The Effect of the Internet on Wages

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Abstract

Who benefits from technology adoption in the workplace? To explore, I combine worker-level wage data with information on broadband adoption by Brazilian firms to estimate the effects of broadband on wages. Overall, wages increase 2.3 percent following broadband adoption. Consistent with the theory of biased technological change, wages increase the most for workers engaged in non-routine cognitive tasks and returns are negative for routine cognitive tasks. There is no effect of broadband adoption on wages for either routine or non-routine manual tasks. Additionally, I estimate the effect of broadband on selected quantiles of the within-firm wage distribution and find evidence that within-firm wage inequality increases following broadband adoption. Both new hires and the firm's existing employees benefit from broadband adoption, which indicates that broadband's effects are not driven only by better recruitment of new employees.

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1 Introduction

Who benefits from technology adoption in the workplace? Technology can substitute for some workers while complementing others. Specifically, the "task approach" to labor markets highlights the potential for digital technologies to substitute for workers in performing routine tasks, while complementing workers in non-routine tasks (Autor et al., 2003). To date, empirical work on this hypothesis has largely relied on industry-, region-, or to a lesser extent, firm-level data. In contrast, this paper uses worker-level wage data in conjunction with firm-level information on technology use over time. Specifically, I study how broadband Internet technology affects the wages of individual workers *within* firms.

I find that wages increase 2.3 percent following firm broadband adoption, but the effect of broadband is heterogeneous. Regressions of wages on the task profile of jobs suggest that broadband complements employees performing non-routine cognitive tasks, while substituting for workers in routine cognitive tasks. Intuitively, both routine and non-routine manual tasks are unaffected by broadband.

The differences in the returns to broadband across tasks have implications for within-firm wage inequality. I examine changes to the entire wage distribution within firms following broadband adoption using a grouped quantile regression estimator (Chetverikov et al., 2016). Wage increases following broadband are concentrated in the right tail of the wage distribution; in other words, within-firm wage inequality increases after broadband adoption. This result contributes to a literature that emphasizes the role of firms in determining pay inequality (e.g. Cobb, 2016; Gartenberg and Wulf, 2017b; Nickerson and Zenger, 2008), and provides the first direct evidence connecting adoption and use of advanced information technology to a widening pay gap within an organization.

As evidence of broadband enhancing the productivity of existing workers, rather than only improving the recruitment of new workers, I show that wages increase for both new hires and existing employees following broadband adoption. Furthermore, firm directors—who are most likely to also be firm owners—appear to capture large rents from the introduction of broadband, a pattern consistent with increased firm productivity post-adoption.

The analysis combines an employer-employee matched dataset from Brazil with firm-level data on technology use over time. By linking information on which firms use broadband with data on their individual workers, I can estimate the effect of broadband within firms over time. Additionally, I can examine changes in the wages of individual workers while controlling for worker characteristics and unobserved firm heterogeneity.

This paper is the first to combine within-firm variation on technology use with large-sample microdata on the wages and characteristics of individual workers. While other research has examined the impact of technology — including the Internet—on wages, prior studies have not observed changes in the technology used at individual firms over time. Recent research on the effects of the Internet in Brazil (Almeida et al., 2017; Dutz et al., 2017), Africa (Hjort and Poulsen, 2017), Norway (Akerman et al., 2015), and the United States (Forman et al., 2012; Gillett et al., 2006; Kolko, 2012) relies on geographic variation in Internet availability and/or cross-sectional variation in firm adoption. In contrast, I observe the same firm and workers before and after the adoption of broadband. The results of this paper are consistent with prior work, which shows broadband substitutes for workers engaged in routine tasks while complementing workers engaged in non-routine tasks.

Broadband technology is especially worthy of study because of the Internet's pervasiveness and policymakers' interest in public investments in broadband infrastructure. Nearly 50 percent of people worldwide now access the Internet. The transformation of the Internet from a technology used by fewer than 1 percent of people in the mid-1990s to the ubiquitous network of today has potentially large effects on firm operations and jobs.

Although a number of studies suggest that broadband, and Internet access generally, is a skill-biased technological change, few if any provide concrete examples of how or why this might be the case. The next section provides anecdotal evidence from interviews with Brazilian managers suggesting that broadband use in firms can assist workers with non-routine cognitive tasks while substituting for workers in performing routine cognitive tasks.

2 Anecdotal Evidence

This section provides examples, through interviews with managers in Brazilian firms, of how broadband can affect firm operations. Although several papers suggest broadband complements workers in performing non-routine tasks, while substituting for routine tasks, few are specific about how high-speed Internet access might do this.

