Pink Tech: Did Computers and the Internet Reduce the Gender Wage Gap? Evidence from Brazilian Data

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ABSTRACT

Despite the increase in female participation in the Brazilian labor market and a reduction in the average wage gap between men and women, there are gender inequalities in the distribution of workers within sectors and occupations and different degrees of formalization of employment (Bruschini 2007; Itaboraí and Ricoldi 2016). Some studies associate the reduction of the wage gap with a set of skills held by women in certain occupations, making them more able to face technological challenges (Black and Spitz-Oener 2010). We study the factors that are related to the reduction in the wage gap by turning our attention to the job tasks performed by men and women. Could tasks associated with occupations with a greater female presence allow women better reactions in terms of wage growth and formal employment in the face of a series of technological challenges? The results indicate that in markets more specialized in routine tasks the growth of wages and job formality for women is higher than for men. This evidence is robust to the inclusion of regional internet density as an independent variable.

Keywords: *Brazilian labor market; Gender wage gap; Internet; Routine Tasks.JEL: J01,J16,J70,B54*

RESUMO

Apesar do aumento da participação feminina no mercado de trabalho brasileiro e da redução da diferença salarial média entre homens e mulheres, há desigualdades de gênero na distribuição dos trabalhadores por setores e ocupações e diferentes graus de formalização do emprego (Bruschini 2007; Itaboraí and Ricoldi 2016). Alguns estudos associam a redução da diferença salarial a um conjunto de competências detidas pelas mulheres em determinadas ocupações, tornando-as mais aptas para enfrentar os desafios tecnológicos (Black and Spitz-Oener 2010). Estudamos os fatores que estão relacionados com a redução da diferença salarial, voltando nossa atenção para as tarefas de trabalho desempenhadas por homens e mulheres. As tarefas associadas a ocupações em setores com maior presença feminina poderiam permitir às mulheres melhores respostas em termos de aumentos salariais e crescimento de emprego formal quando diante de desafios tecnológicos? Os resultados indicam que em mercados mais especializados em tarefas rotineiras o crescimento relativo dos salários e da formalidade do trabalho para as mulheres é maior do que para os homens. Esta evidência é robusta para a inclusão da densidade regional da internet como uma variável independente.

Keywords: *Mercado de trabalho; Gap de gênero do salário; Internet; Tarefas rotineiras*

Área Anpec: 13 *Economia do Trabalho*

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1 Introduction

In the last two decades, we have seen increasing female participation in the Brazilian labor market and a reduction in the average wage gap between men and women. In 2010 women received 67.7 percent of men's income. In 2019 women were occupying 43.7 percent of jobs and received 77 percent of the value of men's income (IBGE, 2010; 2020). The average monthly income of employed women (IBGE, 2010) in 2010 was R$ 1074.00 (US$ 606.78) and the men's was R$ 1587.00 (US$ 896.61). In 2019, average women's earnings were R$ 1,985.00 (US$ 503.07), 77.69 percent of men's earnings which were R$ 2,555.00 (US$ 647.67) (IBGE, 2020).

The gender wage gap is more salient in some sectors of activity. In 2010 in the scientific and technical sector, women held 45 percent of jobs and received an average of 63 percent of the men's earnings. In the sector of personal and domestic services, where workers have the lowest average earnings, women are 84 percent of the employed workforce, earning on average 52 percent of the men's wages (IBGE, 2010). In the domestic services sector, with informality reaching 72.5 percent of workers, only 26.5 percent of employed women hold a formal job, receiving on average 92 percent of men's wages.

In most developed countries we can observe a rising segregation by skill groups in employment prospects with impacts in local labor markets (Schlitte 2012). The literature also identified a strong relationship between occupational segregation and gender wage differential (Anker 1998; García-Mainar, Montuenga, and García-Martín 2018). Thus, the drivers of concentration and segregation are studied as part of the gender inequality concerns and politics (Browne 2006; Borrowman and Klasen 2020; Das and Kotikula 2019). Blau and Kahn (2017) suggest that explanations reported in the literature, such as schooling, experience, sectors of activity or type of occupation are not enough to understand the phenomena and new factors could be used to explain the differences in outcomes.

Moreover, the gender segregation in the labor market does not seem to be fully explained by differences in skill levels between men and women. We have that, on the one hand, female concentration in certain occupations with lower wages and fewer opportunities for promotion are associated with a higher gender wage gap. On the other hand, gender differences in outcomes might also indicate that women's work is socially and culturally devalued (García-Mainar, Montuenga, and García-Martín 2018).

In development countries there are still severe constraints to women's participation in labor market (Leone and Baltar 2006; Bruschini 2007; Madalozzo 2010) hence it is important to assess whether the drivers of gender inequality in the Brazilian labor market could affect women's abilities to face the current competition for jobs.

The task approach has been successfully applied to the analysis of the effect of new technologies on the labor market (Autor, Dorn, and Hanson 2015; Autor and Dorn 2013). One of the possible effects of new technologies is the change in educational and training requirements to apply for jobs (Spitz-Oener 2006; Zeyer-Gliozzo 2020). Another effect regards the change in abilities to face new technologies and survive in the world of work (Acemoglu and Restrepo 2019; Autor and Price 2013; Akerman, Gaarder, and Mogstad 2015).

Within the many approaches to study gender inequality in the labor market, the analysis of the characteristics of the tasks performed in each type of occupation has not been explored enough

in the case of Brazil. Nevertheless, current studies suggest that abstract tasks, which require skills that are not easily replaced by technology, are negatively correlated to the probability of being informal and would be important in explaining another type of inequality related to the wage gap between formal and informal jobs (Sulzbach 2020).

We study the factors that are related to the reduction in the gender wage gap and we pay attention to the tasks performed by men and women. Could tasks associated with occupations with a greater female presence allow better reactions in face of new technological challenges? Our empirical strategy uses Brazilian Census data and we follow Autor, Dorn, and Hanson (2015) and Autor and Dorn (2013) work to measure specialization in routine jobs in local labor markets. We delimit local labor markets as the Census micro-regions, and perform the exercise in two steps. First, we estimate the change in the average wages and job formality of men and women, considering the characteristics of the labor market in 2000 and 2010. This step reduces the influence of demographic changes on earnings and formality from 2000 to 2010. Second, we assess the relationship between the gender differences in wage growth and in job formalization and the type of tasks performed in each local market.

Our working hypothesis is that the computarization of routine-intensive jobs is more likely to affect men's situation in the labor market. Typically female work, either manual or abstract, would be less prone to being replaced by technology. Our results indicate that in markets more specialized in routine tasks the growth of wages and job formality for women is higher than for men. The results are robust to the inclusion of regional internet density as an independent variable, and the inclusion of male-female differences in the initial endowment of job tasks. Moreover, we find that internet density is positively correlated to higher wage growth for women. We interpret this result as indicating the presence of *pink-tech* in the labor market. Although computerization of tasks was initially implemented to increase productivity, technology could bring unintended positive and differentiated results for women.

