# Payments Under the Table:

## Employer-Employee Collusion in Brazil

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**Abstract**

We study formal workers who receive part of their salary *off the books*, which we refer to as "payments under the table" (PUT). We surveyed Brazil's formal employees, accountants, and firm owners, providing the first comprehensive evidence on PUT. Despite the widespread belief about low evasion rates of third-party reported income, PUTs are sizeable and proportionally larger for higher-income workers, accounting for almost 0.32% of the GDP. We provide a conceptual framework in which employer and employee bargain over the government's forgone revenues that arise due to PUTs. A Nash Equilibrium guarantees that PUTs depend on both employees' and employers' marginal cost of evasion, which we test on the data. First, we leverage discontinuities on social security benefits to show that workers closer to retirement have incentives to reduce PUT to increase their pension. Then, we use novel data on PUT-related labor lawsuits to induce exogenous variation in employers' perceptions of risks. We find a significant reduction in PUT for incumbent workers of firms that were sued for PUT, suggesting that employers learn about the risk associated with PUT. [1]

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[1]We make all the surveys publicly available for anyone interested in studying this novel topic. Email jfeinmann@berkeley.edu to request the data. In a follow-up paper, we extend the survey to other Latin American countries.

# 1 Introduction

Informal employment is widespread in developing countries and has large consequences for state capacity in terms of revenue collection and social security coverage. The available data and theoretical models have shaped how we conceptualize it. On the one hand, household and labor force surveys measure informal workers as those who do not contribute to social security, meaning that a worker is either entirely formal or entirely informal. On the other hand, models explaining the existence of informal employment are based on the firm's decisions to comply with regulation, either to operate entirely in the shadows (Rauch 1991) or to hire some workers *off the books* (Ulyssea 2018). Informal ties among formal employees have received much less attention. One possible explanation is that employers report the formal wages of employees, leading to third-party reporting, which is commonly assumed to entail low evasion rates (Kleven et al. 2016). As a result, the literature has overlooked the employer-employee relationships in which a formal employee can collude with the employer to underreport wages.

This paper challenges the current view on informality, studying the phenomenon of formal workers receiving part of their wages *off the books*, a practice we refer to as "payments under the table" (PUT). We show that, in Brazil, PUTs are widespread and sizable, shifting our concept of informality to the wage rather than to the worker level. This new margin is crucial for the government's capacity, as it severely affects revenue collection and redistribution. Furthermore, the extent of PUTs highlights the limits of third-party reporting when employers and employees find collusion beneficial. Understanding the incentives supporting collusion is critical to designing policies that reduce PUTs.

We begin by presenting the results of a novel large-scale survey that we conducted among Brazilian formal employees. We complemented it with a survey of firm owners and several interviews with accountants to provide a comprehensive picture of PUTs. Not only do we document the extent of PUT, we also identify employees and firms that

are more likely to engage in it. In addition, we provide evidence of collusive behavior and describe the tools (payment methods and accounting strategies) to perform PUT. Second, we provide a simple conceptual framework for thinking about collusive tax evasion, where employers' and employees' incentives shape the optimal share of misreporting. To test the model, we rely on two separate quasi-experimental variations that induce exogenous changes in incentives to collude for employers and employees.

We find that PUT is widespread: 24% of formal employees admit to receiving a fraction of their salary off-the-books. Additionally, the average PUT receiver reports receiving 20% of their labor earnings as PUT. Importantly, the fraction of earnings received as PUT increases in total labor earnings, conditional on receiving PUT. This highlights a regressive component of PUT that previous work has missed. Although PUTs are widespread, the likelihood of receiving PUTs sharply decreases with firm size, consistent with higher audit probabilities and double booking costs for large firms. Employees who have a closer relationship with the owners are more likely to admit receiving PUTs. In the same way, the vast majority of firm owners report that PUT comes from a mutual agreement with the employee. Finally, employees and firm owners say that cash is PUT's most common payment method. However, high-income individuals are more likely to report more sophisticated methods, such as virtual apps and contractor arrangements.

Taking advantage of our survey, we conducted a back-of-the-envelope calculation to determine the amount of government revenues lost due to PUTs. We benchmark this number with forgone revenues due to classic informality. Despite evading only a fraction of wages, PUTs imply greater revenue losses for income taxes than classic informality (6.8% vs. 4.2%). Most informal employees earn below the income tax threshold, meaning no income taxes would be collected by formalizing them. This highlights the importance of the regressive component associated with PUT. On the other hand, classic informality produces larger revenue losses for social security contributions. However, social security contributions mirror social security benefits, meaning income tax losses are more relevant to the final government budget balance.

We develop a simple theoretical framework for collusive tax evasion. Employers and employees bargain over the surplus they take from the government, which depends on all the tax rates that they both save by misreporting wages. However, the model incorporates the differential costs of participating in PUT for the employer and the employee, capturing potentially opposite incentives crucial to making third-party reporting work. We show that, in a Nash Equilibrium, it is optimal to increase PUT until the marginal surplus equals the sum of employers' and employees' marginal costs. At the same time, any relative bargaining power should be captured by the share of the surplus that goes to each part of the collusion (*incidence*). Under mild assumptions, increasing the marginal costs of employees or employers reduces PUT. We use our survey to uncover the most critical determinants of employers' and employees' cost functions. Then, we leverage quasi-experimental variation in both of them to test the model's key predictions.

First, we leverage the fact that workers closer to retirement have greater incentives to report higher wages to increase their pension. In addition, these incentives drop discontinuously at the ceiling of social security contributions because the pension is capped at a maximum. This produces a kink in the employees' cost function for underreporting, predicting bunching in reported wages at the ceiling. Using the Brazilian matched employer-employee, we find strong evidence of the bunching, which was not previously documented in the literature. Furthermore, the model predicts that the size of the bunching will increase as individuals approach retirement. Indeed, the excess mass is larger for workers closer to retirement. To rule out alternative theories, we characterize who the bunchers are regarding where they work, their demographics, and their wage dynamics. Consistent with the survey evidence, bunchers are more likely to work in smaller establishments, hold managerial positions, and own an external firm that can be used to receive the PUT. Finally, bunchers exhibit a clear strategic behavior in terms of wage dynamics. Following them across the years, we observe that they are very likely to update their salaries, targeting the new ceiling. Following them within years, we observe that they are less likely to vary the reported wages, which is

especially surprising in the Brazilian context, where an additional 13th salary is paid in December.

Second, we use novel data on PUT-related labor lawsuits to shed light on situations where the collusion breaks down and how employers respond to it. This data contains the identifiers of the employees suing and the firms sued, which can be merged with the matched employer-employee and ownership records. We begin by showing that, conditional on separation from the firm, workers who end up suing the firm are about 40% more likely to be fired than those who do not. This magnitude is four times larger than the difference in the probability of being fired between workers with higher education and workers with less than high school. This provides strong evidence that conflict happens in the workplace, and the employee breaks down the collusion by suing the firm. We interpret the collusion breakdown as an increase in employers' marginal costs of engaging in PUT. Therefore, we use a *stacked matching difference in difference* strategy to see how employers respond to PUT-related lawsuits. We show that firms increase by 1% the reported wages of incumbent workers who never sued the firm. Based on the evidence from our survey, this increase represents about a sixth of the total wages underreported, which makes the estimates quite sizeable. Consistent with the survey (and bunching) evidence, we find larger effects for smaller firms and managers. On the other hand, we show neither effects on task reallocation nor hours worked within the firm for incumbent workers, ruling out alternative explanations. The qualitative evidence from the interviews with accountants suggests two potential mechanisms. The first is that employers update upwards the perceived probability of being sued. The second is that the real risks increase because other employees become more likely to sue. Although it is hard to differentiate between the two (and they are likely both in place), we provide suggestive evidence in favor of the first. We built a network of firms connected through owners, meaning that we can observe all the firms owned by each individual. We replicate our *stacked matching difference in difference* strategy using the *connected firms*, defined as those with the same owner of a firm that was sued but not themselves. While noisier, we find significant effects of

about a third of the effects in the sued firms, suggesting that, at least to some extent, a learning process is happening to the owners.

