the work-from-home culture that emerged post-Covid-19 forced a decrease in the salary of workers for Brazil as was recently made evident for the United States (Barrero et al. (2022); Sasso (2022)). Also based on past literature (Goes et al. (2020); ILO (2021)), we hypothesize that the benefits of connectivity will considerably vary depending on the workers' age, gender and level of education.

3 The Setting and Conceptual Framework

In this section, we discuss the potential channels that may explain the main findings by focusing first on how the ability to work from home (WFH) was impacted by occupational characteristics of workers. Next, we document the technology-related demands that make WFH possible. Finally, we develop a framework to explain how individuals are expected to be affected depending on whether they were living in municipalities with available fixed broadband at the moment of the exogenous shock of Covid-19.

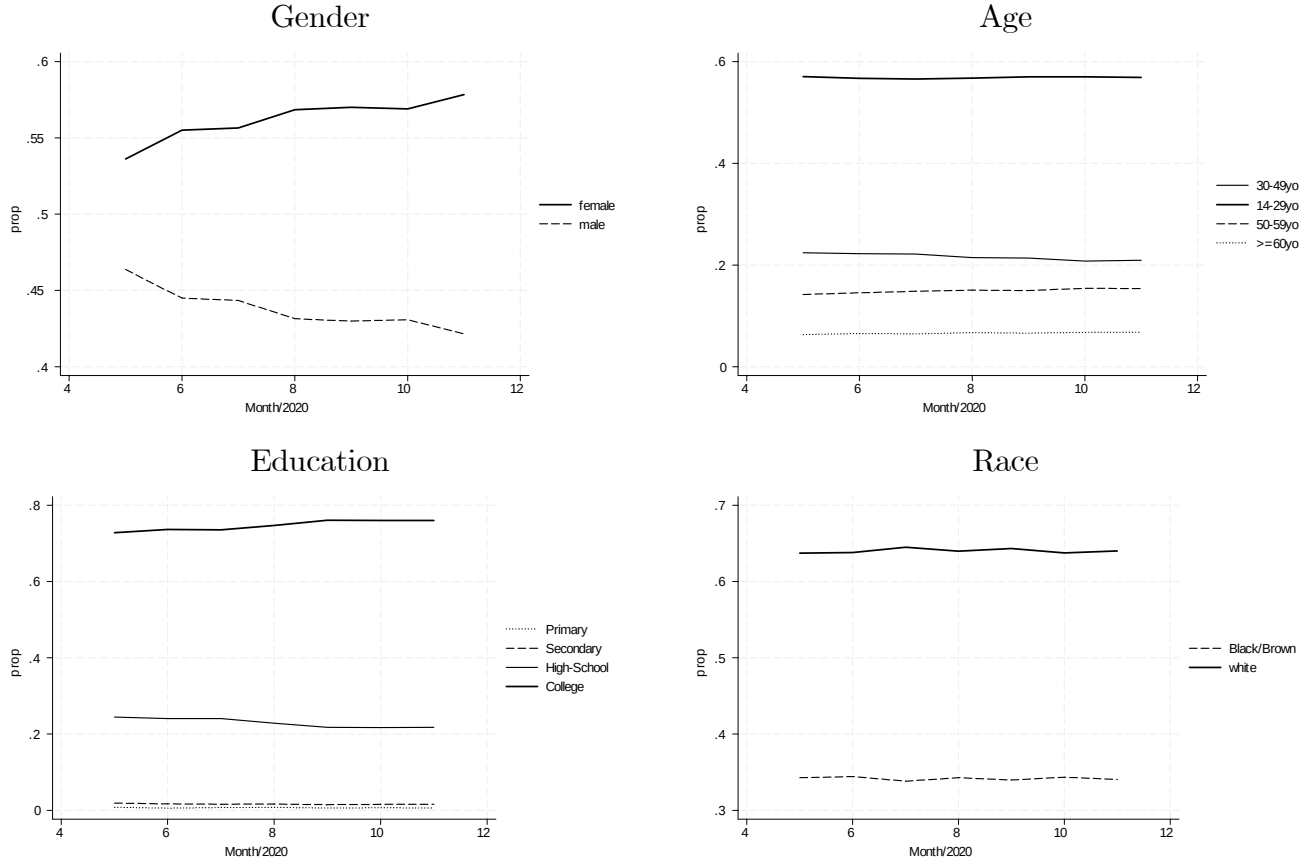
3.1 Labor Market

Occupational characteristics of workers determined not only their vulnerability of contracting Covid-19 (Baker et al. (2020)) but also their ability to work from home (WFH). Figure 1

illustrates this by showing how the practice of working from home in the months following the outbreak of the pandemic strongly varied by gender, age, educational level, and race of the worker. For example, on average 56.1% of people working remotely were women (IBGE (2020))[4]. Globally, 8.2 million people who continued working during the Covid-19 pandemic carried out their work remotely in Brazil, which is equivalent to 11% of the employed population not on leave.

Even though the isolation measures were extended up to June 2020 in Brazil, the habit of WFH has persisted over time. For instance, while about 33% of households declared to have completed work activities through the internet in 2019, this proportion jumped to 38% of households in 2020, and in the subsequent years they were still maintained at relatively higher levels This trend is similar in all Latin America, according to a study published by the International labor Organisation – while only 3% of the labor force in the region worked from home before the pandemic, this figure jumped to 20 to 30% in the year following the outbreak of Covid-19 (ILO (2020)).

Figure 1: Proportion of Individuals Working from Home by Gender, Age, Education, and Race



Notes: Regional Center for Studies on the Development of the Information Society (Cetic, 2020)

[4]The National Sample Survey for Households for Covid-19 (Pnad-Covid-19) was conducted for the months of May to November 2020. Several questions related to the general health of workers as well as their ability to work from home were asked. The exact WFH question was: "Last week, were you in remote work (home office or telework)?".

3.2 The Availability of ICTs and the Pandemic

A key component of the ability to WFH is related to the availability of the telecommunications infrastructure. According to a survey led by the International Telecommunication Union, in two years since the outbreak of Covid-19, the "Covid-bump" on the increase of new users was still not enough to bring fixed broadband connectivity to 2.7 billion (44%) people worldwide (ITU (2022)). In addition, subscriptions to this service have been expanding at a very slow pace (6.7% over the last ten years), with developing countries connected mostly through mobile networks (ITU (2022)).

The OECD and the International Telecommunications Union (ITU) define fixed broadband as internet speed connections above 256 Kbps (kilobits per second) (OECD (2020a)). However, this reference for speed is outdated. Koutroumpis (2019) find that there is a speed-threshold above which there are decreasing marginal returns on economic output, but which increases over time and new skills become available. For example, the telecommunications authority in the United States has a current definition of fixed broadband as a connection with a minimum speed of 25 Mbps (megabits per second) and an upload speed of at least 3 Mbps (FCC (2015)). In this work, to evaluate the ability to WFH, we adopt a much more conservative approach and assume that a household has fixed broadband if the contracted speed is above 2 Mbps. In addition, we consider fixed broadband only if the service is provided through the infrastructure of cable and optic fibre, given their higher reliability (Anders and Jackson (2023); Cetic (2021)). Panels A an B of Appendix Figure A.2 show the reasonableness of this assumption, given that the average number of contracts per municipality below the speed of 2 Mbps and provided with technologies other than cable and fibre are negligible. We also test the sensitivity of the main results to different fixed broadband definitions, as discussed in Section 5.

Finally, following previous work of the threshold definition (Jung and Lopez-Bazo (2020)), we consider that a municipality is covered by fixed broadband if there are at least five points of access per 100 people. Under this specification, municipalities with a lower ICT penetration will not be able to provide workers with the necessary infrastructure to adopt remote work. At the moment of Covid-19 shock, in March 2020, there were 2,469 municipalities covered with fixed broadband, which represents roughly 45% of the 5,570 municipalities of Brazil.