Managers I interviewed described using broadband to facilitate information exchange both within and between firms and customers. A manufacturer of industrial equipment explained how broadband provided constant connectivity with their suppliers that allowed them to automate routine aspects of inventory management:

> "We scan the barcode on the kanban card and new part orders are sent directly to the supplier. This has saved time for the logistics people to spend more time on other tasks, like inventory optimization. It also means we've had some layoffs. We need fewer people to do ordering, and a different set of skills."

The same firm also used broadband to facilitate communication between workers directly involved in production and engineers and managers higher in the organizational hierarchy. Broadband, therefore, complemented the skills of engineers in the non-routine task of reviewing product design issues and communicating solutions:

> "The [machine] operator scans the production order and the computer downloads the CAD drawing from our database. We can share designs worldwide. If there is a problem, he can hit a button on the screen and report it to an engineer, who can diagnose and solve it."

A provider of medical imaging services explained using broadband to automate appointment scheduling, therefore eliminating the routine task of finding open dates. At the same time, this firm leveraged broadband to unify databases across multiple work sites in a single location so that important documents could be shared and accessed from anywhere. This made it easier for doctors to access patient medical records across facilities.

A manufacturer of bottled water used broadband to connect its machines to the company that supplied them so that their performance could be monitored remotely. This change obviated the need for someone who could monitor the machine's controls, eliminating the routine task of documenting and recording information.

In addition to these examples, managers reported using broadband to stay in closer contact with their customers, research competitors, and communicate with subordinates.

3 Data

The data used in this study are richer than data used in prior studies of broadband adoption because they include information on individual workers and their employers over time. This allows me to examine how wages change for different types of workers following firm adoption of broadband.

Data on individual workers come from the *Relação Anual de Informações Sociais* (RAIS) for the years 2000 to 2009. RAIS is an establishment-employee matched survey of all employers in Brazil's formal economy conducted annually by the Ministério do Trabalho e Emprego (MTE). Participation is mandatory. Unique identifiers for workers and establishments in RAIS allow records to be linked across years. Employee records include data on wages, occupation, education, experience, age, gender, and contract hours (but not hours actually worked).

I combine the employer-employee matched data from RAIS with firm-level data on broadband adoption from the Latin American version of the Ci Technology Database (CiTDB) from Aberdeen Group.[1] The European and U.S. versions of CiTDB have been used in prior studies to measure technology adoption (Bloom et al., 2014). CiTDB contains information on communication technologies used by the firm (e.g. xDSL, T1, etc.), which I use to measure broadband adoption. I limit my study to manufacturing firms—which is the largest group of businesses in the data—with technology

[1]CiTDB and Aberdeen Group were formerly owned by Harte Hanks; Halyard Capital acquired Aberdeen and CiTDB in April 2015.

adoption information in Harte Hanks and wages in RAIS so that analyses of the task content of jobs and occupational hierarchy can be more easily interpreted.

Figure 1 shows that broadband use increased substantially from 2000 to 2009; fewer than 20 percent of the sample firms used broadband in 2000, but more than 70 percent had a broadband connection by 2009. Note that these numbers are not necessarily representative of all Brazilian manufacturing firms. The firms surveyed by Harte Hanks—my source of technology data—are larger than the typical firm in Brazil.

To examine how the effects of broadband vary for different types of workers, I use measures from the U.S. Department of Labor's O*NET database to characterize the importance of various tasks for each occupation.[2] O*NET contains hundreds of scales that rate the importance of various activities, skills, abilities, and work contexts for each job. For consistency with prior research (Autor, 2013), I use the same O*NET scales as Acemoglu and Autor (2011) and computer code from David Autor's website[3] to produce four measures of the extent to which each occupation involves various tasks:

1. Non-routine cognitive
2. Non-routine manual
3. Routine cognitive

[2]I use O*NET version 9.0, which was released in December 2005 and is the most recent version to use the SOC 2000 occupation codes. I use this version because I rely on a crosswalk between SOC 2000 and ISCO 88 to match the Brazilian occupation codes with O*NET.

[3]Available at `https://perma.cc/B7SK-VKUV`.

4. Routine manual

Each of these variables is standardized across occupations so that a unit increase equals a one standard deviation increase in the extent to which an occupation depends on the given tasks relative to other occupations.

O*NET scales were developed to measure features of U.S. occupations. I adapt these measures to Brazil by merging both the U.S. and Brazilian occupation codes to the International Standard Classification of Occupations (ISCO 88). This results in instances where a single Brazilian occupation code matches multiple U.S. codes; in these cases I assign the Brazilian occupation to a simple average of the U.S. task measures.