Our paper contributes to several strands of the literature. As expected, we are not the first researchers to think about wage misreporting. Few recent papers have found evidence of PUT (Kumler et al. 2020, Bíró et al. 2022, Bjørneby et al. 2021, Bergolo and Cruces 2014, Gavoille and Zasova 2023, Lauletta and Bérgolo 2023), which is often attributed to collusion between employers and employees to avoid taxes. However, they typically evaluate a specific reform or intervention, recovering only local evidence. They fail to provide a comprehensive picture of PUT, including implications for redistribution and state capacity. An interesting exception is Williams and Padmore (2013), which presents a PUT survey for several European countries (referred to as *envelope wages*). However, the evidence in the paper does not speak to *how* PUTs work in practice, which is crucial to designing effective policies. Moreover, the purely descriptive evidence in the paper cannot test for both employers' and employees' incentives in shaping PUTs.

Second, we directly speak to the public finance literature, which considers third-party reported income to be a silver bullet in reducing tax evasion. In particular, Kleven et al. (2016) points out that wage misreporting must be rare because it requires employer-employee collusion to hold. As the firms grow, holding a collusion becomes more expensive, reducing PUT. Several papers in developed countries have supported this prediction (Kleven et al. 2011, Alm 2012, Bazzoli et al. 2021). However, third-party reporting can be helpful when illegal activities are not widely accepted, enforcement and penalties are high, or government capabilities to merge different sources of information exist. None of these conditions seems to be the norm in developing economies. Importantly, the benefits of third-party reporting come from the opposition in incentives. Doerr and Necker (2021) shows evidence of collusive tax evasion in service provision, a context in which the client and the contractor may be better off. We contribute to this literature by showing what matters for employer-employee collusion to hold. We test our theory using quasiexperimental variation in both employers' and employ-

ees' incentives to collude.

Third, this paper contributes to the literature on informal employment in developing countries. A vast amount of research studies the spread and consequences of informality (Williams and Lansky 2013, Bitran 2014, La Porta and Shleifer 2014, Ulyssea 2020). However, there is no uniform definition of informality (Guha-Khasnobis et al. 2006). The seminal book Levy (2010) defines informal workers as self-employed and employees not registered in the social security system. This definition is not synonymous with illegality. In fact, the only illegal component of informality is the existence of a salaried labor relationship between firms and workers not registered in the social security system. We separate from this definition in two ways. First, we exclude self-employed individuals from the analysis because we focus on employer-employee relationships that can lead to collusive tax evasion. Second, we expand the definition to include all employee payments that should be reported as wages. As long as those PUTs should be paying income taxes and social security contributions, they enrich our definition of informality, extending the classic definition at the wage level rather than at the worker level. Therefore, in our case, informal employment implies some margin of illegality.

Finally, we contribute to the literature on how regulations and labor costs affect informality. This literature has focused both on the informality of firms (Ulyssea 2010, Monteiro and Assunção 2012, Hsu Rocha and de Farias 2021) and on the informality of workers (Gerard and Gonzaga 2021, Lauletta 2021). Most of these papers focus on the lower part of the income or productivity distribution, studying how cost reductions can affect formalization decisions of firms and workers. Our paper contributes to this literature by showing that regulations at the top of the income distribution can spur informal labor relations. Furthermore, we use novel data on PUT-related labor lawsuits to provide evidence on how conflict can arise in employer-employee relationships, leading to a significant reduction in collusive tax evasion.

# 2 Context

Brazil is the largest country in Latin America, with 212 million inhabitants. In 2020, the GDP per capita in PPP was 14,000 US$, an average value for the Latin American region. Furthermore, despite progress in the beginning of the 20th century, Brazil remains one of the most unequal countries in the world: the Gini Index was 53.4 in 2020.

Like most developing countries, informal labor relations are a large component of the Brazilian labor market. Individuals with no link to social security represent 31.3% of Brazilian employees.[2]

In Brazil, identifying formal and informal employees is straightforward and salient to workers, employers, and authorities. Every formal employee must have a document called *Carteira de Trabalho*, in which all her job contracts must be documented. In traditional informality measures, an individual is called an informal worker if she works without a *signed Carteira de Trabalho*. This provides a salient measure that employees are aware of when asked about the formality of their work status. Furthermore, there are no significant penalties to the employee if she works with an unsigned *Carteira de Trabalho*, thus, there is no evidence of individuals under-reporting their informality status because of fear of being sanctioned.

Formal labor ties are associated with benefits and costs for the employee and employer. Employees with a *signed Carteira de Trabalho* are entitled to severance payments, pensions for disabilities, maternity leaves (restricted to women), and unemployment insurance. They also have to contribute to the social security system (the contribution schedule is detailed in Section **??**) and abide by the Brazilian Labor law that, among other things, governs the number of hours worked, paid vacation days, and work conditions. In turn, employers must comply with minimum wages, union wage floors, and contributions to the social security system for each employee. Employers' contributions also vary according to workers' wages.

[2] Among Self-Employed individuals, who comprise 20% of the Brazilian Labor force, this share is even higher. Calculations made with PNAD-C in the first trimester of 2022.

In Table 1, we provide some descriptive statistics of the Brazilian Labor Market and the differences between formal and informal employees. Informal employees are less educated, younger, and their average monthly wage is around 50% of the average wage of employees with signed *Carteira Assinada*.

Table 1: Descriptive Statistics of Brazilian Labor Market

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | All Labor Force | All Employees | Formal Employees | Informal Employees |
| Sh. Female | 0.449 | 0.479 | 0.466 | 0.530 |
| Avg. Age | 36.77 | 35.87 | 36.19 | 34.62 |
| Sh. with less than H.S. | 0.355 | 0.313 | 0.267 | 0.493 |
| Sh. with High School | 0.357 | 0.372 | 0.383 | 0.329 |
| Sh. with Some College | 0.288 | 0.315 | 0.351 | 0.177 |
| Sh. Non-white | 0.549 | 0.552 | 0.534 | 0.621 |
| Avg. Monthly Wage 2019 BRL | 2201.0 | 2192.2 | 2427.9 | 1283.0 |
| Informal | 0.313 | 0.207 | 0 | 1 |
| Employee | 0.702 | 1 | 1 | 1 |
| Observations | 196194 | 132181 | 106630 | 25551 |

Notes: This table was built using first quarter of PNAD-C in 2019. The sample comprises individuals between 18 and 55 years old. Informality is defined for workers as those who are employed without a signed *Carteira de Trabalho*. For self-employed, employers and other workers in the sample of the first column, informality is defined as if they are contributing to the social security.

# 3 Data

This paper combines several data sources. First, we collect our own data based on a survey of employees, firm owners, and accountants. We complement these data with the Brazilian household survey to reweight our sample and recover informality estimates. Second, we use several sources of administrative data. These include the matched employer-employer (RAIS), ownership records, and labor lawsuit records. In what follows, we present each of these data sources.

## 3.1 Our Surveys

We conducted surveys to formal employees, firm owners, and accountants in order to provide a comprehensive picture of PUTs. Appendix 12.1 contains the questionnaires. We make all data publicly available for other researchers interested in the topic.

### 3.1.1 Employees

Using the online survey platform Lucid MarketPlace [3], we conducted the first large-scale survey on PUT in March 2022. We surveyed an initial sample of 12,000 Brazilian employees.[4] That sample had already excluded self-employed, part-time workers, and those under 18 years of age (we validated it with our questions). Furthermore, we excluded informal employees and those employed in the public sector. We proceeded in the same way as the official Brazilian household survey. We ask whether the employee holds ***carteira de trabalho assinada*** or not. This is a very salient question because this card gives formal employees in Brazil access to social security benefits. After the screening, we had about 9,000 formal employees and 7,297 in the private sector. Our survey overrepresents educated people and high-income earners compared to the National Household Survey (PNAD-C). Table (2) provides a balance table comparing our

[3] See Coppock and McClellan (2019) for a study on its external validity
[4] Respondents were compensated for their participation in the survey.

survey with PNAD-C. We reweight our sample based on workers' demographics, firm characteristics, and earnings (see Appendix 10.1.1 for a detailed explanation of the reweighting.).