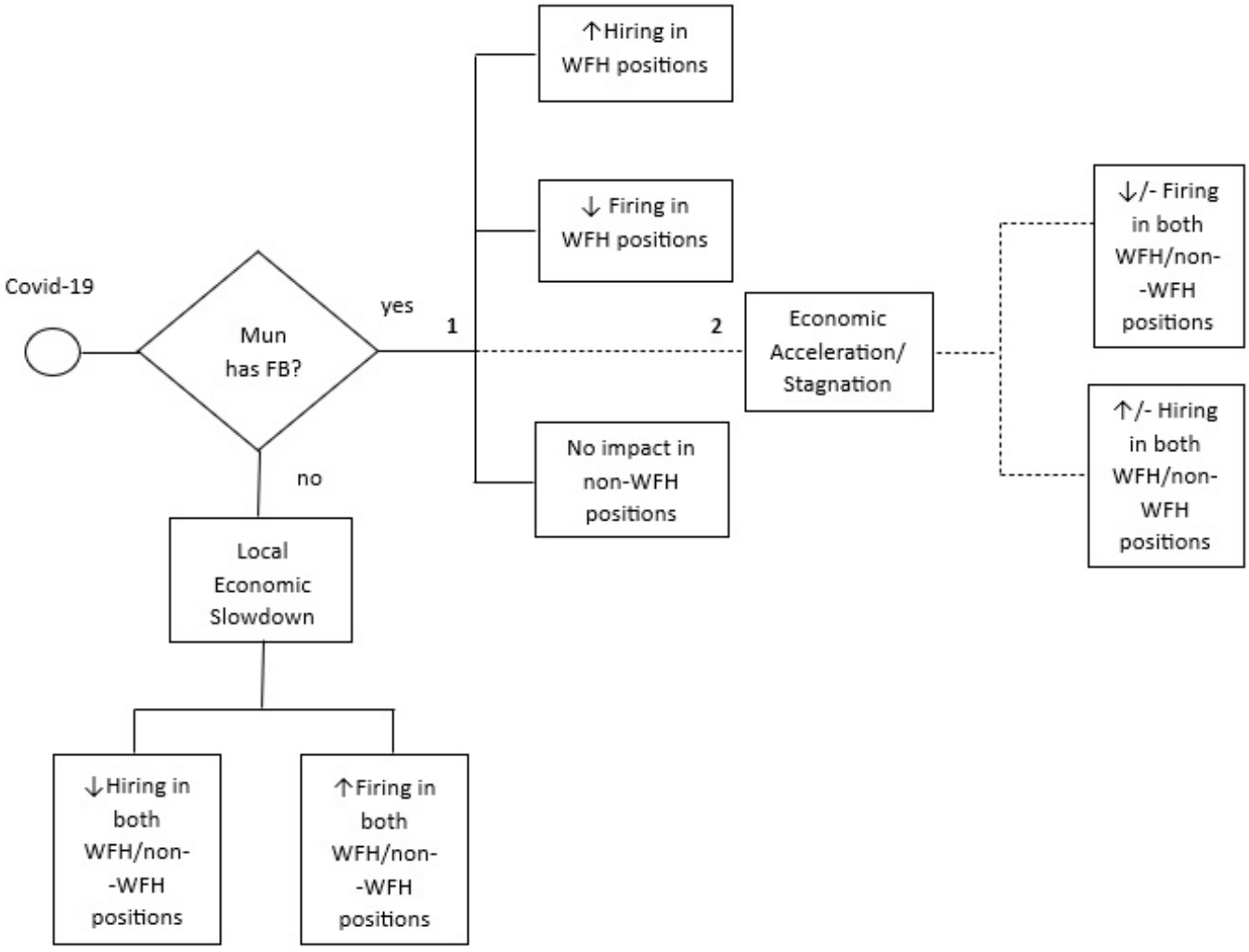
3.3 Conceptual Framework

In this work, we investigate whether the availability of fixed broadband helps workers from being fired and/or new hirings are boosted in connected municipalities compared to markets where the same resources are not available, and whether the internet affects wage levels. We

hypothesize that the availability of internet resources at the moment of the exogenous shock that halted the free movement of individuals led to a distinct pathway for those who had the proper telecommunication infrastructure in place, depending on the profile of the worker (Akerman et al. (2015)) and whether the individual was able to work from home (Beland et al. (2022); Dingel and Neiman (2020)).

As summarized by Figure 2, with the proper internet resources, those whose employment allowed tasks to be performed far from the workplace (WFH) could continue their 'business as usual' or even thrive, depending on what they did (e.g., food delivery, online services). If the worker could not potentially WFH (e.g., veterinarians, dentists), having internet resources is not useful to continue working (node 1, solid).

Figure 2: Conceptual Framework



Note that workers that continue to WFH will generate a positive externality in the economy. They will continue to make money circulate locally, and this is what we call the indirect channel through the "economic acceleration" or at least a stagnation (i.e., growth=0). This indirect channel is going to impact both WFH and non-WFH workers (node 2, dashed).

Assuming that the internet is not available, the municipality will not be able to carry the

economy as usual, so we can expect a local economic slowdown. In this case, both WFH and non-WFH workers will be negatively impacted.

By measuring the impact of the internet resources on those who cannot WFH, we are primarily measuring the indirect channel. This is because any effect observed for this group is coming from the local economy, and not from the ability of the worker to secure their job. In Section 7, we test the validity of this hypothesis by performing a separate analysis by quartile of WFH intensity at the municipality level. We show that the impact of the internet on NWFH workers is stronger for separations and hirings where there is a higher presence of WFH employees, which helps us to corroborate the conclusion that the impact observed for NWFH in the main specification is coming from the indirect channel of the local economy.

What about the impact of the internet on the wage of workers? We hypothesize that, among WFH workers living in connected municipalities, firms might adjust their hiring salary downward to compensate for the 'amenity-value effect' associated with the benefits of staying home for remote workers, which was recently identified in the United States (Barrero et al. (2021)). Among non-WFH workers, the relative difference for wages in connected municipalities is expected to be small or non significant, given that these workers would be capturing only the positive externalities generated by those who can telework.

4 Data and the Empirical Strategy

4.1 Data Sources

Employee data for Brazil comes from the "Relacao Anual de Informacoes" (RAIS), a mandatory survey filled out annually by all tax-registered firms in Brazil. Because late or incomplete information is subject to severe penalties, this dataset has essentially the full coverage of all employees in the formal sector[5]. RAIS is publicly available in two forms: employee-level and firm-level. The employee-level data contains the disidentified worker's information, at the moment of entrance or separation in the labor force, for the contracted gross earnings, the number of hours worked, as well as the worker's sociodemographic characteristics such as education, occupation, age, and gender. Using information on the workers' start and separation dates, we convert this panel to quarterly frequency by summing up the number of employees and averaging the employees' wages and collapsing it at the municipality level per category analysed (education, age, gender). We restrict the dataset to full-time workers above 18 years old and we use data from the second quarter of 2019, i.e., one year before the pandemic outbreak in

[5]Even though the informality rate in the labour market in Brazil can be as high as 34% (IBGE, 2021), teleworking activities are mostly done through the formal sector (Goes et al., 2021)

Brazil, to the fourth quarter of 2020, when the bulk of internet contracts were still rigid. The data is publicly available and was obtained through "Base dos Dados", an NGO in Brazil (dos Dados (2021)).

The firm-level data is an annual dataset that contains the number of active employees reported per firm, and is also granulated per industry and firm size. From this dataset, we summarize the number of firms and the number of employees that are active in the labor force at the end of each year. We drop firms that are not operating or that have zero registered employees. This dataset is used to build the covariate "employees per firm" as one of the matching criteria in the robustness check exercise.

Finally, we tag the 2,694 job positions in Brazil into those that are likely able to work from home (WFH). The same exercise was first done in the United States (Dingel and Neiman (2020)) and later in Brazil, but using survey data (Filho et al. (2023); Goes et al. (2020))[6]. Next, we grouped the job positions of Brazil into the same categories used in the United States and compared the proportion of workers that were classified as able to WFH in both countries to check the integrity of the author's manual assignment. The consolidated coding work can be found at Appendix Table B2. We identified that about 23% of workers are able to WFH, which is much more conservate from what was identified in the United States (37%), but close to previous estimates for Brazil[7].

The data on fixed broadband contains the unique disidentified contracts per municipality per month detailing the type of infrastructure of the internet connection (cable, optic fibre, LTE, radio, satellite, etc.) and contracted speed. We consider contracts above 2 Mbps and with fibre or cable as the infrastructure of connection. Following the international metric of density for fixed broadband (ITU (2022)), we sum all these contracts per municipality per month, divide it by the local population of 2019 (baseline year) and multiply it by 100 to obtain the number of contracts per 100 people. As in previous work (Czernich et al. (2011); Koutroumpis (2019)), density or penetration of fixed broadband is the treatment indicator, and the municipality is deemed connected if there is a minimum density of 5 for fixed broadband in March 2020 (as in Jung and Lopez-Bazo (2020)). The dataset is public and comes from the National Telecom Regulator (Anatel (2023)).

To control for the government transfers that might impact the demand and supply of labor after the onset of Covid-19 in March 2020, we take into account the benefits that were granted both to individuals and to firms. For individuals, the Brazilian government put in place two important pro-poor policies that prevented a sharper rise in poverty and inequality

[6]PNAD – National Survey by Sample of Households.

[7]Filho et al. (2023) estimated that about 18% of workers in Brazil are able to WFH, and Goes et al. (2020) calculated the potential for the country at about 22.7% of the job positions.