After this introduction, we present an overview of the participation of women in the Brazilian labor market, according to the sectors of activity and the type of task performed. Then we present the empirical model to match evidence and discuss results.

2 Evidence on gender differences in the labor market

2.1 Activities

The rate of employment activity was 76 percent for men and 55 percent for women, respectively, according to data from the 2010 Demographic Census (IBGE). Female activity rates increased by 6 percentage points compared to the data from the previous census (2000), indicating an increase in female participation in the labor market. Still, there are gender inequalities that persist in all sectors of economic activity. Some of these inequalities are related to the industry or sector of economic activity in which men and women are inserted, as well as their wages and rate of formalization of employment.

Regarding the sector of activity, there is a higher proportion of women employed in Personal and Domestic Services, Education and Health, as illustrated in Figure 1. This figure shows the

proportion of women in relation to the total number of employees in each sector of economic activity in 2000 and 2010.

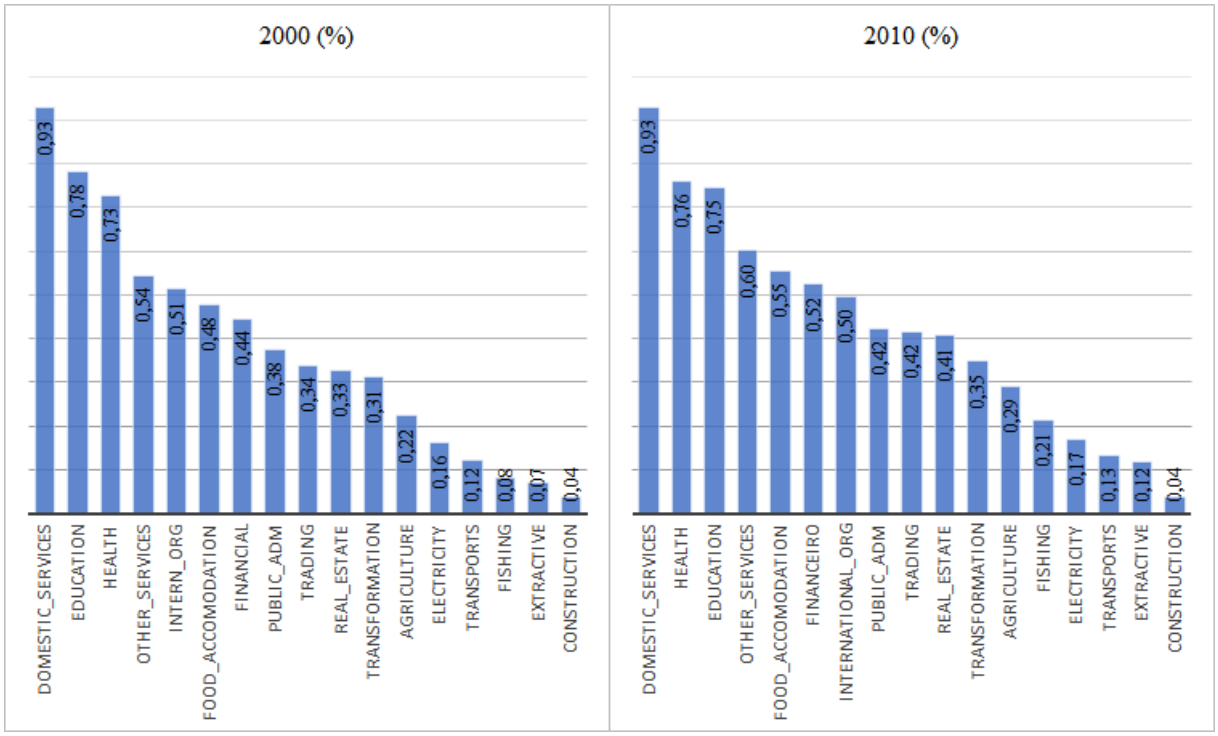

Figure 1: Women insertion on the labor market in Brazil (Census, 2000 – 2010)

In the two years represented in the previous figure, the sector with the highest female participation was that of Domestic Services. This sector is the one with the lowest average earnings (with average monthly values below those of a minimum wage) and the worst rate of formalization of employment (Figure 2) among non-agricultural sectors, according to data from the last two demographic censuses.

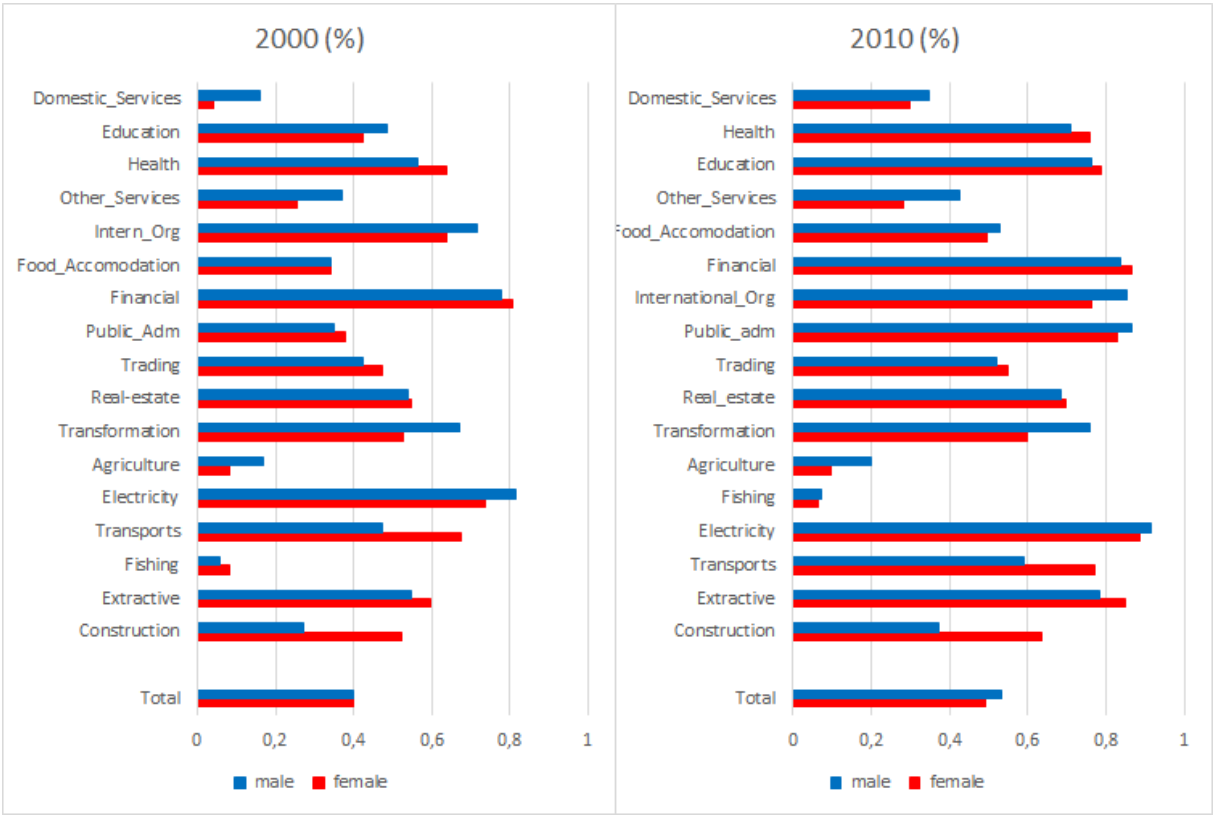

Figure 2: Formalization of employment by sector of activity (Census, 2000 - 2010)

Regarding employment status, there was an increase in formalization in the period from 2000 to 2010, for both women and men (Table 1). This positive variation in the number of formal job positions increases social security for workers in all sectors of activity.