When asking sensitive questions about illegal activities, such as PUTs, an additional concern is the willingness to report the truth. If some respondents are unwilling to admit receiving PUTs, this would imply that our estimates are a lower bound of the actual fraction of employees participating in this activity. However, we conducted a *List experiment* to assess better the unwillingness to admit the truth. The discrepancy between the *List experiment* is important to evaluate the accuracy of our direct question and can also be informative. For example, a large discrepancy may be read as a low social stigma of engaging in PUTs. Figure (19) shows that the *List experiment* reveals that 27% of formal employees participate in PUTs. However, it is not statistically significant from the 24% found in the direct question. We read this as evidence of a low social stigma to admit the truth in the context of PUTs (see Appendix 10.1.2 for details on the experiment).

### 3.1.2 Firm Owners

We partner with Oppen Social, a prestigious survey company in Brazil, to conduct 313 phone surveys, making sure that we were talking to the firm owner or a high-ranked manager with knowledge of the firm's wage-setting policy. The goal was not to conduct a representative survey, but rather to learn about PUTs from the firm's perspective. To have external information as a source of validity check, we targeted firms that were sued for PUTs between 2014 and 2019 (in our administrative data). We were able to reach 63 of them. Then, we also reached 28 firms whose employees appear to be bunching at the ceiling of the social security contribution (Section 6.1 shows why these firms are suspected of participating in PUTs). The remaining (222) are small and medium-size firms from a random sample.

Asking about illegal activities to firm owners is even more sensitive than to em-

ployees. This is because employers are breaking two different laws, the tax and labor laws. The latter implies that they are not making some contributions on behalf of their employees, who are entitled to them. Unfortunately, conducting a *List experiment* requires a much larger sample, whose costs were prohibitive. We claim that the results are a lower bound of the true share of firms participating in PUTs. Figure (17) shows that about 30% of the firm owners admitted to paying under the table to their employees, and about 50% of them are aware of at least one PUT situation.

We asked several questions related to why PUTs are useful for firms, making firm owners think what they would have to change if PUTs were not possible. Furthermore, we ask about the risks associated with PUTs. In particular, we asked whether they have ever been sued for PUTs. Consistent with our targeting strategy, Figure (18) shows that those in our administrative data of labor lawsuits for PUT-related cases are significantly more likely to admit having a PUT-related lawsuit. This validates that we are reaching out to the firms that we are supposed to.

#### 3.1.3 Accountants

We surveyed 55 accountants in two ways. We conducted 36 in-depth interviews for 30/40 minutes and collected the remaining answers through short versions of the questionnaire distributed through the *WhatsApp* group of the Sao Paulo School of Accountants. As in the firm survey, the goal was not to collect a representative survey but to learn about the accounting side of PUTs. In all interviews, the accountants accepted to participate, previously informed about the sensitive content of the questions.

### 3.2 Pesquisa Nacional por Amostra Domiciliar - Continua (PNAD-C)

We use PNAD-C, a national household survey conducted by the Brazilian Institute of Geography and Statistics (IBGE). The survey has been collected quarterly since 2012. PNAD-C contains individual-level data on demographics and labor market informa-

tion, such as wages and hours worked for employees in both formal and informal sectors. In this project, we want to compare and link our survey results to PNAD-C. Given that our survey was collected in March 2022, we use PNAD-C corresponding to the first quarter of 2022.

We use this data for two reasons. First, we build the weights in our survey for formal employees explained in Section 3.1.1, based on the characteristics of formal employees in PNAD-C. Second, we need PNAD-C to recover information on classic informal employees, which is used to compare with PUTs.

## 3.3 Relação Anual de Informações Sociais (RAIS)

RAIS is a matched employer-employee data set that covers the universe of workers in the Brazilian formal labor market and is collected by the Ministry of Labor. Firms must submit annual information on all formal job contracts established in the previous year to the federal government, which uses this information to calculate a series of worker and firm benefits. Firms' compliance in reporting this information is high, as failing to report complete records leads to significant penalties. RAIS only tracks hired workers and does not show firm owners.

Workers in RAIS are identified by their name and CPF,[5] which allows us to follow them across time and match the information in RAIS to other identified data sets. Among other variables, we observe December wages, contracted hours, type of contract (temporary or regular), age, gender, schooling, separation and hiring dates, sector, and occupation.

We use this data to study workers' incentives to bunch at the ceiling of social security contributions when closer to retirement. As we show later, this provides evidence of workers receiving PUT, even when the employers report wages in the administrative records.

[5]CPF is the *Cadastro de Pessoa Fisica* and is an equivalent to the Social Security Number

## 3.4 Ownership Data

In addition to the employer-employee data, we observe who owns the firms. Although RAIS does not record who are firm owners, we built ownership records from both restricted and publicly available data sources. We ended up covering 95% of total owners. The construction of this data set is detailed in Appendix 10.3.

The matched owner-employer-employee data allow us to explore which type of employers/owners are more likely to engage in PUT and understand if there are matched owner-employee characteristics such as match in gender or in race that determine PUT. With this, we also rule out the possibility that the workers observed in RAIS engaging in PUT are the owners employing themselves.[6]

Finally, this data allows us to build the network of firms connected through ownership. Therefore, in Section 6.2.3, we are able to study the effects of lawsuits on *connected* firms, rather than on those directly affected.

## 3.5 Lawsuit Data

Through a partnership with Data Lawyer, we collected the universe of lawsuits related to PUT (*pagos por fora* in Portuguese) in Brazil between 2014 and 2019. These lawsuits are cases in which an employee sues an employer. The data contains detailed information on the case, including employees and employer identifiers, judges, and lawyers involved, the amount of money claimed and paid, and the resolution. These cases provide evidence of collusion breakdown, which we use to understand why collisions may fail and how employers learn about the risks associated with PUT.

Finally, we also purchased all these lawsuits' PDFs, which contain valuable information about the amount of PUT, how it was paid, etc. Unfortunately, these PDFs are sent by the employee's lawyer to the judge (it is the initial request made); therefore,

[6]We find that employees for whom we have evidence of engagement in PUT are likelier to be the company owners. Therefore, we decided to drop all employees who are also owners of the firm where they work to ensure that at least two people are involved in setting employees' wages.

they are not systematized in a particular format or structure. This means that we cannot apply a procedure similar to the one used to construct the ownership records. We developed a program that uses AI technology to process and interpret the lawsuits' PDFs. In Appendix X[7], we present the full methodology. We will make the codes available for anyone interested in processing non-systematized text information.

[7] Available in the following version of the paper.

# 4 Payments Under the Table: The Big Picture

This section shows the results of our novel survey about PUT in Brazil. We focus our attention on formal employees working full-time in the private sector. Appendix 12.1 provides the exact questions we ask to filter our sample. One advantage of our setting is that there is a clear definition of formal employees who must have a card that provides access to social security benefits. We use this definition, which the Brazilian government also uses.

Like most online surveys, it overrepresents high-income earners and highly educated individuals. We rely on the government household survey to reweight our sample (see Appendix **??** for details). Table (2) presents a balance table comparing our survey with the government household survey. Column (2) shows our survey re-weighted. We can approximate most of the summary statistics, which makes our results more reliable in representing Brazilian formal workers.

To validate our results, we also complemented the employee survey with the survey of firm owners and accountants. We collected 313 firm owners' responses and about 50 interviews with accountants. These complementary surveys are not intended to be representative of the Brazilian population. However, we use them to understand the accounting side of PUT, and some technical features that employers involved in PUT can provide useful information. We validate these additional surveys in Appendix X.