(IMF (2021)). The first was the expansion of the program "Bolsa Familia" to include 1.2 million new families that had been on a waiting list. The second initiative was the creation of the "Auxilio Emergencial", an emergency aid program targeting 67 million recipients among informal, self-employed, and unemployed workers living in low-income households, as well as existing "Bolsa Familia" beneficiaries. A monthly benefit of R$ 600[8] was distributed between April to August 2020 and then restricted to 45 million workers until the end of 2020 with a monthly payment of R$ 300 (Bank (2020)).

Appendix Figure A.3 shows the average distribution of the financial aid and beneficiaries per municipality over time. Throughout the year 2020, the average number of beneficiaries per municipality increased from about 8 thousand to 14 thousand individuals[9], while the financial aid decreased from R$ 6 million to R$ 4.5 million (Ministry of the Economy, 2020).

A series of benefits were also granted to firms to maintain the liquidity and the fluidity in the credit market, benefiting companies of all sizes, with an increase in concessions and a reduction in average interest rates (BCB (2020))[10]. A sample for the month of August of 2020 of these grants was obtained with the Central Bank of Brazil and used as a control in the regressions of the main specification, given that these resources were targeted to protecting the labor market.

The financial aid granted through "Bolsa Familia" and the "Auxilio Emergencial" are from the Ministry of the Economy (of the Economy (2020)). The data on the monthly and accumulated confirmed cases and deaths from Covid-19 per municipality comes from the Ministry of Health (Coronavirus (2023)). Both datasets are available from April to December of 2020 and were collapsed into quarterly data.

Table 1 above reports the summarized statistics of the labor, socioeconomic, and Covid-19 related characteristics across municipalities by connected and non-connected municipalities.

[8] Approximately US$133.00 by converting it to the exchange rate of R$ 4.48 on March 1st, 2020.

[9] This corresponds to approximately 21 to 37% of the average population per municipality (President's Office, 2021).

[10] The programs are Pronampe, FGI-PEAC, PESE, and shared alienation.

Table 1: Descriptive Statistics

	Connected		Non-Connected	
	Mean	Std. Dev.	Mean	Std. Dev.
A. Labor Market				
Stock Employees/Firm	11.02	6.53	15.05	14.32
+New Employees/Firm	4.32	3.29	5.01	6.59
- Separated Employees/Firm	4.60	3.36	5.80	8.27
Wage at Hiring	1536.39	243.30	1522.01	375.48
Wage at Separation	1546.4	288.69	1509.68	366.20
B. Socioeconomic Characteristics				
GDP per capita	33124.17	29628.2	17861.38	1842.06
Population	65156.99	329718.1	15889.98	21858.1
Literacy Rate	90.46	6.59	81.12	8.38
Share of Rural Population	0.25	0.19	0.45	0.19
Gini Index	0.48	0.06	0.52	0.06
Area	839.96	2160.24	2071.40	7214.56
Distance to Capital	239050.3	151190.7	267228.2	17272.9
Pre-Paid Mob. Subs/100pp	475.07	191.53	371.99	152.91
Post-Paid Mob. Subs/100pp	343.71	209.71	150.58	109.94
C. Covid-Related Statistics				
Confirmed Cases/1000pp	34732.52	22087.02	28527.89	21477.65
Deaths Covid-19/1000pp	640.45	443.84	514.90	414.69
Benefic. Aid Progr./1000pp	779.46	226.67	976.42	218.39
Financial Aid/1000pp	420165.6	116860	510526.2	110542.9
Financial Aid/Firms	6009.72	13235.9	2934.32	8386.89

Note: This table reports the summary statistics of average municipality-level characteristics. Data sources: labor market (all from 2020, except stock of employees per firm (2019)): Ministry of labor (2021a). Socioeconomic characteristics: GDP (millions R$, 2019), population (2019), literacy rate (2010), Gini index (2010), share of rural population (2010), and distance to capital: Brazilian Statistics and Geography Institute (IBGE). Pre- and post-paid mobile subscriptions (2019): National Telecommunications Agency (Anatel). Covid-19 related statistics: Ministry of Health (cases and deaths), Ministry of Finance (2020) (financial aid to individuals) and Central Bank of Brazil (financial aid to firms) (BCB, 2020).

5 Empirical Strategy

To analyze the effect of the internet availability on employment outcomes following the onset of Covid-19, we rely on a traditional two-way differences-in-differences model, that is:

$$Y_{m,t} = \theta_m + \delta_{t,r} + \beta treated_m * POST_t + \gamma X_{m,t} + \varepsilon_{m,t} \quad (1)$$

where $Y_{m,t}$ is a labor-related outcome for municipality m at quarter t. The main outcomes of interest are the municipality's variation in: (1) separation; (2) hiring; (3) wage at separation; (4) wage at hiring. To measure the channels discussed in Section 3, separate regressions are run for WFH, non-WFH, and for the full labor dataset. The variables are disaggregated by the education level, age group, and gender. $treated_m$ is a dummy that is equal to 1 if the minimum fixed broadband density of 5 contracts per 100 people were in place at the moment of the Covid-19 outbreak, in March of 2020. $POST_t$ is a dummy variable that is equal to 1 for periods beyond the first quarter of 2020. θ_m are municipality fixed effects that remove time-invariant heterogeneity across municipalities, $\delta_{t,r}$ are time-region fixed effects that allows for the control of common regional shocks to a given economic outcome (Beland et al. (2022))[11], and $X_{m,t}$ are a vector of control variables. The baseline specification controls for the accumulated number of Covid-19-related deaths and the total benefits received by firms to cope with the impacts of the pandemic, but is also robust as only pre-treatment variables are considered (GDP, population, etc). We cluster the standard errors at the municipality level to account for serial correlation and we weight the regression by the population size at the baseline year (2019) to estimate the aggregate effect of technology availability on the labor market (as in Fonseca and Matray (2021)).

The coefficient of interest β represents the average differential change in the outcome variable $Y_{m,t}$ from the pre- to post-treatment periods for the treated municipalities relative to the change in $Y_{m,t}$ for the control municipalities (Liberti (2020)). The outcomes are in natural logarithmic, which means that the coefficients can be interpreted approximately as percentage changes.

To provide evidence in favour of the parallel-trends assumption and assess the coefficients pre-shock, we also estimate equations of the following form:

[11] The "immediate region" classification of the Brazilian Institute of Geography and Statistics is used. These are groupings of municipalities that have the urban network as their main reference and have a local urban center as their base. The grouping considers the connection of nearby cities through dependency relationships and displacement of the population in search of goods, provision of services and work. There are 510 immediate regions in the country (IBGE, 2017).

$$Y_{m,t} = \theta_m + \delta_{t,r} + \sum_{t=2019q2}^{2020q4} \beta_t (p_t * treated_m) + \gamma X_{m,t} + \varepsilon_{m,t} \quad (2)$$

where p_t is an indicator that equals 1 if the quarter= t and 0 otherwise. This estimation allows the effect of the treatment to vary by quarter, which permits to determine the timing of the effect or whether there is any differential pre-trend for treated municipalities. Each β_t informs the differential change in the labor outcomes for treated municipalities relative to the excluded period (Liberti (2020)), which is the Covid-19 shock in the first quarter of 2020.

One particularity of the labor dataset is that firms tend to misreport the quarterly flow of employees, concentrating the employee information adjustments in the fourth quarter of each year (of Labour (2021)). Appendix Figure A.4 illustrates this point by plotting the monthly flow of separated workers. Even though the unique DiD coefficients are not compromised using log(level), the quarterly pre- and post-coefficients are impacted, i.e., the parallel trends assumption cannot be demonstrated. To solve this challenge, the outcome variables were estimated as the seasonal first quarterly difference, i.e., $x_q - x_{q-4}$. This is a common procedure in time series data with regular seasonal patterns (Pardoe (2023)), in which the approach simultaneously accounts for municipalities-specific trends and seasonality. The coefficients interpretation, however, is different. While the transformation of the outcome variable in log provides us with the mean percentage change of the outcome of interest, the log of the seasonal first difference is a measure of the growth rate of the variable. When we use this transformed variable in the main specification, most results stand well qualitatively (see Section 7 for complete discussion).

One challenge to be addressed is that the number of municipalities that have access to fixed broadband is not static in time. In fact, Panel A of Appendix Table B1 shows that the number of connected municipalities with fixed broadband increased by about 10% between 2019 and 2020. To avoid contamination in the results, we exclude these municipalities from the analysis. This assumption does not impact the results qualitatively [12].