Despite the positive consequences on the way in which women enter the labor market, the scale of the change was not sufficient to reduce gender inequalities. The increase of 7% observed in the formalization rate among women was less than the 10% observed among men.

Table 1: Status of employment, proportion of workers by gender (Census, 2000 – 2010)

	2000 (%)			2010 (%)		
Status of employment	Male	Female	Total	Male	Female	Total
Employees (formal contract)	39	41	40	49	48	48
Military a	05	09	06	04	08	06
Employees (no formal contract)	23	29	25	18	25	21
Self employed	30	18	25	26	18	23
Employers	04	02	03	02	02	02
Total number of workers	37,432,477	22,266,415	59,698,892	46,747,788	33,753,227	80,501,015

Source: IBGE, demographic census data (2000 and 2010). Note: (a) Military and statutory civil servants.

Gender inequalities are a structural feature of the Brazilian labor market. In general, regardless of the sector of activity, women receive lower incomes than men in the same occupation. According to data from the 2010 demographic census, the average monthly income of employed women was R$ 1,074.00 (US$ 1,879.50), while that of men was R$ 1,587.00 (US$ 2,777.25).

This difference in remuneration between women and men is more expressive in some sectors of activity, as shown in Figure 3.

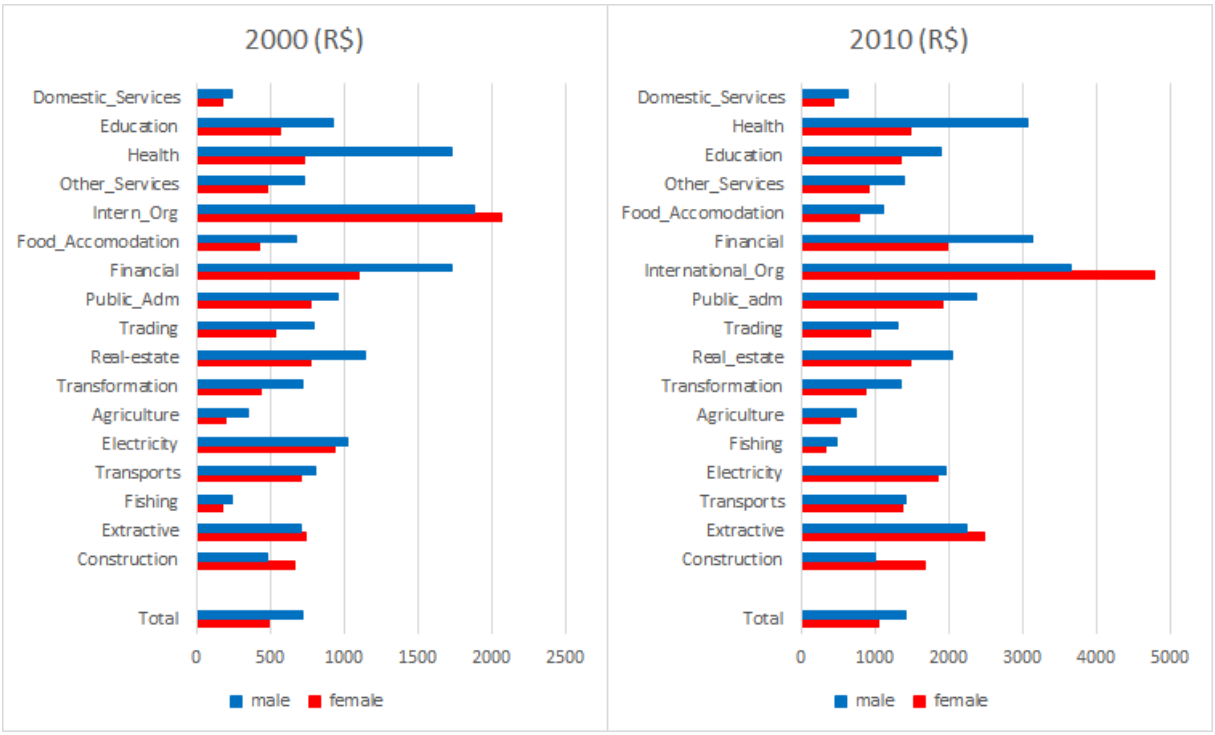

Figure 3: Wages by sector of activity (Census, 2000 - 2010)

The female workers, however, have a higher level of education than the average for men. This data can be checked in Table 2, which presents statistics on the Brazilian labor market in 2000 and 2010.

Higher education among women does not guarantee that they will enter the labor market in formal positions, nor that they are better paid. Despite suggesting that there has been a reduction in inequality in educational access, this phenomenon contributes to the perpetuation of gender inequalities in labor relations.

2.2 The tasks

The tasks are classified into two groups depending on the skills required from a worker to perform them: (i) routine tasks; (ii) non-routine tasks. According to Spitz-Oener (2006), non-routine tasks can be more analytical, interactive or manual intensive. Hence, it is possible to find more than one classification criteria. To describe the Brazilian labor market, we classify tasks into three groups: non-routine abstract (NRA), non-routine manual (NRM) and routine (R) tasks.

The set of skills demanded from workers that perform NRA tasks on a daily basis includes creation, evaluation and interaction, which cannot be simulated by a computer. One typical example of an NRA-intensive occupation is the activity of a teacher. NRM tasks depend on manual skills and don't follow a specific pattern, so workers that perform this kind of task

Table 2: Statistics from the labor market, 2000 - 2010.

Panel A: Mean - 2000				
	Women		Men	
Variable	Informal	Formal	Informal	Formal
Age(years)	35.08	33.52	35.33	34.15
Education(years)	7.07	9.07	5.73	7.72
Income (R$)	416.70	583.00	601.06	882.48
Hours	38.20	42.06	45.87	47.04
Married	0.57	0.50	0.65	0.69
Urban	0.80	0.94	0.71	0.90
In school	0.15	0,15	0.11	0,11
Panel B: Mean - 2010				
	Women		Men	
Variable	Informal	Formal	Informal	Formal
Age(years)	36.71	35.11	36.71	35.50
Education(years)	7.37	10.80	6.44	8.98
Income (R$)	747.42	1330.91	1116.43	1662.80
Hours	34.60	39.73	40.39	43.21
Married	0.59	0.55	0.62	0.66
Urban	0.81	0.96	0.74	0.93
In school	0.16	0.16	0.14	0.12

Source: prepared by the authors based on demographic census data (2000 and 2010)

cannot be easily replaced by machines either, as is the case of a bus driver, for example. Finally, routine (R) tasks are the ones that can be performed by a computer or a machine instead of a person. These basic characteristics of tasks are the reason why non-routine tasks (NRA and NRM) are expected to positively relate to wage growth when there is greater access to the Internet, because these tasks are complemented by technology, unlike routine tasks, which are replaced by technology.