Table 2: Balance Table

| | (1) Lucid | (2) Lucid Reweight | (3) PNAD |
|---|---|---|---|
| *Demographics* | | | |
| Female | 0.478 | 0.421 | 0.394 |
| Age: 18-30 | 0.413 | 0.343 | 0.361 |
| Age: 31-45 | 0.490 | 0.458 | 0.427 |
| Age: 46-55 | 0.0774 | 0.159 | 0.152 |
| Age: more 56 | 0.0187 | 0.0396 | 0.0603 |
| Less than Highschool | 0.0692 | 0.160 | 0.200 |
| Highschool | 0.268 | 0.473 | 0.518 |
| More than Highschool | 0.662 | 0.366 | 0.282 |
| *Firm Size* | | | |
| Establishment size: 1 to 5 | 0.132 | 0.132 | 0.124 |
| Establishment size: 6 to 10 | 0.0883 | 0.116 | 0.128 |
| Establishment size: 11 to 50 | 0.218 | 0.222 | 0.207 |
| Establishment size: more than 50 | 0.561 | 0.530 | 0.540 |
| *Total Wages* | | | |
| Income: less than 3000 | 0.593 | 0.759 | 0.788 |
| Income: between 3000 and 6000 | 0.250 | 0.170 | 0.150 |
| Income: more than 6000 | 0.158 | 0.0707 | 0.0622 |
| Observations | 7297 | 7292 | 57903 |

*Notes:* This table compares different summary statistics for our survey (column 1), our survey reweighted (column 2) and the government household survey (column 3)

## 4.1 Extent of PUT

The first challenge of a survey on illegal payments is to accurately communicate to respondents what exactly we mean by PUTs. Note that the concept entails very different types of situation, from receiving half of the salary in cash every month to using the firm's credit card for personal expenditures. We want to capture at least general features. The first is the illegal nature of PUTs, meaning that taxes or social security contributions must be avoided. Second, some degree of periodicity, meaning that it has to correspond to payments made in the wage concept. The following paragraph is the exact explanation we provide to respondents about PUTs.[8]

> "In Brazil, **some formal workers (with CTA[9]) receive part of their wages under the table, meaning that they are not registered on the firm's payroll.** Therefore, total wages have two parts:
>
> - **In firm's payroll** (paying taxes and making contributions to social security)
> - **Not registered in firm's payroll** (saving taxes or social security contributions)
>
> The following questionnaire concerns this type of informality: formal employees (with CTA) who receive part of the wage under the table. **It is important to remember that all responses are anonymous 100% and only used for this research project. We thank you for your collaboration.**"

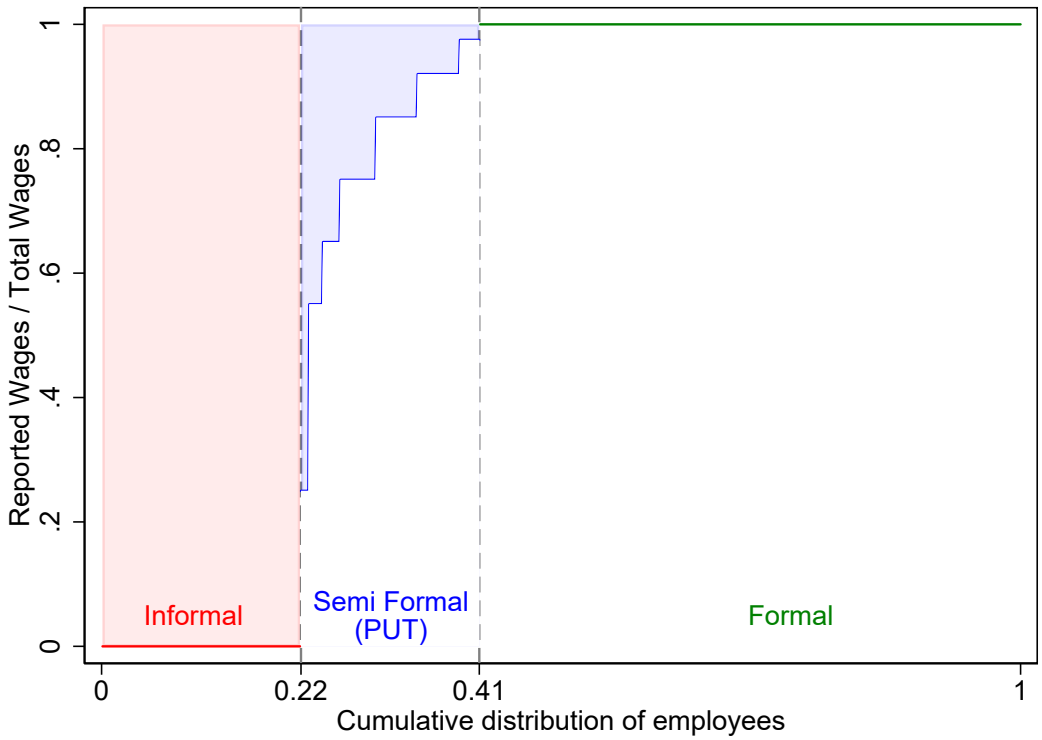
We first document that about 24% of formal private employees (21% of all private employees) admit to receiving PUT. On average, PUT receivers underreport 20% of their wages. A classic concern with sensitive questions is the willingness of respondents to admit the truth. Appendix **??** shows a list experiment that validates our

[8] Own translation from Portuguese

[9] Card that gives access to social security benefits (formal employees hold a CTA, informal employees don't)

direct question on PUTs. We follow the current literature to design the experiment (Castañeda et al. 2020, Coffman et al. 2017). Figure (1) characterizes informal employment in Brazil at the wage rather than at the worker level. We move from a dichotomous definition of informality to a more continuous version of it, as we expect the real world to work. We notice that ignoring PUTs leads to missing the blue-shaded region, which is informal payments made to formal employees. Including PUTs, the sum of the red and blue-shaded region characterizes informal employment in Brazil.

Figure 1: Lorenz Curve for Underreported Wages

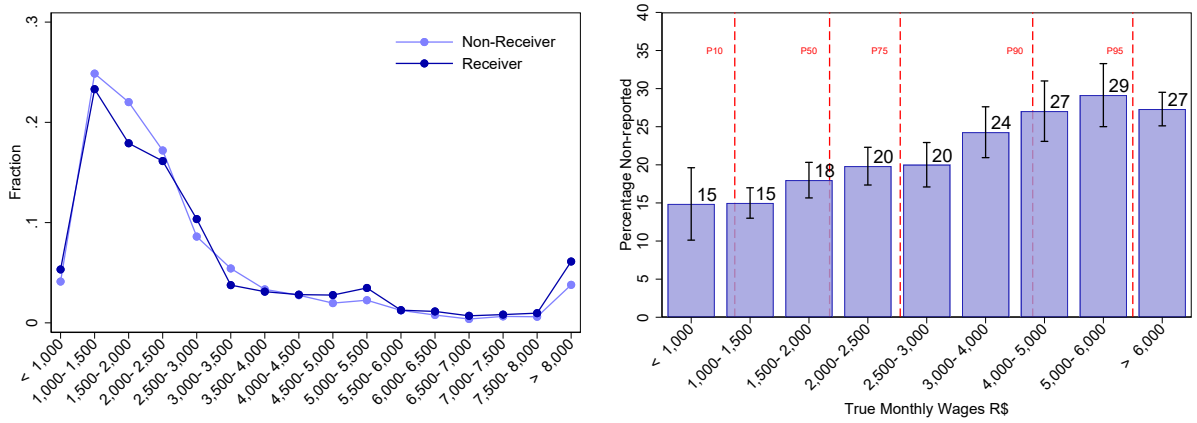



*Notes*: This Figure shows the ratio of under-reported wages over total wages for employer-employee relationships in the Brazilian economy. Panel (a) considers the classical informal employment definition, meaning that workers are fully formal or fully informal. Panel (b) incorporates PUTs. The blue shaded area represents the extra under-reported wages.