[12] Table with results available upon request. Even though Brazil is mostly connected to the internet through mobile coverage, our argument is that this type of technology is not relevant to spark changes in the labor market because of the high demand in data for activities that are typical of WFH, which would imply prohibitively high costs in contracts with telecom carriers, so this is not the primary technology to adopt teleworking initiatives. In addition, the number of both pre-paid and post-paid mobile subscriptions per 100 people was drastically reduced between 2019 and 2020 – in a few instances by more than 50%, depending on whether we are examining the statistics of theconnected (T) or non-connected (C) municipalities Anatel (2023).

6 Results

6.1 Main Results

Table 2 presents the results estimating the effects of fixed broadband availability on separation, hiring, and their respective contracted wages using the baseline differences-in-differences specification.

Table 2: Main Results

	Separation		Hiring	
	Employees	Wages	Employees	Wages
Panel A - WFH	-0.236***	0.002	0.188***	-0.042***
	(0.021)	(0.010)	(0.020)	(0.009)
Observations	33,105	33,105	33,246	33,246
Panel B - non-WFH	-0.046***	0.009	0.130***	-0.001
	(0.016)	(0.007)	(0.019)	(0.006)
Observations	33,429	33,429	33,530	33,530
Panel C - All Workers	-0.107***	0.005	0.135***	-0.023***
	(0.015)	(0.007)	(0.017)	(0.006)
Observations	33,793	33,793	33,900	33,900
Time-Region FE	y	y	y	y
Municipalities FE	y	y	y	y
Controls	y	y	y	y
p-value (WFH-non-WFH)	0.00	0.57	0.04	0.00

Notes: differences-in-differences coefficient estimates. Outcome variables are in log. The observations are at the municipality-quarter level, with municipality and time-region fixed effects and standard errors clustered at the municipality level. Controls are the accumulated deaths related to Covid-19 and the financial benefit received by firm through government funding in response to the pandemic. Regressions weighted by the population of the municipalities at the baseline year. The reported p-value of the difference between WFH and non-WFH refers to separations and hirings of employees.

Panel A presents the results for workers with the potential to WFH, Panel B measures the indirect impact of internet connectivity on the labor market through the economy, since these are exclusively employees that cannot work remotely because of the nature of their occupations, and Panel C captures the direct and indirect impacts of high-speed internet on the labor market. We also add the p-value of the difference between the estimations for WFH and non-WFH

workers.

On average, the availability of fixed broadband is associated with smaller separation rates and higher hiring rates in the aftermath of the sanitary crisis. Those that could work from home were separated from their jobs at a 24% smaller rate and hired at a 19% higher rate in connected municipalities compared to workers where high-speed internet was not disseminated. These results are statistically significant at 99% confidence level. By contrast, there is no indication that workers that were separated had a different average salary in connected municipalities compared to non-connected municipalities, although new workers seem to be getting contracts that have about 4% smaller wages where fixed broadband is available. This result is aligned with the literature in the United States showing that remote workers are being hired with lower wages post-pandemic to compensate for the indirect benefits they receive by working from home (Barrero et al. (2022); Sasso (2022)).

Since the nature of most job positions does not allow working from distance, whatever happens to this category of workers is a consequence of the indirect channel of technology on the economy. Panel B shows that workers that could not WFH but lived in connected municipalities were separated at a 4.6% smaller rate and hired at a 13% higher rate than workers that also could not work from home and lived in municipalities without enough high-speed internet. These estimates suggest that even when individuals cannot use the internet to WFH, their jobs are still relatively more protected than for workers living in municipalities without the same resources.

In Panel C of Table 2, the coefficients of the outcome variables are half-way through between WFH and non-WFH positions. In general, connected municipalities terminate jobs at an 11% smaller rate and hire at a 14% higher rate, with some suggestion that those entering the labor force have average wage contracts that are 2% smaller[13].

6.2 Results by Gender

Women have a distinctive representation in WFH positions, since they occupy about 60% of the all teleworkable positions (2019/2020)[14].

[13] As an added exercise, I also excluded from the sample the federal public servants. They have job stability and get tenured after two years, so the internet resources might not in principle impact the inflow and outflow of these workers. The results remained robust compared to the main specification.

[14] These statistics are based on the total outflow and inflow of employees, which is summed up monthly for all municipalities and then averaged.

Table 3: Impact by Gender (WFH)

	Separation		Hiring	
	Employees	Wage	Employees	Wage
Panel A: High-Skilled				
Male	-0.266***	-0.011	0.035**	0.012
	(0.020)	(.013)	(0.017)	(0.013)
Female	-0.224***	-0.008	0.146***	-0.017*
	(0.021)	(0.011)	(0.021)	(0.009)
Observations	32,381	32,381	32,309	32,309
p-value (Male - Fem)	0.15	0.86	0.00	0.07
Panel B: Low-Skilled				
Male	-0.250***	-0.074***	-0.200***	0.025
	(0.038)	(0.028)	(0.038)	(0.035)
Female	-0.177***	-0.078*	-0.108*	0.018
	(0.039)	(0.043)	(0.055)	(0.03)
Observations	19,290	19,290	17,275	17,275
p-value (Male - Fem)	0.18	0.94	0.17	0.87

Notes: differences-in-differences coefficient estimates. Outcome variables are in log. All other specifications: please see Table 2.

Panel A of Table 3 brings the main estimates by gender separated by the level of skill. Following previous literature (Fonseca and Van Doornik (2022)), high skilled workers (HS) are those that have at least some post-secondary education in Brazil. From all estimates, the number of new hired HS female workers in connected municipalities compared to non-connected municipalities stands out as higher compared to their male counterparts (third column of Panel A). Note that this does not happen when we contrast the results in the low-skilled category (Panel B). There is weak evidence that high-skilled women are being hired at smaller wage rates, which is aligned with the main results showed in Table 2.

Importantly, the results are robust when we exclude part-time workers, when we vary the definition of high/low-skilled workers, and when we control for the industry of the worker[15].

The secondary impact of the internet availability is detailed in Appendix Table B3. High-skilled women are both separated less and hired more than men in connected municipalities than in non-connected municipalities. Agan, there is weak evidence that women are being hired at a slighly smaller wage rate (-1.9%) than women in non-connected cities, which is not observed among men.

Appendix Table B4 complements the analysis by gender by dividing workers between the

[15]Table available upon request.

"youngest" (<=39 years old) and the "young" (>=40 years old) workforce.We notice that the youngest women are hired more than men, regardless of their age, an outcome that is aligned with the main results displayed in Table 3.

6.3 Event Study and Pre-Trends

To validate the pre-trends analysis, we conduct an event study focusing on the availability of fixed broadband at the moment of the pandemic shock, that is, March 2020, when the lockdown measures started to be implemented in Brazil. An event study corresponds to the municipality covered with this internet technology with a minimum density of five contracts per 100 people. At the moment of the shock, 2,496 out of the 5,570 municipalities were covered with high-speed internet.

To circumvent the problem of the high cyclicality of the labor data discussed in Section 4, we work with the first quarterly difference, which accounts for the municipalities-specific trends and seasonal patterns and provides us with the growth rate of the outcome variables.

In Appendix Figures A.6 and A.7, we plot differences-in-differences coefficient estimates of separation and hiring growth rates for the quarter-over-quarter difference of the log along with 95 percent confidence intervals for three lags and three leads of fixed broadband coverage using the baseline specification. The graphs are separated by WFH and non-WFH positions.

By the end of the fourth quarter of 2020, the growth rate of separations for WFH positions was 36% smaller in connected municipalities compared to non-connected municipalities. Similarly, the growth rate for hirings for WFH positions are 20% larger in connected municipalities compared to non-connected municipalities by the fourth quarter of 2020, with an average growth rate of 4.4% per quarter.

The secondary effects of high-speed internet on the labor market through the economy, i.e., through non-WFH positions, show a similar pattern. On average, these workers have a separation growth rate of 14% smaller and a hiring growth rate 21% higher than the equivalent workers without high-speed internet access.

By visual inspection, it is possible to observe that the parallel assumption holds well in this exercise for all graphs, with the coefficients centered around zero in the pre-shock period. These results were robust to a falsification test, in which the shock was simulated to be one year before the actual Covid-19 outbreak. In this scenario, there are not statistically significant pre- or post-shock outcomes[16].

[16] Graphs available upon demand.