Figure 4 illustrates the proportion of tasks that workers performed on their main jobs in a daily basis in Brazilian labor markets (2000 and 2010). There is an evident change in the distribution of tasks among women in the informal labor market. Between 2000 and 2010, the data suggests women have switched from performing more routine tasks to concentrating on non-routine tasks. In the formal labor market, they are more often performing NRA tasks, while in the informal market, they perform more NRM tasks. Regardless of gender heterogeneity , this general movement was expected with the computerization of jobs. The distribution of tasks among men remained similar over the years. We also note that men do more routine than non-routine tasks.

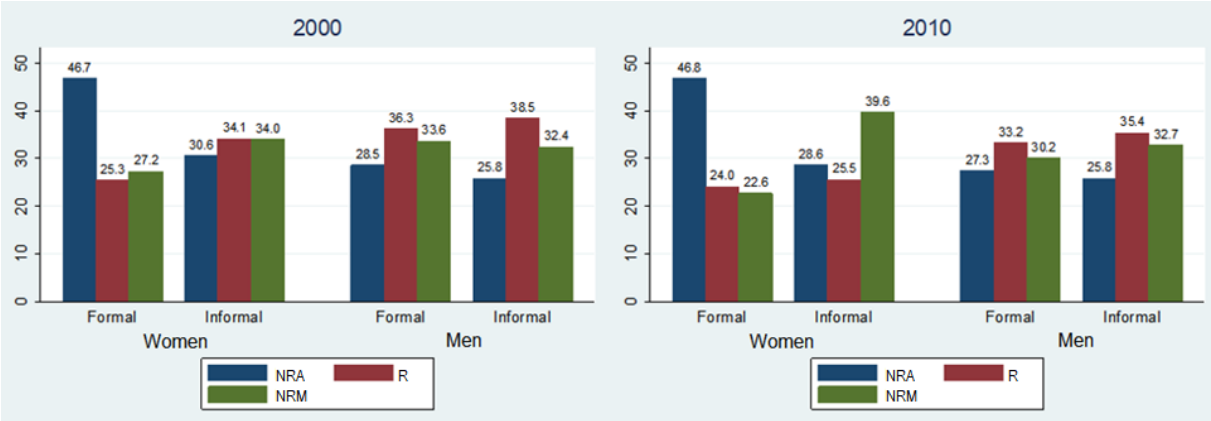

Figure 4: Proportion of Tasks (Census, 2000 - 2010)

We also analyze workers' characteristics according to the type of task they usually perform more frequently. Table 3 shows the distribution of workers by gender and status of employment, in three scenarios established based on the relative importance of tasks in the main occupation. We take the 75th percentile of each task proportion, and interpret that group of workers as "people who are very concentrated in this type of task, compared to other tasks".

In Panel A (Table 3) we analyze the distribution of workers who do much more routine tasks than non-routine tasks ($R > 0.75$ means that among all the tasks performed by these workers, the proportion of routine tasks is bigger than 75%). In Panels B and C, we analyze the distribution of workers with $NRA > 0.75$ and $NRM > 0.75$. Note that the female participation is bigger in these two groups than in the first one. This means women are more concentrated in non-routine tasks, while men seem to be more frequent among workers who concentrate in routine tasks.

Table 3: Proportion of workers by type of most executed task.

	Female - 2000		Male - 2010		Female - 2010		Male - 2010	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Panel A: Routine >0.75								
Formal	0.0721	0.0381	0.1338	0.0819	0.1273	0.0499	0.1986	0.0887
Informal	0.2647	0.0407	0.5294	0.0919	0.2633	0.0429	0.4108	0.0966
Panel B: Non Routine Abstract >0.75								
Formal	0.2039	0.0223	0.2888	0.0449	0.2544	0.0308	0.3493	0.0213
Informal	0.2223	0.0334	0.2850	0.0335	0.1975	0.0268	0.1988	0.0228
Panel C: Non Routine Manual >0.75								
Formal	0.1254	0.0529	0.2317	0.0946	0.1858	0.0504	0.2948	0.0748
Informal	0.2328	0.0436	0.4101	0.1055	0.2224	0.0380	0.2970	0.0853

Source: prepared by the authors based on demographic census data (2000 and 2010). Panel A uses the upper quartile of the distribution of routine tasks. Panel B uses the upper quartile of the distribution of non-routine tasks. Panel C uses the upper quartile of the distribution of non-routine manual tasks.

Figure 5 shows how skills demanded from women and men differ in some industries. Note that

the first four sectors of activity (Domestic Services, Education, Health and Other Personal Care and Social Services) are the ones with the greatest female participation in the Brazilian labor market. The next four (Transports, Fishing, Extractive and Construction) are the sectors with the least proportion of female workers. In all sectors with a greater participation of women (the stereotypes of female work), we found a greater presence of NRA and NRM tasks. In other sectors, women also perform more non-routine activities than men.