The next step is to describe who, among the formal employees, are the PUT receivers. Regarding the wage distribution, Figure (2a) makes the point that PUTs are widespread. However, Figure (2b) shows that conditional on receiving PUTs, higher-

income employees evade a larger fraction of their salary. This implies that among the total wages of formal private employees in Brazil, about 6% is paid under the table. Furthermore, the top 5% richest formal private employees evade twice as much as the bottom 50%. Figure (24) in Appendix 8 shows the employers' responses to who they are more likely to pay under the table. Consistently, they report that high-skilled and long-tenure workers and managers are more likely to participate in PUT.

Figure 2: Distribution of Payments under the Table across the Wage Distribution




(a) Extensive Margin

(b) Intensive Margin

*Notes*: Panel (a) shows the fraction of formal private employees receiving PUT for each reported wage group. Panel (b) shows the average percentage of the underreported wage for each true wage bin. It is calculated on the basis of the midpoints of the bin options provided to respondents. The x-axis in panel (b) corrects the reported salary to account for underreporting based on a follow-up question in which we asked if they answered their salary thinking about their total or reported salary. The black vertical lines represent 95% confidence intervals. We reweighted all statistics based on *sex, age, education, establishment size, and income group*.

To gain perspective on the importance of PUT, we conducted a simulation exercise in which we recovered the revenues that the government would collect if all PUT were eliminated with full compliance with earnings reporting. In particular, we focused on revenues coming from income tax and social security contributions (both from the employer and the employee). We conducted the same exercise for "classic" informality.[10] This exercise presents challenges and requires several assumptions. Till it is important

[10]Those employees who do not contribute to the social security system.

to provide a benchmark of the fiscal costs of this type of informality and how this can change the way tax evasion has been thought of in the literature. In Appendix 11, we explain all the assumptions we made to develop credible estimates. It is worth noting that we do not simulate the government expenses on social security associated with PUT formalization. As mentioned before, many social security benefits are linked to the amount reported, so they would also increase (the same logic applies to classic informality). In this sense, while the only component of our calculations that should be considered pure revenue lost is the income tax, evasion of social security contributions reduces the state's capacity to provide social benefits.

Table 4: Evasion in Perspective

| Sources of Evasion by Type of Informality | % of GDP | % of Total Gov Revenues | % of Revenues from Wage Bill |
|---|---|---|---|
| **Payments Under the Table (PUT)** | | | |
| *Income Taxes* | 0.11% | 0.46% | 1.27% |
| *Contributions to Social Security* | 0.21% | 0.93% | 2.57% |
| Total | **0.32%** | **1.39%** | **3.84%** |
| **Classic Informality** | | | |
| *Income Taxes* | 0.10% | 0.45% | 1.25% |
| *Contributions to Social Security* | 0.79% | 3.40% | 9.39% |
| Total | **0.89%** | **3.85%** | **10.64%** |

Notes: This table reports back of the envelope calculation for revenue gains due to eliminating classic informality and payments under the table. Other components may affect the estimates see

Split by type of tax, we find that PUT implies more revenue lost than classic informality. On the other hand, for SSC, classic informality is more relevant than PUT. This is consistent with how tax rates and tax brackets are designed. The income tax rate for low-income earners is zero, so formalizing employees will imply minimal revenue collection. On the other hand, SSCs are capped, so the marginal contribution rate is zero for high-income earners. This means that formalizing the payments under the table for high-income earners will not bring more SSC.

## 4.2 Mechanics

We use our surveys to characterize which employees and firms participate in PUTs. Consistent with the collusion story, employees in managerial positions, family businesses, or those in frequent contact with owners are more likely to engage in PUTs. In addition, employees who have more frequent contact with owners are more likely to evade a higher share of their wages. Table (5) shows that these results are robust to controlling for various demographics and fixed effects. Figure (23) Appendix 8 also shows that most firm owners report that PUTs start as an agreement between the employer and the employee.

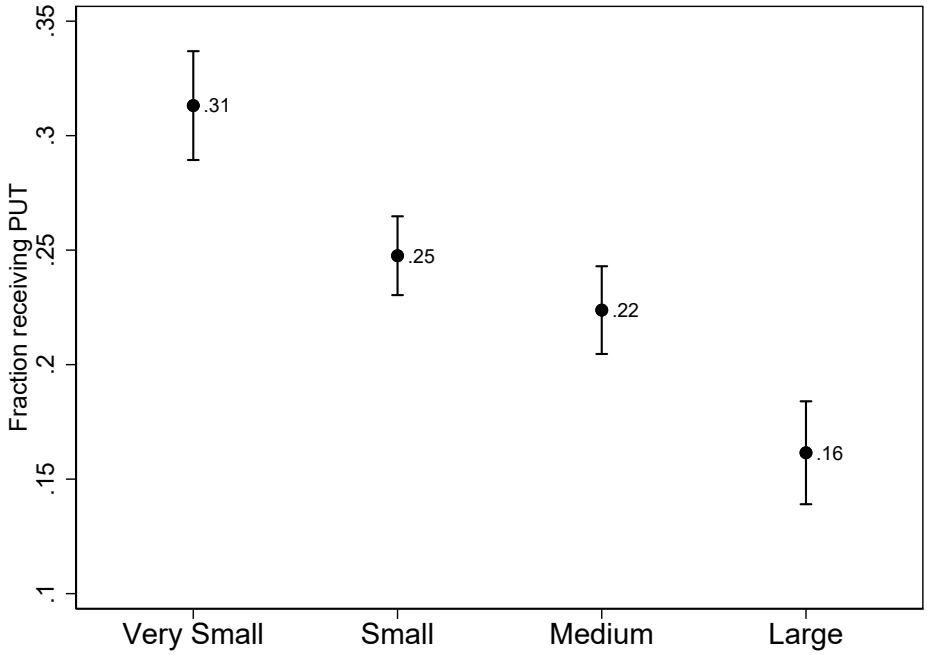
Table 5: Employer-Employee Relationship

| | = 1 if PUT receiver | | | % of wage as PUT | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Managerial Position | .225*** | .229*** | .231*** | 4.22*** | 2.71*** | 1.19 |
| | (0.011) | (0.011) | (0.012) | (0.779) | (0.796) | (0.815) |
| Family Business | .0628*** | .0613*** | .0591*** | -.38 | .299 | .933 |
| | (0.010) | (0.010) | (0.010) | (0.754) | (0.755) | (0.754) |
| Contact with Owners: Always | .122*** | .13*** | .114*** | 4.04*** | 3.92*** | 3.97*** |
| | (0.015) | (0.015) | (0.016) | (1.404) | (1.401) | (1.434) |
| Contact with Owners: Usually | .101*** | .108*** | .097*** | 3.53** | 3.12** | 2.89** |
| | (0.015) | (0.015) | (0.016) | (1.434) | (1.440) | (1.458) |
| Contact with Owners: Sometimes | .0565*** | .0598*** | .0519*** | .407 | .683 | .367 |
| | (0.014) | (0.014) | (0.014) | (1.442) | (1.440) | (1.446) |
| Female | | -.0359*** | -.0382*** | | -1.54** | -.824 |
| | | (0.010) | (0.010) | | (0.778) | (0.775) |
| Some College or More | | -.0391*** | -.0272** | | 4.94*** | 1.54* |
| | | (0.011) | (0.012) | | (0.829) | (0.929) |
| Dep. Var Mean | .24 | .24 | .24 | 22.84 | 22.84 | 22.84 |
| Age FE | No | Yes | Yes | No | Yes | Yes |
| Firm Size x Income Group FE | No | No | Yes | No | No | Yes |
| Observations | 7292 | 7279 | 7279 | 1945 | 1940 | 1940 |

This table explores how different variables related to employer-employee proximity predit the engagement in PUTs (columns 1-3) and how much is it paid under the table (columns 4-6). Our preferred specifications are columns 3 and 6, which control for firm size and income group, key determinants of PUTs. *Managerial Positions* are typically associated with closer ties to the owner of the firm. *Family Business* also involve some higher level of connection between the employees in the firm. Finally, we asked how often the have *contact with the owners*. We leave in the base those who answer never. We also add some demographics (gender and education) to benchmark the results.