Additionally, I use occupation codes from RAIS to divide each establishment's workforce into hierarchical layers. My approach mirrors the method used by Caliendo et al. (2015) in their study of French manufacturers. Specifically, I assign each worker to one of the following four layers:

1. Directors (e.g. Chief Executive Officer, Chief Financial Officer)
2. Managers (e.g. Sales Manager, Branch Manager)
3. Supervisor (e.g. Foreman, Logistics Supervisor)
4. Workers (e.g. Welder, Production Line Feeder, Fish Cooker)

Like Caliendo et al. (2015), I find the grouping of occupations into layers reflects meaningful differences between employees. Table 1 shows the mean and selected percentiles of the wage distribution by layer. Directors and managers have higher wages than supervisors, who have higher wages than workers (at all percentiles).

[Figure 1 about here.]

[Table 1 about here.]

4 Methodology

I use a staggered difference-in-differences research design that identifies the effect of broadband adoption on wages by comparing firms that did and did not adopt broadband over the ten-year period between 2000 and 2009.

The main models of interest examine the effect of broadband adoption on workers, allowing for the effect of broadband to differ by occupation:

$$\ln w_{ijt} = \beta_0 D_{jt} + \beta_1' D_{jt} * K_{it} + \theta' K_{it} + \delta' X_{ijt} + \gamma L_{jt} + \alpha_j + \lambda_{\kappa(j)t} + \epsilon_{ijt} \quad (1)$$

where w_{ijht} is the real wage of worker i at firm j in year t. D_{jt} is an indicator variable for broadband use by firm j and K_{it} is a vector of continuous measures representing the task content of worker i's occupation in year t. The task measures capture the extent to which the worker's job involves routine vs. non-routine and cognitive vs. manual tasks. The vector X_{ijt} is a set of time-varying worker covariates that includes education, current job experience, sex, age, age-squared, and log contract hours.[4] Some specifica-

[4]The data do not include actual hours worked, but do include hours in the labor contract. Full-time work in Brazil is 44 hours per week.

tions also include log employment, L_{jt}, to control for the possibility that larger firms pay higher wages and are more likely to adopt broadband (Oi and Idson, 1999). Employment, however, could itself be affected by broadband adoption; I therefore use employment as the dependent variable in other analyses and omit it from most models. The model includes both firm (α_j) and industry-year ($\lambda_{\kappa(j)t}$, where $\kappa(j)$ is the industry of firm j) fixed effects that control for unobserved firm heterogeneity and annual shocks that affect all workers within an industry equally.

Combining employer-employee matched data with information on technology use over time allows me to examine how the entire wage distribution within firms changes following broadband adoption. To do so, I implement the grouped quantile regression approach from Chetverikov et al. (2016). Specifically, I estimate:

$$Q_{\ln w_{ijt}|D_{jt},\eta_{jt}}(\tau) = \alpha_j(\tau) + \lambda_{\kappa(j)t}(\tau) + \gamma'(\tau)z_{ij} + \beta(\tau)D_{jt} + \epsilon(\tau, \eta_{jt}) \qquad (2)$$

where $Q(\tau)$ selects the τth quantile of log wages for firm j in year t, D_{jt} is an indicator for firm broadband adoption, z_{ij} is a vector of individual-level covariates, and α_j and $\lambda_{\kappa(j)t}$ are firm and industry-year fixed effects.

The grouped quantile approach allows me to estimate how broadband adoption affects inequality within firms. Greater effects of broadband in the upper quantiles of the wage distribution than in lower quantiles imply that inequality within firms increases following broadband adoption.

In addition to studying the effect of broadband on wages, I also examine how employment changes at the firm level following broadband adoption:

$$L_{jt} = \beta D_{jt} + \alpha_j + \lambda_{\kappa(j)t} + \epsilon_{jt} \tag{3}$$

Table 2 presents summary statistics of variables used in the analyses. Just over half of observations are for people working in firms that use broadband.

[Table 2 about here.]

5 Results

5.1 Wage Effects

Overall, wages increase 2.3 percent following firm adoption of broadband. Table 3 shows the effect of broadband adoption without distinguishing between occupations or types of employees. The results in columns 2–3 include firm and year fixed effects, while columns 4–5 include firm and industry-year fixed effects. The estimates are stable across specifications and show a positive average effect of broadband adoption on wages. Comparing the results of columns 2 and 4 with those of columns 3 and 5 shows that the estimate of the broadband effect is insensitive to controlling for firm size. The increase in wages following broadband adoption, therefore, is not explained by bigger, growing firms paying both higher wages and simultaneously choosing to adopt broadband.