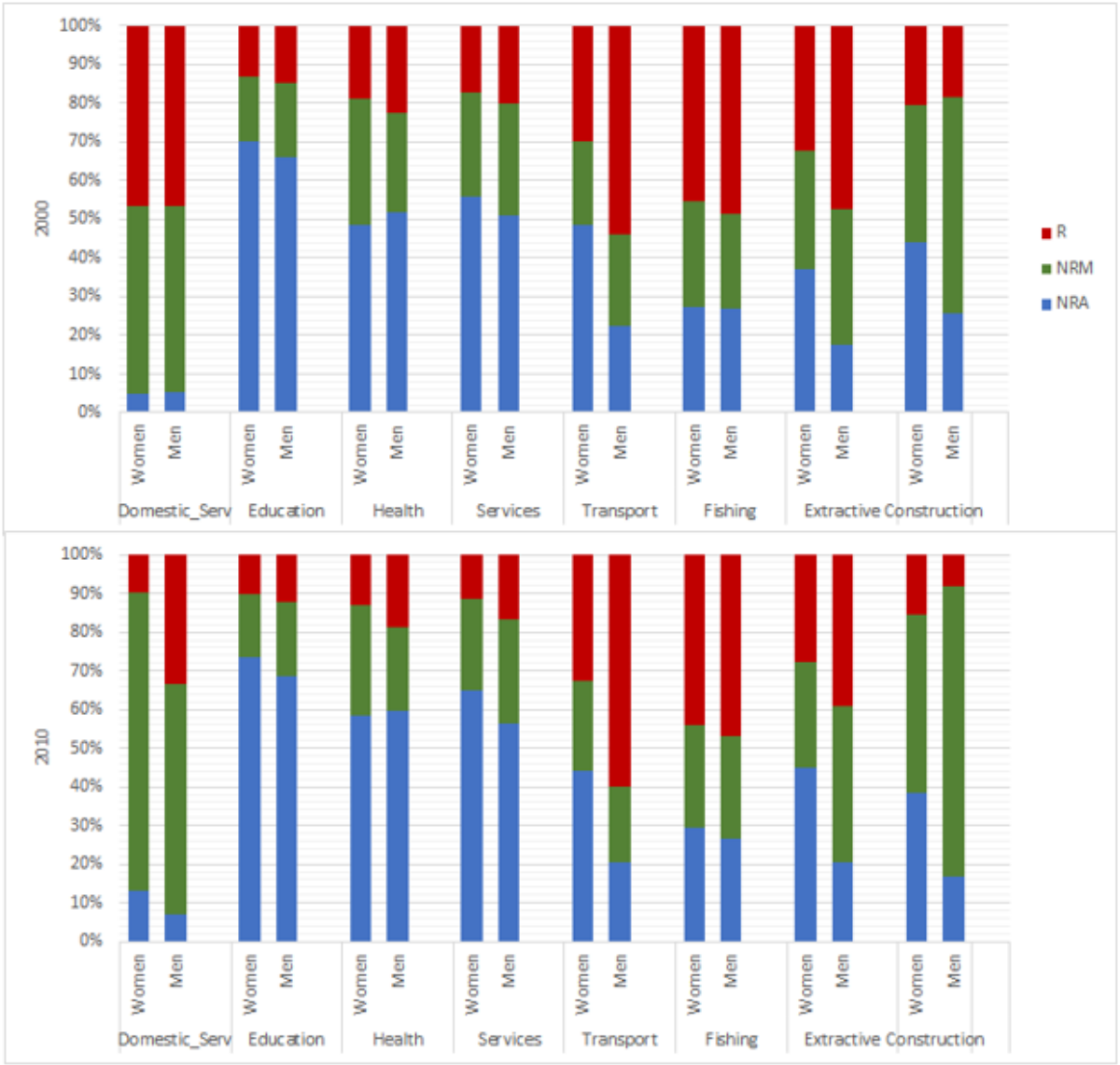

Figure 5: Proportion of tasks by gender in selected sectors (Census, 2000 - 2010)

3 Measuring the local market exposure to technology

In their pioneering work, Author, Levy and Murnane (2003) formalized the theory on how computerization shifted the demand for skilled labor and changed the type of tasks performed by workers in their jobs. The literature has since expanded to include the analysis of the polarization of the United States labor market. Autor and Dorn (2013) find evidence that computeriza-

tion substitutes low-skill workers in performing routine tasks while complementing non-routine tasks. Non-routine tasks include the abstract, analytical, and interactive tasks typically performed by workers with higher educational levels, whose trajectories have diverged from the path of less-skilled workers reallocated to service jobs.

The effects of computerization on the labor market are not equivalent to the result of other well-studied shocks such as the increase in trade flows with China. Author, Dorn and Hanson (2015) analyze the simultaneous impact of technological progress and trade with China on the employment level in the United States. The authors find that computerization affects the composition of employment in the sectors, reducing employment in occupations characterized by routine-tasks such as clerical, production, and sales, while increasing employment in managerial, technical, and professional occupations. The import competition coming from increased trade flows, on the other hand, is associated with a net employment decline, especially for manufacturing and non-college workers.

Acemoglu and Restrepo (2019) underline that the net effect of automation on employment is an open question. Technological advances allow greater flexibility in factor allocation and increase productivity. While some workers find their jobs being replaced by automation, increased productivity contributes to the demand for labor in non-automated tasks. Moreover, technological advances create demand for new skills and tasks while not completely eliminating previous ones.

Our variable indicating exposure to computerization was constructed following Autor, Dorn, and Hanson (2015) and Autor and Dorn (2013) and measures the degree to which local markets are historically specialized in routine job activities. We start with 594 4-digit occupational categories in the 2010 census that were classified by Reis (2016) according to the description of job tasks given by the Brazilian Code of Occupation (COD). Each occupation is described by a set of tasks separated into routine, manual, and abstract categories. The variable RTI_k is an index increasing in the participation of routine tasks in the occupation k:

$$RTI_k = ln(T^R_{k,t}) - ln(T^M_{k,t}) - ln(T^A_{k,t})$$

Where $T^R_{k,t}$, $T^M_{k,t}$ and $T^A_{k,t}$ are, respectively, the routine, manual, and abstract tasks inputs in occupation k in year t. To distinguish high and low participation of routine tasks in each occupation, we use a binary indicator for occupations in the upper 66th percentile of the RTI_k distribution. The final variable used in the regressions is the microregion j employment share measure equal to the fraction of the local market's employment assigned to routine task-intensive occupations:

$$RSH_{jt} = \left[\sum_{k=1}^{k} L_{jkt} I(RTI_k > RTI^{p66})\right] \left(\sum_{k=1}^{k} L_{jkt}\right)^{-1}$$

Where L_{jkt} is total employment in microregion j, at time t, in occupation k, and I(.) is an indicator function taking value equal to one if the occupation was classified as routine intensive.

We expect that historical differences in industry specialization across microregions persist over time, suggesting an instrumental variable approach that uses information in previous decades

regarding the routine task intensity in different industries. Consider the share of routine tasks among workers in industry i given by $R_{i,t-1}$ and the employment in industry i in the local market j given by $E_{i,j}$. The instrumental variable suggested by Autor and Dorn (2013) follows a Bartik-type structure that combines the national value of $R_{i,t-1}$ in all Brazilian states except the one that includes microregion j and the industry employment in the region, so that the instrument is given by:

$$ivRSH_j = \sum_{i=1}^{I} E_{i,j,t-1} R_{i,-j,t-1}$$

Information on occupations in the Brazilian census is less extensive than in developed countries since codes and definitions have changed over time. It is possible to map the occupational codes in the 2010 census to the 2000 data and 1991 data using cross-paths made available from the Brazilian Institute of Geography and Statistics (IBGE). To incur in minimal loss of information, the construction of RSH_j and RTI_k use the 2000 census, and the 1991 census data is used in the $ivRSH_j$ variable. The availability of personal computers in the early nineties was severely halted by import tariffs, which declined in the first half of the decade with a broad trade liberalization program. We are comfortable using the 1991 industry structure as an instrumental variable correlated to potential computerization inside firms in the following decade.