However, even when there is a clear positive correlation between wages and firm size (see Figure (20) in Appendix 8), we find that PUTs are more likely to occur in small and medium firms than in large firms. This is consistent with previous work by Bíró et al. (2022) and Bjørneby et al. (2021). Furthermore, Kleven et al. (2016) predicts that the problem of wage misreporting should be more prevalent in small firms and almost negligible in large firms. Nevertheless, we still find that 16% of the employees who report that more than a thousand co-workers admit to receiving PUT.

Figure 3: Proportion receiving PUT by firm size

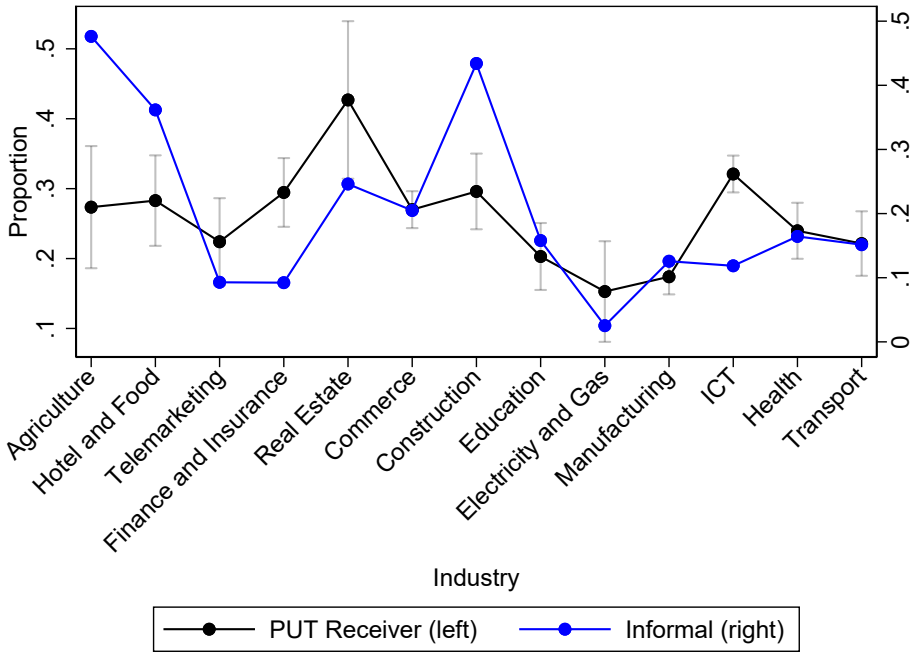



*Notes*: This figure shows the proportion of survey respondents that report receiving PUT for each firm size.

Using our survey and PNAD, we find that industries with a higher proportion of classic informality also have a higher proportion of PUT receivers[11] This may be explained by the underlying characteristics of industries that make illegal activities more likely to occur. Consistent with this story, we find that more than 50% of the employees who receive PUT are paid in cash. Industries like ”Hotel & Food” or ”Construction” will likely be more cash-intensive.

[11] Brief note on industry definition adjustment

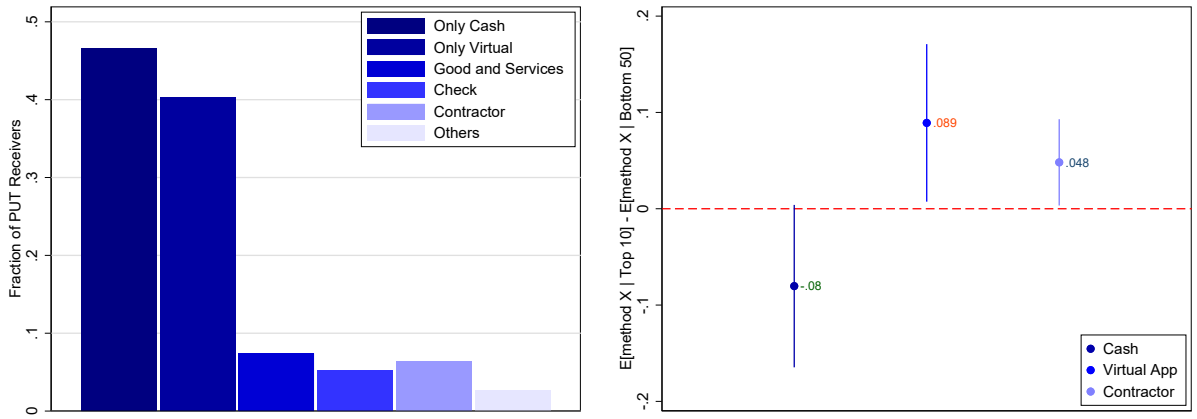
Figure 4: PUT and Classic Informality by Industry




*Notes*: This figure shows the proportion of respondents that reported engaging in each type of informality within each industry. Black denotes the proportion that reports receiving payments under the table (left axis). Blue denotes the proportion of workers that report being informal (right axis). Vertical bars represent 95% confidence intervals.

Finally, in Figure (5a), we observe that cash is the most common method for receiving PUTs. However, higher-income employees are more likely to use more sophisticated methods. For example, cash is 14% less likely for the top 10% than for the bottom 50%. Instead, virtual apps and contractor arrangements are 21% and 81% more likely for the top 10% than for the bottom 50%, respectively.

Figure 5: Payments Methods




(a) Methods (b) Difference by Income Group

*Notes*: Panel (a) shows the proportion of workers who report receiving PUT under each payment method. Horizontal bars represent 95% confidence intervals.

We validate this result with the survey of firm owners. We find very similar patterns, with cash and virtual apps being the main methods for PUT.

# 5 Conceptual Framework

This section presents a simple conceptual framework to capture the collusive behavior behind PUT. A crucial element of collusive tax evasion is that a pair of agents can get a surplus from the government. With PUT, the size of the surplus depends on the sum of all tax rates evaded through under-reporting. Let $\alpha$ be the share of wages paid under the table and let $R(\alpha)$ represent this surplus. The first thing to note is that, for any given wage, increasing $\alpha$ leads to a larger surplus as long as the government should collect something from it.[12] A second point is that collusion can be profitable even without direct taxes to one of the agents. For example, employees earning below the taxable income threshold can find it profitable to collude as long as they get a share of the labor costs saved by the employer.

Therefore, conflict of interest is crucial in preventing collusive tax evasion. In other words, the strength of third-party reporting relies on the opposite incentives of the parties. This is true in different contexts (e.g., *value-added taxes*). When incentives are aligned, third-party reported income cannot prevent collusive tax evasion (Doerr and Necker 2021). PUTs are not the exception, highlighting the importance of understanding employers' and employees' costs of colluding. Let $C_F(\alpha)$ and $C_W(\alpha)$ represent the costs of PUT for the employer and the employee, respectively. $C_F(\alpha)$ may include perceived risks (e.g., audits and lawsuits), and monetary costs (e.g., double-booking and accounting strategies). On the other hand, a key cost for the employees is the social security benefits they do not receive for the under-reported part.