[Table 3 about here.]

There are several caveats to a causal interpretation of these results. First, firms might increase wages for other reasons that happen to coincide with broadband adoption. Without controlling for these factors, wage increases will be erroneously attributed to broadband. Second, even if broadband causes wages to increase, the firms most likely to benefit from the technology will be more likely to adopt, in which case estimates from the sample of adopters will be greater than the effect of introducing other firms to broadband. Third, trends in wages prior to broadband adoption might be different from trends in wages at firms that do not adopt. In this case, firms that do not adopt broadband are a poor control group for the adopters.

I cannot correct for omitted variables without an instrument. The problem of firms selecting into broadband use, however, is partially mitigated by the ten-year sample period. Figure 1 shows that most firms in the sample eventually adopt broadband. Additionally, the long sample period allows me to examine wage trends prior to broadband adoption. Figure 2 shows coefficient estimates from a modified version of the model in column 4 of Table 3 that includes separate dummy variables for years before and after adoption. These single year estimates are imprecise, but show that the largest wage increases happen in the years following broadband adoption. There is, however, some evidence that wages at adopting firms begin increasing relative to non-adopting firms in the year before broadband adoption.

[Figure 2 about here.]

The effect of broadband is heterogeneous; workers in occupations that require more non-routine cognitive tasks see larger wage gains than workers in occupations that are intensive in routine cognitive tasks. Table 4 shows regressions in which broadband adoption is interacted with occupation-specific measures of task intensity. The coefficients on non-routine cognitive and routine cognitive tasks have opposite signs, suggesting that broadband complements workers performing non-routine cognitive tasks and substitutes for workers in routine cognitive tasks. A one unit increase (roughly one standard deviation) in the intensity of non-routine cognitive tasks implies an additional 3.5–4.5 percent wage increase following broadband adoption. In contrast, a one unit increase in the intensity of routine cognitive tasks implies a 4–5 percent decrease in wages, which cancels out the baseline increase of 4 percent from broadband adoption.

[Table 4 about here.]

Table 4 also indicates that the effect of broadband adoption does not vary in the intensity of manual tasks. This is consistent with the intuition that broadband ought to have small, if any, effect on tasks that require interaction with equipment and using one's hands.

Overall, the broadband/task interaction effects of Table 4 are consistent with the routinization hypothesis (Autor et al., 2003) that computer technology complements and increases demand for non-routine tasks while substituting for routine tasks. In the case of broadband, this pattern is pronounced for cognitive tasks, but not present for manual tasks.

My estimates for the wage effects of broadband are larger, although roughly similar in magnitude, to those of Dutz et al. (2017), who examine the regional wage effects of Brazil's Internet (but not specifically broadband) rollout. They report a two-year cumulative wage increase of 4.1–4.8 percent for middle- and high-skill occupations in manufacturing in response to an increase in Internet access, but no wage effect for low-skill occupations.[5] A possible explanation for the larger effect estimates in this paper is that, unlike Dutz et al. (2017), I observe the adoption decisions of individual firms instead of relying on measures of regional broadband availability.

5.2 New Versus Existing Employees

The effect of broadband on new employees is the same as the effect on existing employees. This suggests that wage increases from broadband adoption are not driven only by firms recruiting better workers post-adoption. Table 5 shows the effect of broadband adoption on wages allowing for the effect to differ by whether an employee is in his first, first two, or first three years of working at the firm. The results show that newly hired employees do not earn an additional wage premium from broadband adoption over that earned by existing employees.

[5] Internet access in Dutz et al. (2017) is measured using the share of schools with Internet in each municipality. The reported effects are based on increasing Internet access from 0 to 100 percent (i.e. going from no access to every school having access).

[Table 5 about here.]

5.3 Wage Effects and Organizational Hierarchy

Wage increases following broadband adoption are greatest for workers higher in the organizational hierarchy: directors and managers see larger increases than lower-level workers. Columns 1 and 4 of Table 6 show that directors and managers earn 8–9 percent more following broadband adoption compared to a main effect of just over 2 percent for all employees.

[Table 6 about here.]