In table 4 we show some characteristics of the local labor markets with the Census 2000 data. In the top panel we display information for all microregions, indicating the situation of the labor market (the share of formal employment, the logarithm of earnings, and the logarithm of per capita GDP), and the profile of the population and labor force (share of high school dropouts, unskilled workers with less than secondary, urban areas, share of persons under 25 years old, share of unskilled male workers). The lower panel has the same variables only for the areas in the upper quartile of the RSH_j distribution. It is clear that areas that concentrate routine-intensive jobs also face lower wages, less job formality, and a more precarious skill-level of workers.

The second technological change in the labor market we consider in this article is the roll-out of broadband internet. Starting in 2007 the Brazilian Communications Regulatory Agency (Anatel) provided information per municipality for the number of broadband internet subscriptions. The variable used in our exercise is the density of access which counts the subscriptions per 100 households.

The variables used to construct the instrument for $Internet_{j,2007}$ come from the 2000 census and include the average household ownership rate of personal computers and the ownership of telephone landlines. We link this information to the 1999 MUNIC data from IBGE on infrastructure at the city level, which indicates the presence of internet providers in the municipality. In the early 2000s the main mode of internet access was dial-up services. We created an instrument for internet density in 2007 that uses the chance of access to dial-up in area j in 2000. That final variable consists of the following product:

$$ivInternet_{j,2000} = Computers_{j,2000} X Telefones_{j,2000} X Provider_{j,1999}$$

Table 4: Statistics for the labor market, 2000 - 2010.

	(1)	(2)	(3)	(4)
Panel A: Local labor markets in all microregions				
	Formal employment	Log earnings	Dropouts	Unskilled
Mean	0.39	2.90	0.28	0.44
Std. Dev.	0.15	0.40	0.06	0,05
	Urban	Young	Unskilled male	Log(GDP)
Mean	0.80	0.24	0.07	1.61
Std. Dev.	0.17	0.02	0.01	0.72
Panel B: Local labor markets in the upper quartile of RSH				
	Formal employment	Log earnings	Dropouts	Unskilled
Mean	0.13	2.61	0.33	0.49
Std. Dev.	0.07	0.18	0.06	0.03
	Urban	Young	Unskilled male	Log(GDP)
Mean	0.49	0.22	0.09	0.45
Std. Dev.	0.09	0.01	0.01	0,.37

Note: Author's calculations with census data. All variables are dated from the beginning of the period in 2000. 413 observations at the microregion level. Population weighted statistics

Figure 6 (Graphs A1 and A2) shows the correlation between instruments and variables of interest in the data. One should note that the chance of connecting to the internet in 2000 is small and varies across regions. Even though the technology of access changed from 2000 to 2007, both in quality and access mode, $ivInternet_{j,2000}$ and $Internet_{j,2007}$ are positively correlated.

The statistical offices in Brazil do not collect data on information technology (IT) investment at the establishment level. The intuition behind our choice is that historical knowledge of computers should persist in a region, providing workers with higher affinity to IT once the latter is adopted by firms. Moreover, there is substantial heterogeneity in technology provision across regions since the initial expansion of network services relied on the local infrastructure of landlines bought by each private company from regional-level public services. Figure 7 shows the regional distribution of $ivInternet_{j,2000}$ in the country. As expected, the chances of a household accessing dial-up internet were small, but varied across areas.

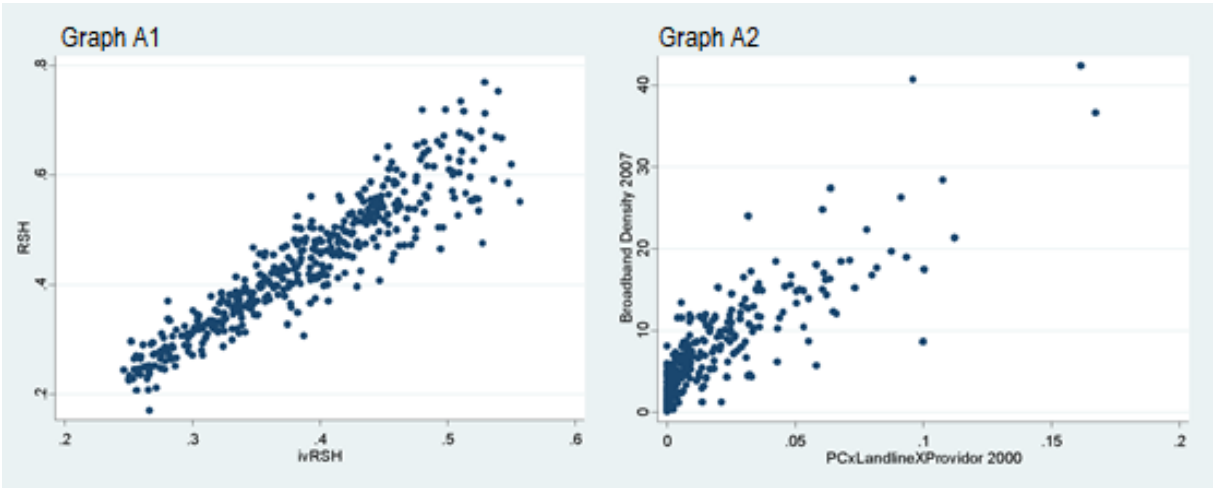

Figure 6: Correlation between instruments and variables of interest in the data

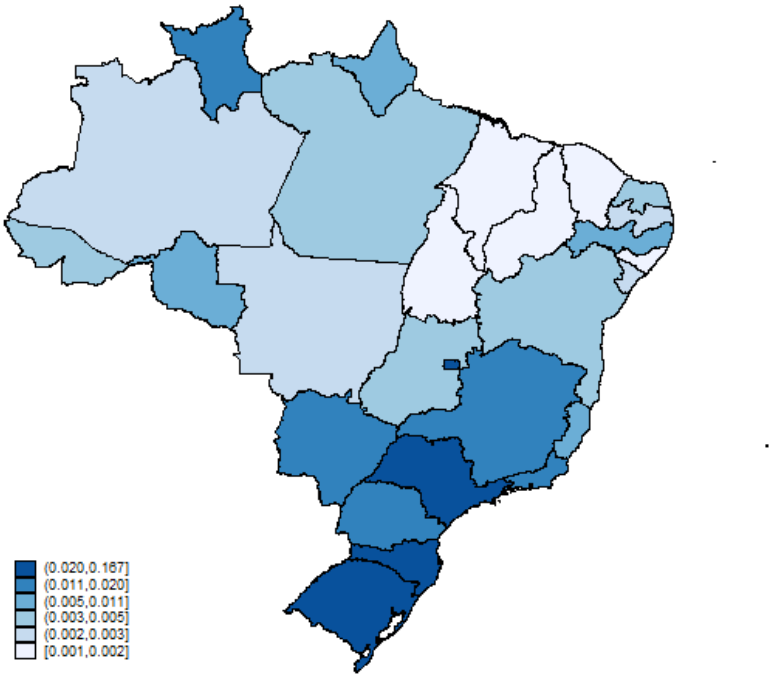

Figure 7: Probability of household access to internet with dial-up in 2000

Finally, we provide a check of the mechanism linking gender gaps in the labor market and technology exposure. Our working hypothesis is that in markets where female labor concentrated on non-routine tasks, women's jobs should be less challenged by technological changes. Figure 8 (Graphs A3 and A4) shows in the horizontal axis the regional difference in female minus male share of routine job tasks in 2000 or $\Delta_g Share\_routine_{2000\,j}$.