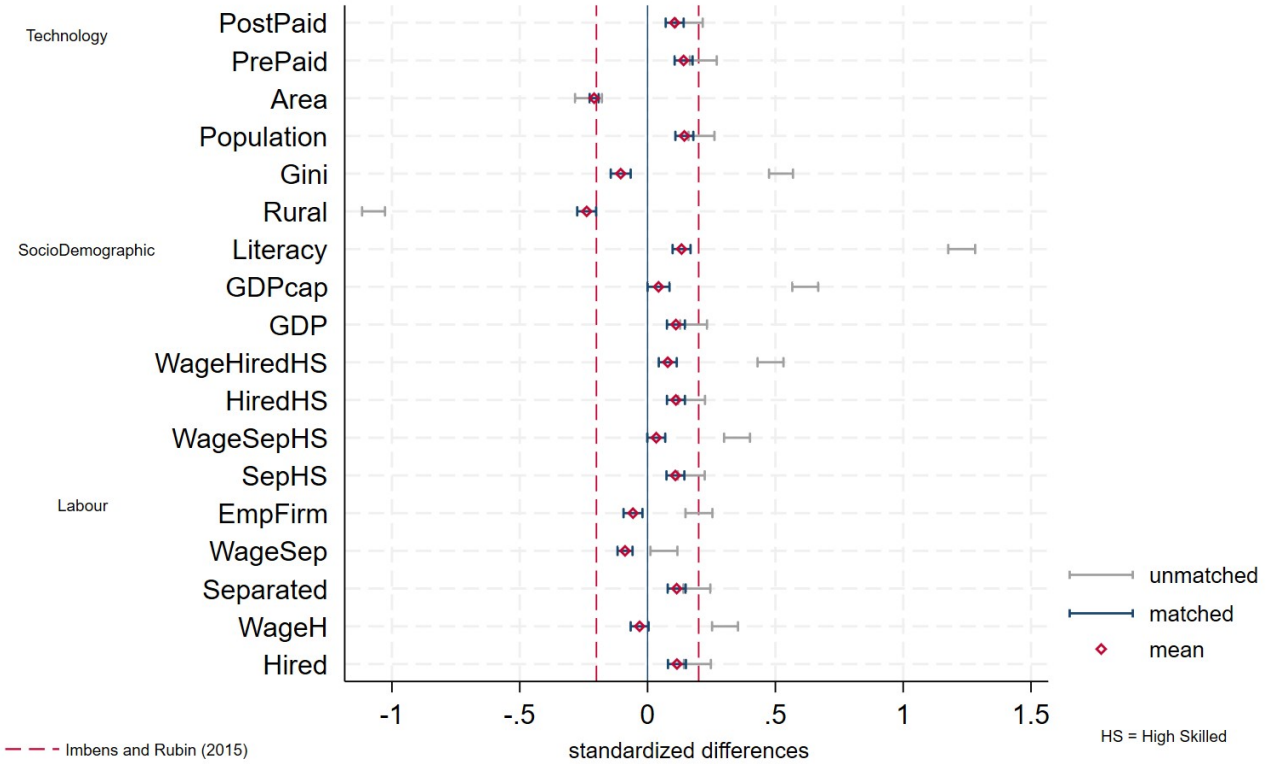
7 Robustness Checks

In this section, we propose to adopt an alternative estimation strategy, matched-DiD, to test the robustness of our main specification. We also discuss sensitivity tests that we ran for the treatment and controls. We finalize this section by discussing the implications of correcting for the ciclicality of the data and an additional test that shows the indirect impact of technology on the labour market. For the sake of length, all table and graph results from subsections 7.2 to 7.5 will be part of an Online Appendix and are available upon request.

7.1 Alternative Specification: Matched DiD

The identification strategy for the matched-DiD approach assumes that there are ex-ante differences between connected and non-connected municipalities, but it does not require that either the initial level of internet connection to be random nor assumes that there is a common support in the level of covariates across municipalities. Instead, this strategy requires that the outcomes of connected and unconnected municipalities would have evolved similarly absent the economic shock brought by the pandemic (as in Fonseca and Matray (2021)).

Figure 3: Covariates Balance



Notes: The figure shows coefficient estimates and 95% error bands of the difference between connected and non-connected cities along different variables. All variables are normalized to have a mean of zero and a standard deviation of one in the full sample.

Because municipalities are different ex-ante, we match with replacement on the pre-Covid-19 levels of the GDP per capita and the stock of employees per firm, i.e., one variable that captures

the sociodemographic characteristics of municipalities and another variable that synthesizes the labor market. We show in Figure 3 that this parsimonious strategy ensures that the standardized differences between the treatment and control groups are within the threshold limit of 0.20 established in the literature (Imbens (2015)) over a rich set of technological, sociodemographic, and labor characteristics.

Table 4: Matched DiD

	Separation		Hiring	
	Employees	Wage	Employees	Wage
Matched WFH	-0.236***	-0.006	0.126***	-0.047***
	(0.023)	(0.019)	(0.022)	(0.012)
Matched WFH	-0.036**	0.011*	0.089***	-0.002
	(0.018)	(0.006)	(0.021)	(0.007)
Matched All	-0.046***	0.000	0.069***	-0.009
	(0.021)	(0.008)	(0.021)	(0.007)
Observations	23,079	23,079	23,070	23,070
Time-Microregion FE	y	y	y	y
Municipalities FE	y	y	y	y
Controls	y	y	y	y
p-value (WFH=non-WFH)	0.00	0.39	0.22	0.00

Notes: Coefficients are in log, to capture the average impact of internet access on labor outcomes for municipalities with internet access compared to non-connected municipalities. The counterfactual municipalities reported for the match-DiD are identified by matching municipalities over employees per firm and GDP per capita of the baseline year (2019).

After this baseline matching procedure, the total sample is composed of 4,031 municipalities (of which 1,562 is in the control group). Appendix Figure A.5 displays the spatial distribution of treated and control municipalities. Connected and non-connected cities are spread out across the territory, except in the North and part of the Northeast region where the population occupation is scarcer due to geographical barriers. After this matching procedure, we run again the standard TWFE DiD as in the main specification over the matched sample (eq. 1).

Table 4 shows the matched-DID for WFH positions, non-WFH positions, and the full labor force. The results of the main specification and the matched-DiD are qualitatively similar, with some of the matching coefficients relatively attenuated compared with the main specification.

7.2 Treatment Definition

One potential threat in the identification strategy of this work is the definition of the treatment, i.e., fixed broadband. There is not a formal threshold established to determine whether a locality has enough of this technology in place, but two common metrics followed by international organizations are the density of fixed broadband, or the number of contracts per 100 people, and the contracted speed (FCC (2015); ITU (2022)). Beyond adopting a definition that was previously used in the literature (Jung and Lopez-Bazo (2020)), we run a sensitivity analysis by measuring the impact of different definitions of fixed broadband on separation and hiring rates for WFH positions. Three metrics are modulated: the density – from 5 to 15; the contracted speed – below or above 2 Mbps; and the type of infrastructure in place to provide fixed broadband services, i.e., cable and fibre or all technologies, which include satellite and radio.

The highest magnitude of the coefficients is for the baseline specification, i.e., assuming that the municipality has fixed broadband when there is a minimum of 5 contracts per 100 people with the infrastructure of cable and fiber and a minimum contracted speed of 2 Mbps. As the specification becomes more stringent for the density of contracts, the magnitude of the coefficients falls. The same happens if we consider instead any contracted speed and any infrastructure to provide the service. However, in all cases the results are qualitatively similar, i.e., workers from municipalities with fixed broadband have smaller separation rates and higher hiring rates than their peers where no service is available.

7.3 Modulating Controls

Recall that the baseline specification controls for the accumulated number of Covid-19-related deaths and the total benefits received by firms to cope with the impacts of the pandemic. Similar estimates are obtained when these controls are not used in the regressions, reducing concerns that the results are driven by the unequal impact of the pandemic on individuals and firms. We also test the results against different specifications, notably by not weighting the regressions by the baseline population, excluding the controls one at a time, and eliminating the restricted sample of municipalities that obtained fixed broadband during the period analysed. Al results are qualitatively similar, with the highest impact on the results for the weight in the regressions.

7.4 Correction for Cyclicality in the Data

The results in the main specification were not corrected for the cyclicality of the data. We chose to do so because an ideal detrending of the data would need to count on several historical datapoints, which we do not have. Still, because we attempted to remove the cyclicality of the data by capturing the seasonal first quarterly difference when performing the regressions to capture the pre- and post- estimates, we recalculate the mean estimates by correcting for the cyclicality of the labor data. Most of results stand well "qualitatively", i.e., we observe the same direction of the impact and the same correspondence of statistical significance. However, the internet has no (indirect) impact when correcting for cyclicality on the number of separated non-WFH employees. Another difference is that wages at separation for potential WFH employees is statistically negative, which we had not observed in the main specification.