The effect of broadband is especially large for directors at the top of the organizational hierarchy. Columns 2–3 and 5–6 split the managers and directors group into two separate coefficients, and columns 3 and 6 add another coefficient for supervisors, who are grouped with workers in the other columns. The estimates suggest that directors earn 18–19 percent more following firm adoption of broadband. This is about 9 percentage points more than the increase for managers. Most firms in the sample are private companies. The directors in this sample are therefore more likely to have an ownership stake in the firm than if the firms were public. The wage increases for directors are consistent with firm owners capturing large gains as a result of broadband increasing firm productivity. Unfortunately, I do not have data on revenue or non-labor inputs to explore this hypothesis. Akerman et al. (2015), however, report that firms in Norway earn large rents from broadband adoption, and Jung and López-Bazo (2017) find a positive effect of broadband on regional productivity in Brazil.

The greater effect of broadband for directors and managers implies that within firm wage inequality increases following adoption. To more thoroughly examine this pattern, I use the grouped quantile regression estimator from Chetverikov et al. (2016) to assess how broadband adoption affects the distribution of wages within firms.

Figure 3 plots the effect of broadband on selected quantiles of the wage distribution. Figure 3a shows results from a model without worker-level controls, while Figure 3b is based on a model that controls for experience, age, and two education dummies (high school and college completion). The sample in the latter model is also restricted to firms with at least 10 employees to allow for the inclusion of the worker-level controls.

Although the estimates for the individual quantiles are imprecise, the pattern of point estimates in Figure 3 suggests that broadband has larger effects on the right tail of the wage distribution than on wages in the left tail. In other words, high wage workers benefit more than low wage workers from broadband adoption and inequality within firms increases.

[Figure 3 about here.]

Broadband's effect in widening the within-firm wage distribution is noteworthy for the literatures on vertical pay comparisons within firms (e.g. Gartenberg and Wulf, 2017a,b; Kacperczyk and Bazzazian, 2015), the antecedents of compensation policies (e.g. Chin and Semadeni, 2017; Fredrickson et al., 2010), and the role of firms in determining pay inequality (e.g. Cobb, 2016). This paper provides the first direct evidence connecting adoption and use of advanced information technology to a widening pay gap within an organization. Furthermore, this paper provides estimates of broadband's effect across the entire wage distribution; existing research on pay dispersion is largely focused on top-management teams and key employees.

Prior work suggests that pay inequality can have psychological costs (Larkin et al., 2012), and can negatively impact performance (Fredrickson et al., 2010; Siegel and Hambrick, 2005). Unfortunately, I do not have data to assess either the first order effect of broadband on performance or any second order effects operating through employee motivation. I also lack data on performance-linked compensation that would allow me to examine how different components of pay change in response to technology adoption.

5.4 Employment Effects

Broadband has positive effects on firm-level employment. Column 1 of Table 7 indicates that employment increases roughly 5.4 percent following broadband adoption. Columns 2 and 3 show separate regressions for managerial and non-managerial employees respectively. These estimates are not statistically different from zero at conventional significance levels, and the point estimates do not suggest different employment effects for workers and managers following broadband adoption. Columns 4–6, which include industry-year fixed effects instead of just year fixed effects, show slightly larger estimates. Column 4 indicates that employment increases about 7 percent following broadband adoption, and columns 5–6 again suggest that the effect is similar for manages and non-managers.

[Table 7 about here.]

6 Conclusion

I combine data on firm adoption of broadband technology over time with data on individual workers to estimate the effects of broadband on wages and employment. Overall, wages increase 2.3 percent following broadband adoption, but the effects are heterogeneous. Consistent with the theory of skill-biased technological change, wages increase the most for workers engaged in non-routine cognitive tasks. Returns for routine cognitive tasks are negative, and intuitively, the effect of broadband does not vary in the intensity of either routine or non-routine manual tasks. Quantile regressions measuring the effect of broadband on the full wage distribution suggest that broadband increases within-firm wage inequality.

Additionally, I am able to compare the returns of broadband adoption for new and existing employees. I find that both new and existing employees benefit from broadband adoption, which suggests the effect of broadband on wages is not solely the result of recruiting better employees post-adoption. Overall employment increases 5–7 percent following broadband adoption.

The results are useful for policymakers evaluating the potential impacts of public investment in broadband infrastructure. Such investments are often predicated on the hypothesis that high-speed Internet spurs economic and wage growth despite limited research on this topic. I show that workers do not equally share the gains from broadband adoption; workers engaged in higher paid occupations that require non-routine cognitive tasks experience larger gains from adoption than workers in occupations intensive in routine cognitive tasks.