The different costs that employers and employees face generate conflict of interest, undermining the probability of collusion. The bargaining process has to devise a solution to the evaded share of the wage, and the surplus distribution between employer and employee. Since stable collusion requires no agents to have incentives to deviate, solving the bargaining process with a Nash Equilibrium is appealing. Therefore, we

[12] This includes cases, where firms subject to profit taxes, can deduct reported wages and reduce taxable profits. In such a case, the profit tax rate reduces the total surplus.

can set up the problem as a Nash Bargaining over the surplus.

$$\max_{\alpha,\beta} \left\{ [\beta R(\alpha) - C_W(\alpha)]^{\theta} [(1-\beta)R(\alpha) - C_F(\alpha)]^{(1-\theta)} \right\} \tag{1}$$

Where $\theta$ is the worker's bargaining power relative to the firm. $\beta$ is the share of the surplus that goes to the worker, while $\alpha$ is the share of the wage that is paid under the table.[13] The FOC with respect to $\alpha$ is:

$$\theta[\beta R'(\alpha) - C'_W(\alpha)][(1-\beta)R(\alpha) - C_F(\alpha)] = -(1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)][\beta R(\alpha) - C_W(\alpha)] \tag{2}$$

This means that the optimal share of PUT weights the marginal benefits that the employer and the employee receive. Note that the bargaining power explicitly enters the expression. On the other hand, working on the expression for the FOC with respect to $\beta$, we find that:

$$\beta^* = \frac{\theta[R(\alpha) - C_F(\alpha) - C_W(\alpha)]}{R(\alpha)} + \frac{C_W(\alpha)}{R(\alpha)} \tag{3}$$

This equation shows that in a Nash Equilibrium, the worker receives a share of the surplus $R(\alpha)$ such that she is able to cover her costs ($C_W(\alpha)$) and to get a share of the *excess* surplus related one-to-one with her bargaining power. Replacing (3) in (2), see Appendix 13.1 for the full derivation, we find that the share of the wage PUT must satisfy:

$$R'(\alpha^*) = C'_W(\alpha^*) + C'_F(\alpha^*) \tag{4}$$

Unlike Equation (2), in the optimum, $\alpha$ depends neither on $\theta$ nor on $\beta$. The reason is that given (3), the surplus distribution is such that it is always optimal to maximize the *excess* surplus. In other words, in a Nash Equilibrium, it is always optimal to maximize the share taken from the government and to resolve any bargaining power between the employer and the employee through the surplus distribution. Under reg-

[13] A more complex version can allow the firm to internalize the following bargaining process, leading to hiring distortions.

ular assumptions on the curvature of the surplus and costs' functions, an increase in the marginal cost of PUT for the employer or the employee leads to a reduced evaded share. [14]

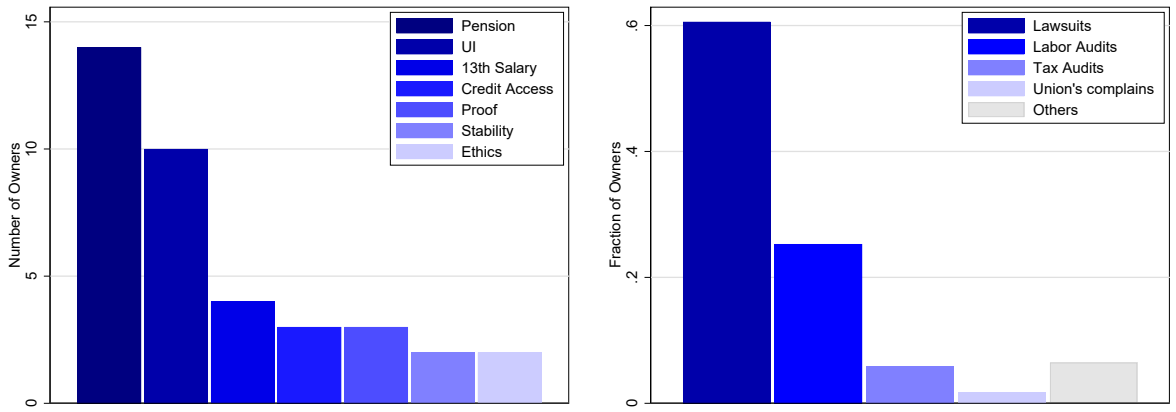
The following sections leverage quasi-experimental variation on employees' and employers' marginal costs of engaging in PUT. Equation (4) theoretically connects the variation in incentives to PUT, allowing us to interpret the variation we see in the data as changes in collusive tax evasion.

[14] In Appendix 13.2, we extensively discuss the assumptions.

# 6 Breaking the Collusion Down: empirical applications

Equation (4) highlights the importance of the marginal costs of engaging in PUT for both, employer and employee, in order to design successful policies that reduce collusive tax evasion. On the employee side, reporting wages brings different benefits, including wage proof for your next employer or for credit access, and higher unemployment insurance and pension. Moreover, not all individuals value these benefits in the same way. Early career employees may put a higher value on wage proofing, while workers closer to retirement may value pensions more. In a similar way, small firms may be less likely to be audited than large firms, or cash-intensive firms may find easier to fund PUT with much distortion in the firm's accounting. This section tests whether changes in employees' and employers' marginal costs affect PUT. We leverage our survey to firm owners and accountants to qualitatively understand which are the most important determinants of $C_W(\alpha)$ and $C_F(\alpha)$, and what to expect from changes in these incentives.

Figure 6: Main components of PUT costs for employers and employees




(a) Employees' reasons to lower PUT

(b) Main PUT risks for the firm

This figure is based on responses to the survey of firm owners. Panel (a) builds on two questions. The first asks whether an employee has ever asked to lower PUT. Conditional on answering *yes*, we ask the main reason for doing so. Then, Panel (a) orders the options we listed to firm owners. Panel (b) asks *what is the main risk that firms face when participating in PUT?*. We restrict the sample to those who believe that PUT is a widespread practice.

Figure (6a) shows that pension is the most important reason for which employees want to reduce PUT. On the other hand, Figure (6b) suggests that labor lawsuits are the main risks for employers to engage in PUT. Moreover, firm owners and accountants agree that, to some extent, owners react to a labor lawsuit by reducing PUT on the rest of the employees. Therefore, we leverage quasi-experimental variation on pension benefits and lawsuit risks as they seem to be very important determinants of $C_W(\alpha)$ and $C_F(\alpha)$.

We use the ceiling to the Brazilian social security system, which introduces a discontinuity in $C'_W(\alpha)$, given that the pension is capped at a maximum and cannot be increased by additional reporting above the ceiling. On the other hand, we use a *stacked matching difference in difference* to evaluate the effects of being sued by PUT, which pushes $C'_F(\alpha)$ up, on reported wages of other incumbent workers.

## 6.1 Employees' incentives to collude: changes in $C'_W(\alpha)$

### 6.1.1 Institutional Context

Brazil has a pay-as-you-go pension system, meaning that current pensions are funded by current employees, whose pensions will be funded by the next generation of employees, and so on. This is a popular system in many countries around the world (OECD et al. 2014). Benefits typically depend on contributions through a formula that weighs employee's wages and contribution years. Nonetheless, the pay-as-you-go system has a weaker link between the contribution and the benefits, relative to privately funded pensions. For example, the formula may put higher weights on certain contribution years than others, reducing the incentives to contribute in the less favorable years. Second, many countries define a maximum pension for retired employees. This amount is linked to a contribution ceiling, above which reporting an additional dollar does not increase the pension.

On the other hand, there is a large literature about behavioral biases on retirement

savings, with consensus around the idea that a significant share of workers is present bias and narrow framing, negatively affecting retirement savings (Goda et al. 2015, Shin et al. 2019, Benartzi and Thaler 2007, Goda et al. 2019). Moreover, Dolls et al. (2016) finds that salience about the expected pension benefits increased retirement savings. In a pay-as-you-go system, lower retirement savings can be achieved with PUT, affecting the expected pension through the formula in place.

In Brazil, the monthly pension is calculated based on the following formula:

$$P = \delta \frac{1}{k} \sum_{i=1}^{k} \max \{w_i, \bar{w}\} \tag{5}$$

Where $\delta$ is a coefficient that depends on the number of contributory years, and $\bar{w}$ is the ceiling. $w_i$ and $\bar{w}$ are translated into present values using a pre-specified formula. The $k$ salaries are selected to be the highest 80% of salaries earned during the contributory period. As workers' earnings profile increases in tenure, workers closer to retirement are more likely to affect their pensions with their current salaries. However, it is virtually impossible to separate regulatory from behavioral incentives, given that they are both continuous in age for the Brazilian case. Therefore, we will take an agnostic stand on the underlying mechanism, and only work with the implication that workers closer to retirement have larger incentives to report wages in order to increase their pension. The following quote from our interviews summarizes employees' behavior.