7.5 Confirming the Indirect Impact of WFH on the Labor Force

To show the plausibility of the interpretation of the "labor demand side spillover effects" of WFH on NWFH workers discussed in Section 4, we split the data by calculating the proportion of WFH workers per municipality and divide them into quartiles. For municipalities with a high proportion of WFH employees, a higher impact of the internet on NWFH workers should be observed. Likewise, for municipalities with a low proportion of WFH employees, we should identify a smaller or null impact on the NWFH employees. The impact of the internet on NWFH separated employees is observed only for the last quartile. For hired workers, the impact is positive and statistically significant only for the last two quartiles. These results help corroborate our reasoning that the impact of the internet on NWFH is coming indirectly through the local economy.

8 Implications and Final Remarks

Digitization has the potential to move us toward a more fair society. In this work, we show that the availability of broadband has a positive impact on the protection of workers, with fewer separations and more hirings compared to workers living in non-connected cities. This is true when we meansure both the direct and the indirect channels of the internet on the labour market.

More important perhaps is our finding that the availability of the internet revealed to be specially beneficial for women, a promising result given that remote work can foster gender equality through more flexibility in work arrangements (Goldin (2022)) and the reduction of

commuting times (Caldwell and Danieli (2024)).

Collectively, our results emphasize the need for policymakers to pay attention to the opportunities brought by digitization. Combined with a fair and coherent employment policy framework that aims to create decent jobs for all workers regardless of their profile (education, age, gender), Brazil can perform better if we make sure that the internet resources are evenly available. In the words of the International labor Organisation:

"*Connectivity is becoming a new human right. However, successful interventions adopt a holistic approach to digital transformation that includes a coherent employment policy framework, the proper technological infrastructure in place and investments in skills development.*" (ILO (2020))

Although there are numerous studies dedicated to estimating the impact of ICTs on labor productivity, less attention has been paid to the effect of internet technologies to protect workers, particularly women in developing countries. This paper adds to this literature by taking advantage of the exogenous shock of Covid-19 and the comprehensive datasets for labor and fixed broadband availability for Brazil to examine this subject. By consolidating the labor data at the municipality-quarter level, we avoid the endogeneity problem that may occur between labor outcomes and ICT availability. In addition, the fact that about half the country counted with a minimum density of fixed broadband contracts at the moment of the shock that halted the free movement of people creates an appealing scenario to compare a fairly similar number of connected and non-connected municipalities. We also show that the main results are robust to a broad range of definitions for the availability of fixed broadband at the municipality level.

Another contribution of this work is that it offers a clear separation of the direct and indirect channels of the internet availably on the labor market. As expected, the smaller separation rates and the higher hiring rates for connected municipalities than non-connected municipalities is more evident for WFH positions. However, the positive spillovers of the internet on the labor market are also identified and estimated.

From the point of view of the estimation strategy, we take advantage both from the DiD and the matched-DiD approaches to measure the impact of the internet on workers jobs and wages. The DiD uses the more stringent specification of time-region fixed effects instead of time fixed effects only, which allows to control for local shocks in the labor market at each period of time. Using the quarter-over-quarter differences, we show that the parallel trends for the outcome variables hold well. In the matched-DiD, we consider the potential heterogeneity in both observable and unobservable characteristics between treated and untreated municipalities. We exclude from the sample municipalities that gained access to fixed broadband in the period of analysis to avoid the contamination of the results and we also restrict the data to three

periods pre- and post-shock, to avoid the endogeneity that may come from non-sticking fixed broadband contracts that was identified in the beginning of the year of 2020 following the outbreak of the pandemic.

Despite having demonstrated the causal effect of internet availability on the labor market, this study has a couple of limitations. First, although the short panel dataset does enable us to eliminate unobservable characteristics of workers that are time-invariant, it does not allow the investigation of the long-term effects of the internet on labor. Second, one limitation of the labor data is that only the information on the inflow and outflow of workers is available, but not the stock of employees distributed by several of the outcomes of interest (gender, education, age, etc.). Future research including the stock of employees distributed by these categories will likely improve the precision of the estimates.

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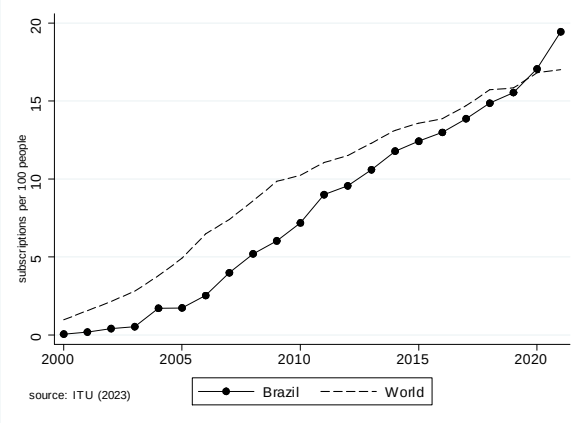
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A Figures

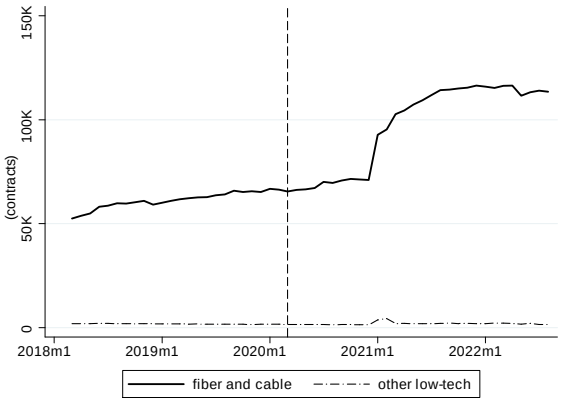
Figure A.1: Fixed Broadband Subscriptions per 100 People



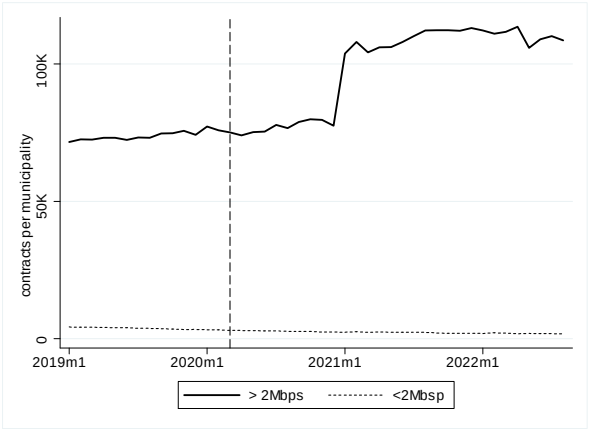
Notes: Data comes from the International Telecommunication Union (ITU)

Figure A.2: Evolution of Fixed Broadband Contracts

Panel A: Average Contracts by Infrastructure

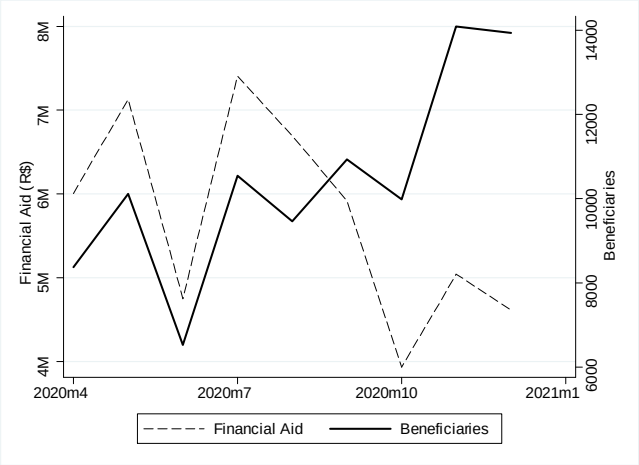


Panel B: Average Contracts by Speed



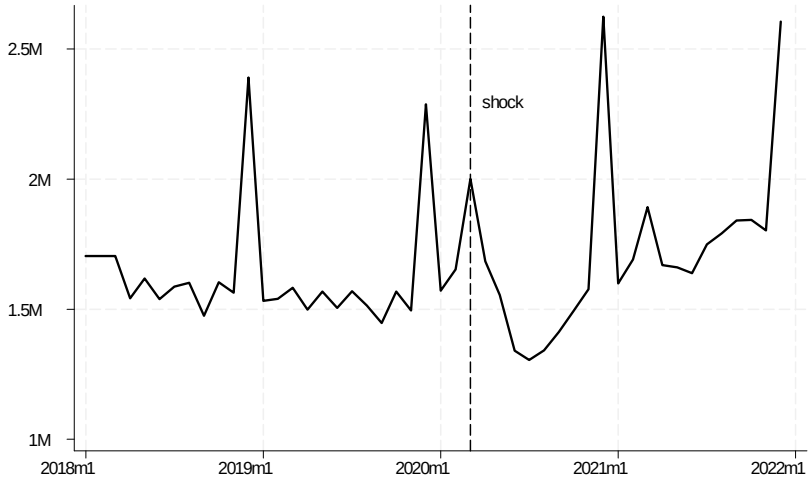
Notes: the number of contracts is summed at the municipality level and averaged per time period by high-quality infrastructure (fibre and cable) and other types of means of access (e.g., satellite, radio, LTE, etc) (Panel A). The number of contracts is summed at the municipality level and averaged per time period by contracted speed above and below 2 Mbps (Panel B). Source: National Telecommunications Agency (Anatel).