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Figure 1: Adoption of High-Speed Internet

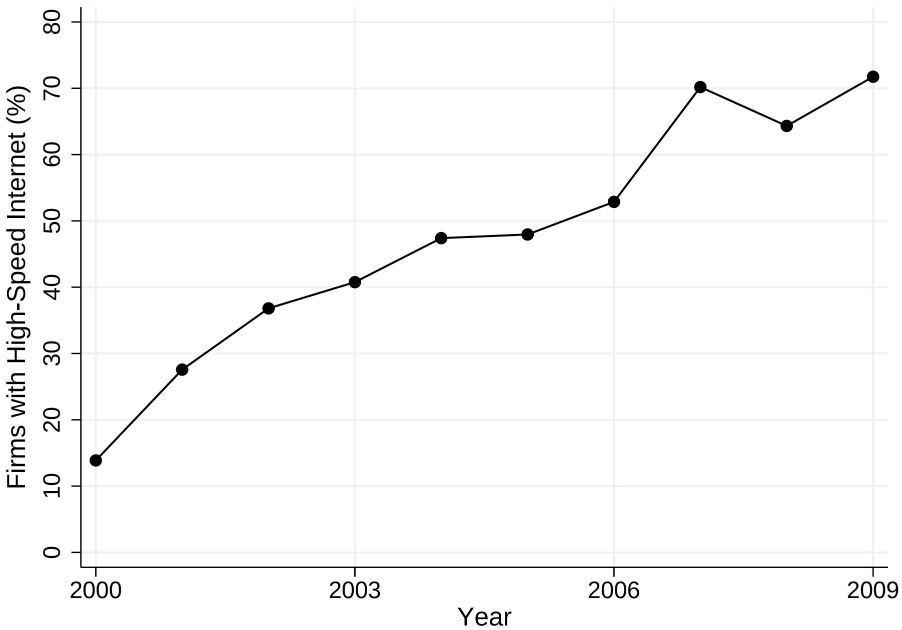
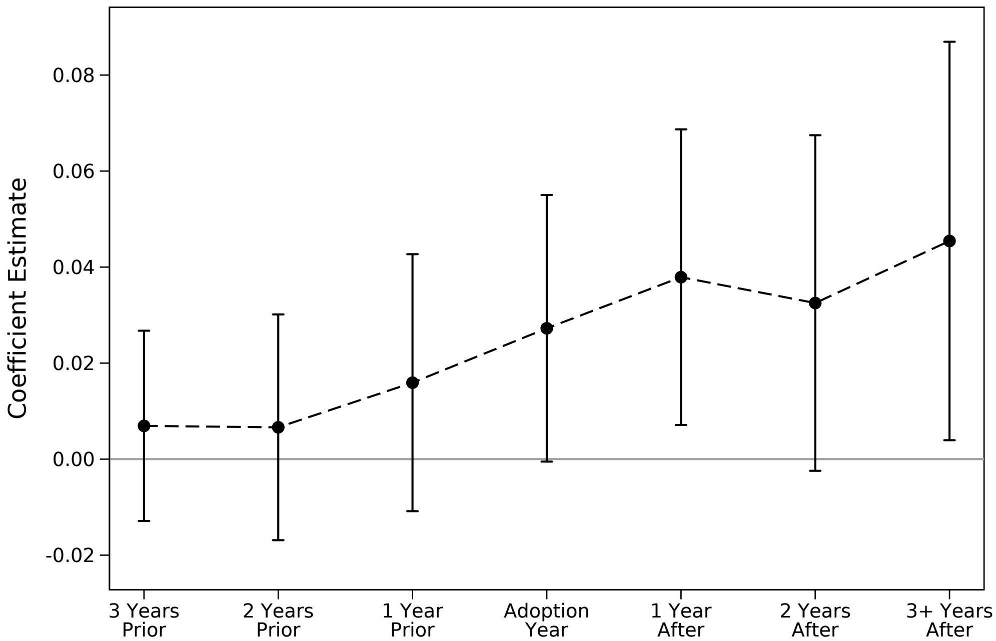
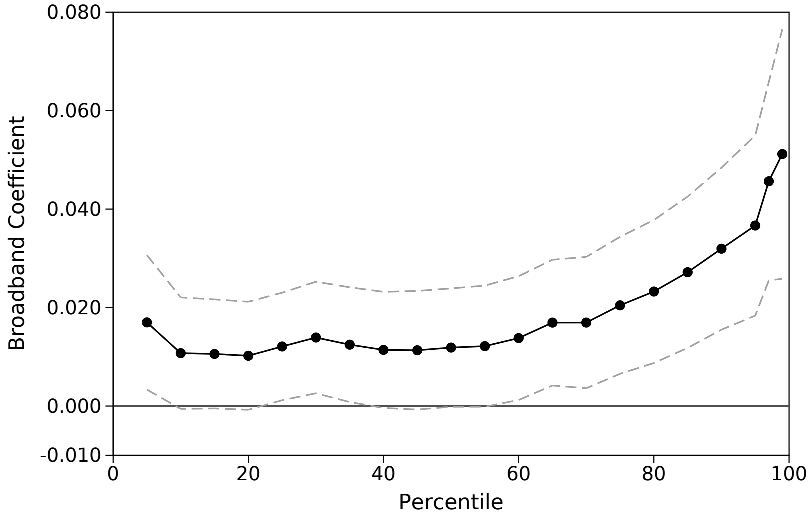