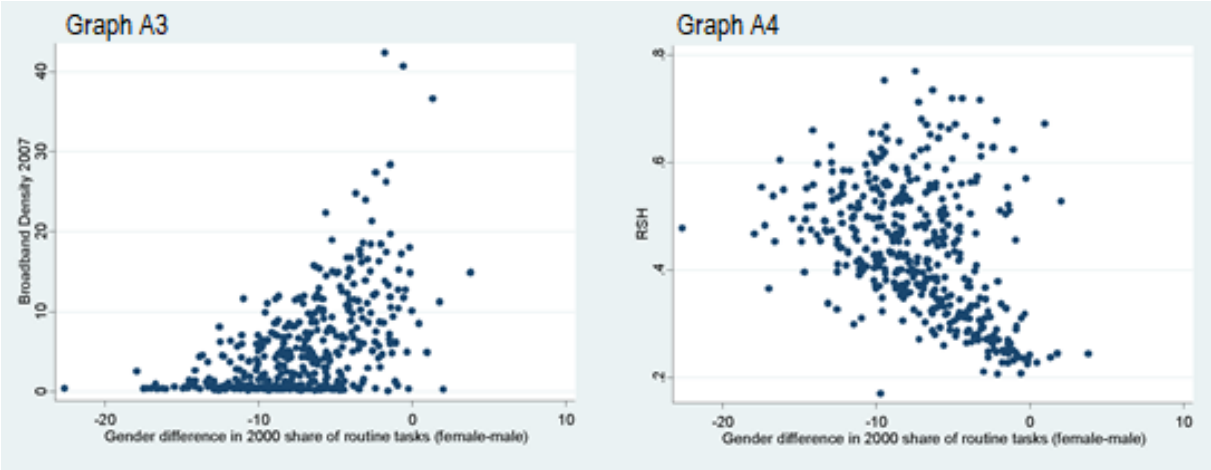

Figure 8: Gender gaps in the labor market and technology exposure

There are differences across markets, but the average value of $\Delta_g Share\_routine_{2000j}$ is negative. Interestingly, the correlation between $\Delta_g Share\_routine_{2000j}$ and RSH_{j2000} is negative, and the relationship between $\Delta_g Share\_routine_{2000j}$ and $Internet_{j2000}$ is positive. The data suggest that broadband expansion could have benefited women in markets where their relative participation in non-routine tasks was higher and possibly complemented by internet use. We assess this relationship in the next section with regression exercises.

4 Econometric analysis

The empirical strategy of this study was developed in two stages. In the first stage we estimate the variation between 2010 and 2000 average wages and job formality of men and women, considering the characteristics of the workers in the local labor market. In the second stage, we check whether there is a relationship between the growth in wage and formalization of employment and the type of task most frequently performed in the region.

For each census year and gender group we run the following regression with ordinary least squares:

$$log\,(y_i) = b_0 + b_1 age_i + b_2 age_i^2 + \sum_1^k \alpha_k edu\_dummy_{ik} + \mu_j + u_i \tag{1}$$

$$emp_i = b_0 + b_1 age_i + b_2 age_i^2 + \sum_1^k \alpha_k edu\_dummy_{ik} + \mu_j + u_i \tag{2}$$

where y_i are earnings of worker i, and emp_i is a dummy indicating with one whether the worker has a formal job. The covariates include age, age squared, dummies for educational levels, and a dummy for each microregion μ_j. The coefficients for μ_j capture average log wages in equation and formalization rate in equation (2) in the local labor market, netting out the demographic

changes in experience and education of workers. This first step serves to calculate the decennial growth of wages and formal employment: $\Delta\mu_j = \mu_{2010j} - \mu_{2000j}$.

The dependent variable for the second step of the exercise is the difference over time between women's and men's average outcomes or $\Delta\mu_j$, given by $\Delta_g\Delta\mu_j$. We call this difference the gender gap, since a higher $\Delta_g\Delta\mu_j$ indicates that women's situation is improving, or their average wages (or job formalization) are growing faster than men's average wages (or job formalization).

We estimate the following equation using two-stage least square:

$$\Delta_g\Delta\mu_j = \delta_0 + \delta_1 RSH_{2000j} + x_j\beta + \gamma_s + \varepsilon_j \tag{3}$$

Where RSH_{2000j} is constructed as the proxy developed in Autor and Dorn (2013) for the specialization in routine tasks in a local market. The instrument for RSH uses the product of the industry employment structure in the previous decade and the routine share of jobs in the industry in the 1991 census. We include in the specification the dummies for states γ_s, and covariates x_j that represent the characteristics of the area such as changes between 2010 and 2000 in the logs of industry, services, and agriculture output, and the changes in the share of unskilled workers, share of high-school drop-out, share in workers in urban areas, share of young workers, and share of young unskilled male workers.

As discussed previously, routine tasks are prone to be substituted by technology while also concentrating male workers. We conjecture that in markets specialized in routine tasks the growth of wages and job formality for women will be higher than for men, hence we expect a positive δ_1 estimate in equation (3).

To further the argument that technology has improved women's position in the labor market by a greater extent than men's position, we consider a more direct measure of technological advancement given by the density of access to broadband internet. We have information for the number of subscriptions per 100 households for broadband access in each Brazilian city starting in 2007, which we aggregate to form $Internet_{2007j}$. We estimate the relationship between the difference in women's and men's $\Delta\mu_j$ and internet density in the local market. As discussed previously, internet access only expanded in Brazil after the privatization of telecommunications companies starting in 1999.

We run the following extension of equation (3) in the regression with two-stage least square:

$$\Delta_g\Delta\mu_j = \delta_0 + \delta_1 RSH_{2000j} + \delta_2 Internet_{2007j} + x_j\beta + \gamma_s + \varepsilon_j \tag{4}$$

We also perform a check of the mechanism that connects the reduction of the gender gap and the realization of job tasks by women. Using the distribution of jobs in 2000 we calculate the difference between the share of routine tasks in jobs held by women in the local market j minus the share of routine tasks in jobs held by men in the same region in 2000, given by $\Delta_g Share\_routine_{2000j}$. We estimate the following equation:

$$\Delta_g \Delta\mu_j = \delta_0 + \delta_1 RSH_{2000j} + \delta_2 Internet_{2007j} + \delta_3 \Delta_g Share\_routine_{2000j} + x_j\beta + \gamma_s + \varepsilon_j \quad (5)$$

We expect that in markets where women start with a higher relative concentration in routine tasks the improvement in the gender gap over the decade will be smaller, hence δ_3 should be negative. Table 5 shows the basic statistics of the variables of interest. We stress that the growth in earnings for women was higher than for men across the board. Nevertheless, female labor is still allocated more heavily in informal positions and this source of inequality in job quality has not improved over the decade.