Figure A.3: Emergency Fund and Beneficiaries (source: IBGE)



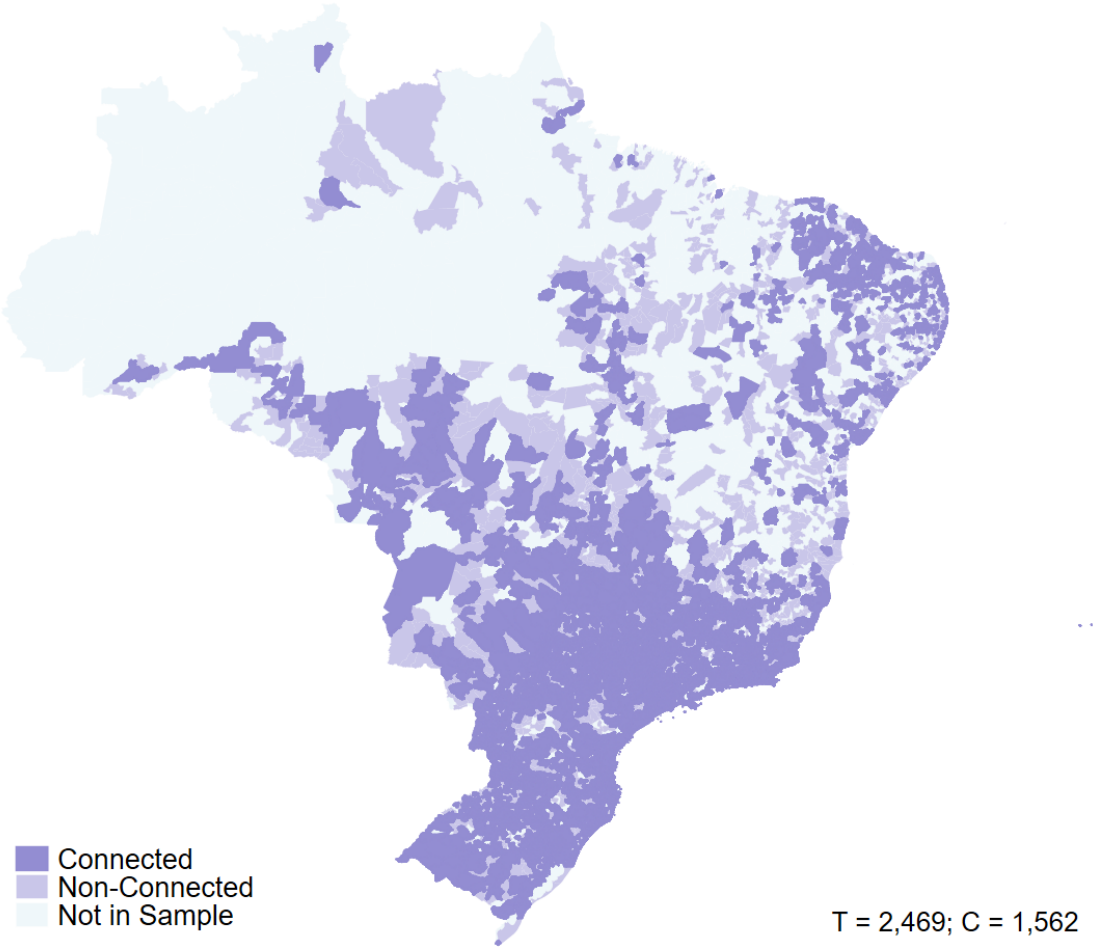
Notes: total financial aid and beneficiaries summed by municipality. Numbers in the graph reflect the mean across all municipalities for payments and beneficiaries (source: of the Economy (2020)).

Figure A.4: Cyclicality of the Labour Dataset (source: Ministry of Labour



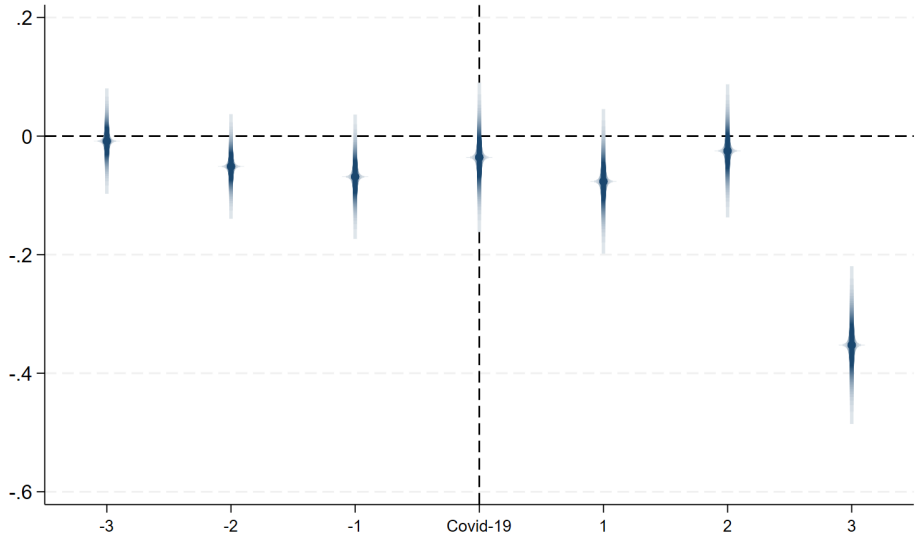
Notes: Source:dos Dados (2021)

Figure A.5: Geographical Distribution of Matched Municipalities (source: Anatel)

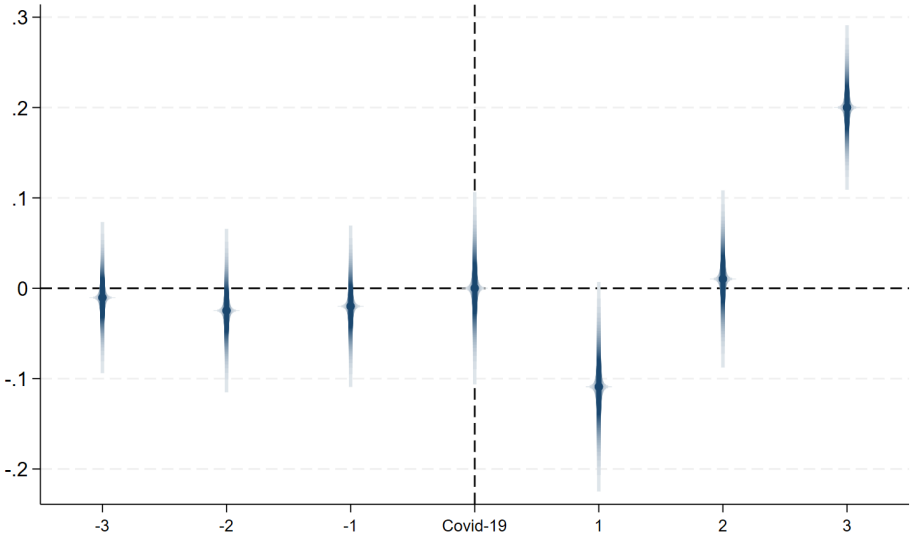


Notes: this figure shows the geographical distribution of connected and non-connected cities in the matched-DiD (total of 3,146 out of 5,570 municipalities). 'Not in sample" are not part of the matched control group.