Figure 2: Wages Before and After Broadband Adoption

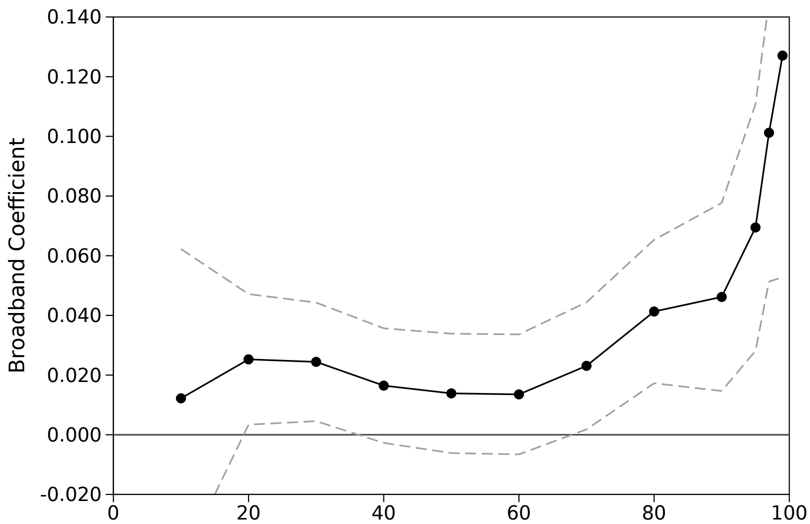


NOTE: Values along the x-axis represent time relative to broadband adoption; e.g. "2 Years After" refers to the second year following adoption.

Figure 3: Quantile Effects of Broadband Adoption



(a) Without worker micro-covariates



(b) With worker micro-covariates

Table 1: Wage Distribution by Hierarchy Level

	Director	Manager	Supervisor	Worker
mean	18,085	8,679	3,763	1,476
p5	1,593	1,053	735	391
p10	3,030	1,692	984	468
p25	7,573	3,458	1,674	636
p50	16,617	7,144	2,953	961
p75	26,403	11,767	4,979	1,648
p90	35,531	17,166	7,365	2,937
p95	40,745	21,779	9,145	4,222

NOTE: Wages are mean monthly wage in 2008 reais.

Table 2: Summary Statistics

	mean	sd	p5	p10	p50	p90	p95
High-speed Internet	0.52	0.50	0	0	1	1	1
Log wage	7.05	0.81	6.0	6.2	6.9	8.2	8.6
Log contract hours	3.77	0.09	3.7	3.7	3.8	3.8	3.8
Tenure in months	60.45	70.92	1.9	3.4	32.7	161.9	211.9
Age	33.11	10.10	20.0	21.0	32.0	47.0	52.0
Female	0.24	0.43	0	0	0	1	1
Education Dummies							
Below Elementary	0.08	0.27	0	0	0	0	1
Elementary	0.09	0.28	0	0	0	0	1
Some Middle School	0.14	0.35	0	0	0	1	1
Middle School	0.15	0.35	0	0	0	1	1
Some High School	0.10	0.31	0	0	0	1	1
High School	0.31	0.46	0	0	0	1	1
Some College	0.05	0.21	0	0	0	0	0
Higher Ed Degree	0.08	0.28	0	0	0	0	1

NOTE: Log wages are log of mean monthly wage in 2008 reais.