Table 5: Basic statistics of the variables of interest.

	(1)	(2)	(3)	(4)
	$\Delta_g\Delta_t$ Log earnings	$\Delta_g\Delta_t$ Formal job	RSH	Internet Density
Mean	3.43	-0.04	0.34	12.84
Std dev.	0.39	0.04	0.08	11.44
	Δ_g Share routine	Providor	Computer	Telephone
Mean	-4.51	0.61	0.10	0.37
Std dev.	3.58	0.29	0.07	0.19

Note: Author's calculations with census data. All variables are dated from the beginning of the period in 2000. Gender gaps in wages and job formality consider the change between the 2010 census minus the 2000 census. 413 observations at the microregion level. Population weighted statistics.

Table 6 shows the results for coefficient estimates in equations (3) to (5). In the first two columns we have the values for δ_1 where the dependent variables are gender gaps in wages and job formalization rates, respectively. Comparing two local markets, an increase of 10 percentage point in the presence of routine-intensive jobs improves the gender gap by 1.9 percentage points for wages and 1.6 percentage points for formalization rates.

The results are robust to the inclusion of internet density in the model specification. In effect, a local market with 10 more internet connections corresponds to 0.02 percentage points relative gain for female wages, while there is no gain in female job formalization. Finally, in columns (5) and (6) we show estimates for δ_3. In a local market where women started with an extra 10 percentage points higher share of routine tasks, we find that the gender gap in wages is relatively worse by 0.04 percentage points. One should note that δ_1 is still positive and statistically significant once we consider differences in the initial endowment of job tasks given by $\Delta_g Share\_routine_{2000j}$.

The posit that the mechanism underlying our results is that the computarization of routine jobs, which historically had higher affinity with male work, would leave women in an relatively advantageous position. Female work, either manual or abstract, would be less likely to be replaced by technology. In order to separate the role of manual and cognitive tasks, we create two analogous variables to RSH: RCA is the share of work in a local labor marlet with intensive use of abstract tasks, and RNM is the share of work using mainly manual non-routine tasks. Both variables are instrumented following the distribution of employment across industries in

Table 6: Results for regression estimates - routine intensive jobs.

Variables	(1) Wages $\Delta_g\Delta\mu_j$	(2) Formal job $\Delta_g\Delta\mu_j$	(3) Wages $\Delta_g\Delta\mu_j$	(4) Formal job $\Delta_g\Delta\mu_j$	(5) Wages $\Delta_g\Delta\mu_j$	(6) Formal job $\Delta_g\Delta\mu_j$
RSH_{2000j}	0.1910**	0.1549***	0.2679***	0.1746***	0.2102**	0.1659***
	(0.0783)	(0.0446)	(0.0880)	(0.0479)	(0.0829)	(0.0460)
$Internet_{2007j}$			0.0020**	0.0005	0.0024**	0.0001
			(0.0008)	(0.0005)	(0.0010)	(0.0004)
$\Delta_g Share\_routine$					-0.0041***	-0.0006
					(0.0015)	(0.0008)
K-P stat.	394	394	142	142	134	134
Observations	413	413	413	413	413	413

Note: Robust standard errors in parentheses. Statistical significance denoted by *** 0.01, ** 0.05, * 0.1 Author's calculations with census data. Population weighted regressions. Columns (1) and (2) show coefficient estimates from equation (3), columns (3) and (4) show estimates from equation (4), and columns (5) and (6) show estimates from equation (5), respectively.

1991.

In table 7 we show the regression estimates repeating equations (3) to (5). We highlight three aspects in that table. First, as expected, an initial higher share of either intensive abstract or manual non-routine jobs in a local market reduces the improvement in the gender gap (columns 1 to 4). Second, the regressions are robust to the inclusion of internet density and initial endowments variables in the equation (columns 5 to 8). Third, cognitively or interactively abstract-intensive jobs, which are likely complemented by technology, play a quantitatively important role in reducing gender inequality in the labor market. A region with a lower 10 percentage point of abstract-intensive jobs sees a relative impromevent in the wage (formalization) gap of 5.9 percentage points (4.3 percentage points) over the decade (columns 5 and 6).

5 Final remarks

The Brazilian labor market's statistics indicate that jobs remain segregated and unequal, as expected in the gender inequality literature. We searched for potential explanations for the reduction in gender wage gap since the 2000s studying the tasks usually performed in different occupations. Analyzing the distribution of workers and occupations in Brazil we present evidence that women are performing more non-routine tasks than men.

Bearing this in mind we shed light on the relationship between the routine task-intensity in local labor markets, the use of technologies, and gender wage and informality gaps. We contribute to the gender inequality studies by analyzing the mechanism that connects the reduction of the gender gap and the realization of job tasks by women. The independent variable of interest (share of local employment in intense routine occupations) and the instrumental variable used are already established in the literature. Our application of the technique to analyze the

Table 7: Results for regression estimates - cognitive and manual non-routine jobs.

	(1)	(2)	(3)	(4)
	Wages	Formal job	Wages	Formal job
Variables	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$
RCA_{2000j}	-0.2836**	-0.2754***		
	(0.1339)	(0.0733)		
RNM_{2000j}			-0.3612***	-0.2139***
			(0.1104)	(0.0640)
$Internet_{2007j}$				
$\Delta_g Share\_routine$	-0.0002	-0.0017**	-0.0002	-0.0016*
	(0.0017)	(0.0008)	(0.0017)	(0.0009)
Obs.	413	413	413	413
K-P	177	177	41	41
	(5)	(6)	(7)	(8)
	Wages	Formal job	Wages	Formal job
Variables	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$	$\Delta_g\Delta\mu_j$
RCA_{2000j}	-0.5877***	-0.4259***		
	(0.2028)	(0.1098)		
RNM_{2000j}			-0.3677***	-0.2074***
			(0.1102)	(0.0639)
$Internet_{2007j}$	0.0044***	0.0022***	0.0005	-0.0005
	(0.0015)	(0.0008)	(0.0007)	(0.0004)
$\Delta_g Share\_routine$	0.0018	-0.0007	0.0000	-0.0019**
	(0.0018)	(0.0009)	(0.0018)	(0.0009)
Obs.	413	413	413	413
K-P	55	55	26	26

Note: Robust standard errors in parentheses. Statistical significance denoted by *** 0.01, ** 0.05, * 0.1 Author's calculations with census data. Population weighted regressions.

improvement of women's situation in the labor market is the novelty in the study.

The results indicate that in markets more specialized in routine tasks the growth of wages and job formality for women is relatively higher than for men. The findings are robust to the inclusion of regional internet density as an independent variable in the specification. We use internet density as a proxy for recent technological changes in the labor market and find that job changes related to this technology seem to not negatively affect women's earnings or formalization of employment. In effect, internet density is positively correlated to the relative improvement of female wages.

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