Figure A.6: Main Results - WFH
Panel A: WFH Positions, Separations

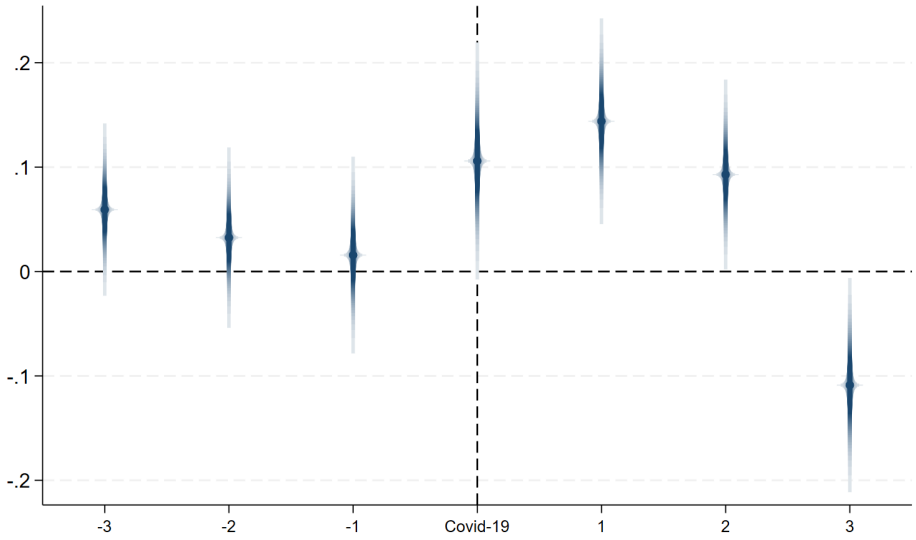


Panel B: WFH Positions, Hirings

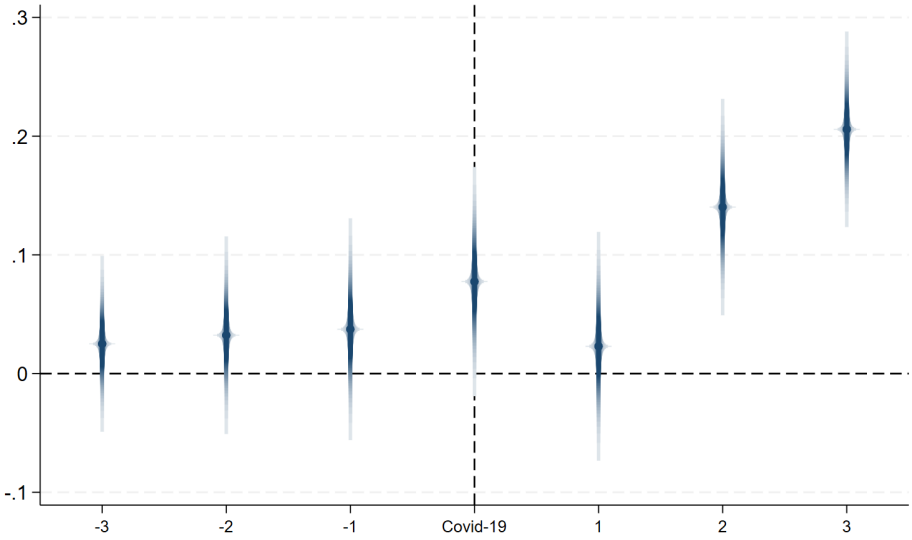


Notes: these figures show the timing of Covid-19 shock and what happens to the outflow and inflow of all workers in municipalities with and without fixed broadband. We plot differences-in-differences coefficient estimates for the quarter-over-quarter difference of the log along with 95 percent confidence intervals. The observations are at the municipality-quarter level, with municipality and time-region fixed effects and standard errors clustered at the municipality level. Regressions weighted by the population of the municipalities at the baseline year..

Figure A.7: Main Results - NWFH
Panel A: NWFH Positions, Separations



Panel B: NWFH Positions, Hirings



Notes: these figures show the timing of Covid-19 shock and what happens to the outflow and inflow of all workers in municipalities with and without fixed broadband. We plot differences-in-differences coefficient estimates for the quarter-over-quarter difference of the log along with 95 percent confidence intervals. The observations are at the municipality-quarter level, with municipality and time-region fixed effects and standard errors clustered at the municipality level. Regressions weighted by the population of the municipalities at the baseline year.

B Tables

Table B1: Infrastructure and Behaviour of Internet Users in Brazil

	2019	2020	2021	2022
Panel A: Use of the Internet				
Completing school activities or research	41	45	41	40
Taking distance learning courses	12	21	18	17
Studying on the Internet on one's own	40	44	40	38
Completing work activities	33	38	36	36
Panel B: Reasons to not use the internet at home				
Does not have a computer in the household	41	42	38	34
Lack of need	47	49	45	43
Lack of interest	53	48	51	48
Has internet access elsewhere	30	37	27	25
Too expensive	59	68	62	59
Does not know how to use the Internet	49	50	47	52
Lack of service availability in the area of the household	25	32	18	16
Concerns about security and privacy	44	47	41	39
Desire to avoid contact with dangerous content	40	43	35	34
Panel C: Infrastructure				
Households with a computer in the house	39	45	39	39
Households with access to fixed broadband (all techs)	61	69	71	71
Households with fixed broadband (fibre and cable)	44	56	61	62
Municipalities with access to FB (all techs)*	52	62	75	79
Municipalities with access to FB (fibre and cable)*	43	53	68	73

Sources are: *National Telecommunications Agency (Anatel); all others: Regional Center for Studies on the Development of the Information Society (Cetic). Access to fixed broadband is defined as the municipality that has at least five contracts with a minimum speed of 2 Mbps connected with cable and fibre per 100 people. "All techs" include fixed broadband contracts with the infrastructure of optic fibre, cable, radio, satellite, LTE, or indetermined.

Table B2: Share of Jobs that Can Be Done from Home

Occupation	U.S. (O'Net)	Brazil (author)
Computer and Mathematical Occupations	1.00	1.00
Education, Training, and Library Occupations	0.98	0.94
Legal Occupations	0.97	0.94
Business and Financial Operations Occupations	0.88	0.92
Management Occupations	0.87	0.77
Arts, Design, Entertainment, Sports, and Media Occupations	0.76	0.38
Office and Administrative Support Occupations	0.51	0.54
Architecture and Engineering Occupations	0.61	0.22
Life, Physical, and Social Science Occupations	0.54	0.52
Community and Social Service Occupations	0.37	0.40
Sales and Related Occupations	0.28	0.42
Personal Care and Service Occupations	0.26	0.10
Protective Service Occupations	0.06	0.00
Healthcare Practitioners and Technical Occupations	0.05	0.07
Transportation and Material Moving Occupations	0.03	0.02
Healthcare Support Occupations	0.02	0.03
Farming, Fishing, and Forestry Occupations	0.01	0.01
Production Occupations	0.00	0.02
Installation, Maintenance, and Repair Occupations	0.01	0.00
Construction and Extraction Occupations	0.00	0.00
Food Preparation and Serving Related Occupations	0.00	0.00
Building and Grounds Cleaning and Maintenance Occupations	0.00	0.00
General Mean	0.37	0.23

Notes: Connected municipalities (T) are those that had at least five points of access of fixed broadband per 100 people with at least 2 Mbps of contracted speed in March of 2020. Connected and unconnected municipalities (C) are matched at the quintile of GDP per capita and stock of employees per firm of 2019. Data sources: Panel A: Ministry of labor (2021a), socioeconomic characteristics of municipalities (top two lines of Panel B and all Panel D): Brazilian Institute of Geography and Statistics (2020), telecommunications data (bottom three lines of Panel B): National Telecom Regulator (2020), Covid-19 related statistics: Ministry of Health and Ministry of Finance (2020).

Table B3: Impact by Gender (NWFH)

		Separation		Hiring	
		Employees	Wage	Employees	Wage
Panel A: High-Skilled	Male	-0.070***	0.000	0.035**	0.005
		(0.013)	(0.064)	(0.017)	(0.011)
	Female	-0.099***	0.007	0.146***	-0.019**
		(0.019)	(0.007)	(0.021)	(0.009)
p-value (Male - Fem)		0.01	0.80	0.00	0.09
Panel B: Low-Skilled	Male	0.020	0.013*	-0.200***	-0.004
		(0.021)	(0.007)	(0.038)	(0.019)
	Female	-0.062**	0.011	-0.103*	0.021
		(0.028)	(0.009)	(0.055)	(0.023)
p-value (Male - Fem)		0.01	0.97	0.15	0.71

Notes: differences-in-differences coefficient estimates. Outcome variables are in log. All other specifications: please see Table 2.

Table B4: Impact by Age (WFH)

		Separation		Hiring	
		Employees	Wage	Employees	Wage
Panel A: Youngest	Male	-0.125***	0.006	0.016	0.009
		(0.017)	(0.011)	(0.017)	(0.011)
	Female	-0.145***	-0.004	0.121***	-0.020**
		(0.014)	(0.012)	(0.019)	(0.009)
p-value (Male - Fem)		0.35	0.64	0.00	0.25
Panel B: Young	Male	-0.091***	0.009	-0.071***	-0.018
		(0.017)	(0.016)	(0.024)	(0.018)
	Female	-0.124***	-0.004	-0.021	0.019
		(0.013)	(0.011)	(0.031)	(0.016)
p-value (Male - Fem)		0.13	0.64	0.20	0.16

Notes: differences-in-differences coefficient estimates. Outcome variables are in log. Individuals are divided between youngest (28-39 years old) and young (40 years old and above).