Table 3: Wage Effects of Broadband

	(1)	(2)	(3)	(4)	(5)
Broadband	0.034***	0.026***	0.026***	0.023***	0.023***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)
Log Employees			0.015**		-0.007
			(0.007)		(0.008)
Worker Controls		•	•	•	•
Fixed Effects					
Firm	•	•	•	•	•
Year	•	•	•		
Industry-Year				•	•
Adj-R^2	0.45	0.69	0.69	0.69	0.69
Firms	3,333	3,333	3,333	3,332	3,332
N	6,949,890	6,949,890	6,949,890	6,949,887	6,949,887

NOTE: Standard errors in parentheses are clustered by firm.
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 4: Wage Effects of Broadband by Tasks

	(1)	(2)
Broadband ×		
Intercept	0.041***	0.040***
	(0.011)	(0.012)
Non-routine cognitive	0.044**	0.036*
	(0.018)	(0.019)
Non-routine manual	-0.004	-0.009
	(0.009)	(0.009)
Routine cognitive	-0.050***	-0.041**
	(0.016)	(0.018)
Routine manual	0.006	0.006
	(0.008)	(0.008)
Non-routine cognitive	0.145***	0.150***
	(0.017)	(0.017)
Non-routine manual	-0.059***	-0.056***
	(0.007)	(0.007)
Routine cognitive	-0.018	-0.023
	(0.016)	(0.016)
Routine manual	-0.006	-0.007
	(0.007)	(0.007)
Worker Controls	•	•
Fixed Effects		
Firm	•	•
Year	•	
Industry-Year		•
Adj-R^2	0.70	0.71
Firms	3,333	3,332
N	6,871,375	6,871,372

NOTE: Standard errors in parentheses are clustered by firm.
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 5: Wage Effects, New vs. Existing Employees

	(1)	(2)	(3)	(4)	(5)	(6)
Broadband ×						
Intercept	0.023***	0.023***	0.024***	0.021***	0.020**	0.022**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
Hiring year	0.009			0.008		
	(0.007)			(0.007)		
First 2 years		0.003			0.001	
		(0.008)			(0.007)	
First 3 years			0.001			-0.002
			(0.008)			(0.008)
Hiring year	-0.136***			-0.136***		
	(0.005)			(0.005)		
First 2 years		-0.155***			-0.154***	
		(0.005)			(0.005)	
First 3 years			-0.152***			-0.151***
			(0.006)			(0.005)
Worker Controls	•	•	•	•	•	•
Fixed Effects						
Firm	•	•	•	•	•	•
Year	•	•	•			
Industry-Year				•	•	•
Adj-R^2	0.69	0.69	0.69	0.69	0.70	0.70
Firms	3,333	3,333	3,333	3,332	3,332	3,332
N	6,949,890	6,949,890	6,949,890	6,949,887	6,949,887	6,949,887

NOTE: Standard errors in parentheses are clustered by firm.
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 6: Wage Effects of Broadband by Hierarchy Level

	(1)	(2)	(3)	(4)	(5)	(6)
Broadband ×						
Intercept	0.024***	0.024***	0.024***	0.022***	0.022***	0.023***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Director/Manager	0.052**			0.063***		
	(0.023)			(0.021)		
Director		0.141***	0.141***		0.153***	0.153***
		(0.042)	(0.043)		(0.042)	(0.043)
Manager		0.050**	0.051**		0.061***	0.061***
		(0.023)	(0.024)		(0.021)	(0.022)
Supervisor			0.002			0.004
			(0.014)			(0.013)
Director/Manager	0.723***			0.718***		
	(0.021)			(0.019)		
Director		1.163***	1.230***		1.152***	1.220***
		(0.033)	(0.034)		(0.033)	(0.034)
Manager		0.688***	0.741***		0.683***	0.737***
		(0.021)	(0.022)		(0.019)	(0.019)
Supervisor			0.469***			0.467***
			(0.010)			(0.010)
Worker Controls	•	•	•	•	•	•
Fixed Effects						
Firm	•	•	•	•	•	•
Year	•	•	•			
Industry-Year				•	•	•
Adj-R^2	0.70	0.70	0.71	0.71	0.71	0.72
Firms	3,333	3,333	3,333	3,332	3,332	3,332
N	6,949,890	6,949,890	6,949,890	6,949,887	6,949,887	6,949,887

NOTE: Standard errors in parentheses are clustered by firm.
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 7: Employment Effects of Broadband

	Total (1)	Managers (2)	Workers (3)	Total (4)	Managers (5)	Workers (6)
Broadband	0.053**	0.044*	0.040	0.071***	0.054**	0.058**
	(0.026)	(0.026)	(0.027)	(0.027)	(0.026)	(0.026)
Worker Controls	•	•	•	•	•	•
Fixed Effects						
Firm	•	•	•	•	•	•
Year	•	•	•			
Industry-Year				•	•	•
Adj-R^2	0.84	0.79	0.85	0.84	0.81	0.76
Firms	3,026	2,722	3,023	2,990	2,990	2,990
N	17,722	15,348	17,696	17,310	17,310	17,310

NOTE: Standard errors in parentheses are clustered by firm.
* $p < .10$, ** $p < .05$, *** $p < .01$