> *Some workers are happy because they avoid paying income taxes and Social Security Contributions. However, they are not thinking ahead. Their pension will be minimal. They realize they did something wrong when they get old.* (Accountant A)

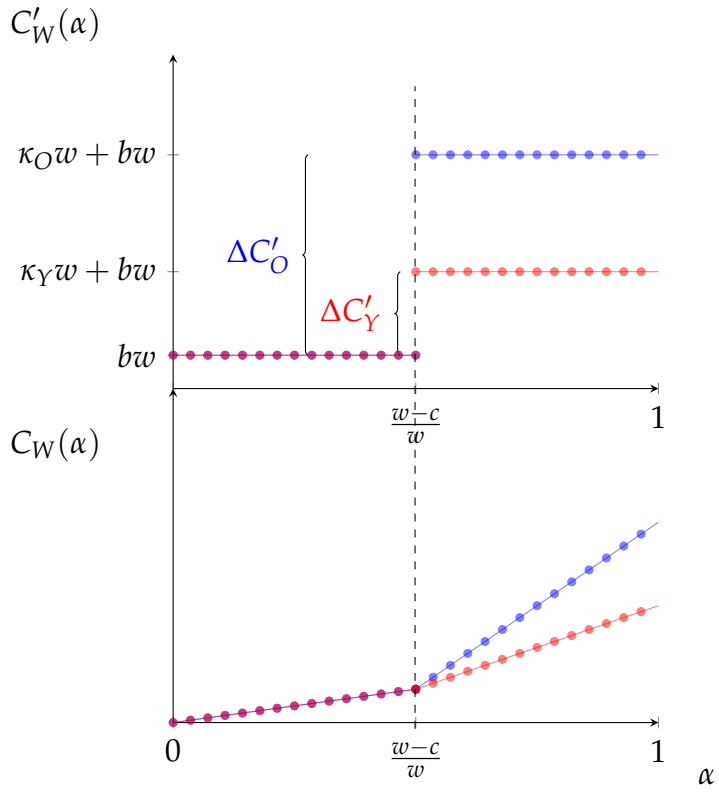
> *These payments under the table were initially beneficial. However, it is currently harmful as I get closer to retirement* (Employee A)

### 6.1.2 Testing the theoretical implication of the ceiling

Let's call $\hat{\alpha}$ the share PUT such that $(1-\hat{\alpha})w = c$, where $c$ is the ceiling to the contributions. That means that, for any given $w$, one $\epsilon > 0$ increase in $\hat{\alpha}$ produces a jump in the marginal cost of evading. This is because when an additional dollar is not reported, reported wages fall below the ceiling, where increasing reported wages increases pension. Therefore, writing the discontinuities regarding $\alpha$ or reported wages is equivalent to a given total wage. Moreover, workers closer to retirement value pension benefits more than young employees. Let's $\kappa_O$ and $\kappa_Y$ refers to *old* and *young* employees' valuation of pension.[15] Figure (7) illustrates the role of the ceiling on employees incentive to engage on PUT.

[15] If we incorporate that contribution rate goes to zero above the ceiling, affecting $R'(\alpha)$, we can reinterpret $\kappa_i$ as the monetary valuation of the pension relative to the contributions. Such contributions are the same for every individual of the same wage. Therefore, the heterogeneity on $C'_W(\alpha)$ is equivalent to the problem where we assume the contribution rate does not change.

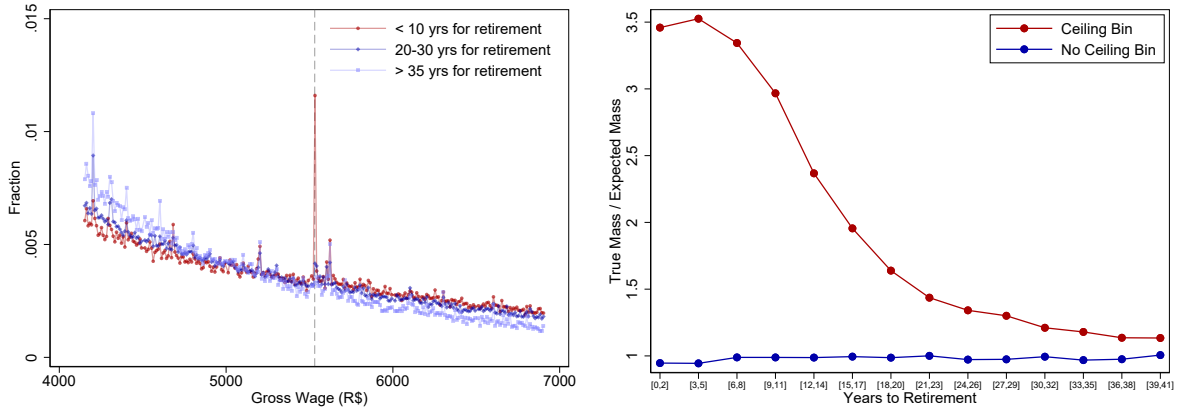
Figure 7: Discontinuity on Employee's Marginal Cost of PUT - $C'_W(\alpha)$ -




This figure shows the jump in marginal costs that employees face for under-reporting an additional dollar above $\alpha = \frac{w-c}{w}$. This jump is larger for employees with a larger valuation for pension benefits. The upper panel plots the marginal costs, while the lower panel shows the total costs, where the jump in marginal costs translates into a slope change.

Several implications can be drawn from Figure (7). First, the discontinuity in the cost function generates bunching at the kink (Saez 2010, Chetty et al. 2011, Kleven 2016). This means that employees bunch at $\alpha^* = \hat{\alpha}$, which implies that for any given $w$, employees have incentives to bunch in reported wages at the ceiling. Second, those incentives are larger for workers closer to retirement age, meaning that *excess mass* is decreasing on the distance to retirement.

Figure 8: Bunching Prediction




(a) Bunching in reported wages

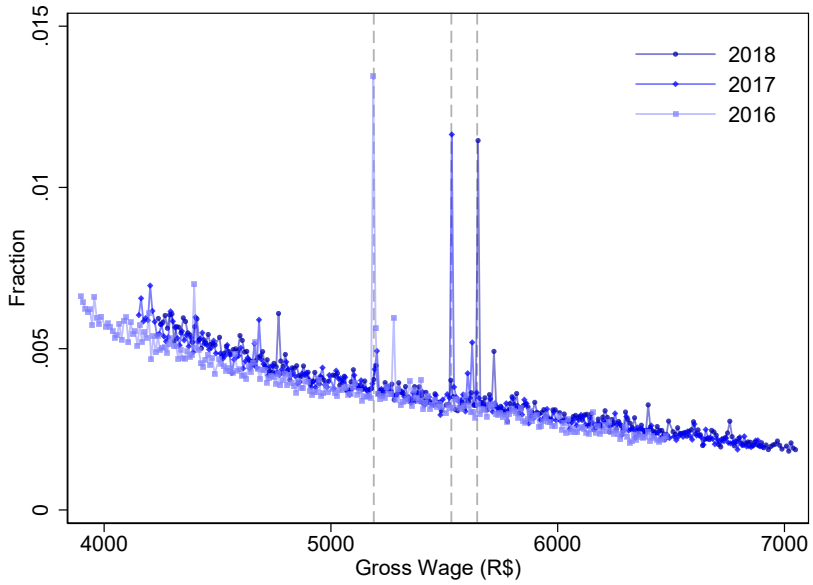
(b) Excess mass by years to retirement

*Notes*: Panel (a) shows the fraction of workers in each wage bin for those among the plot's bandwidth in 2017. The dashed line corresponds to the ceiling (R$ 5,531 in 2017). Bin's bandwidth is R$ 10 (about US$ 2). We dropped bins containing rounding numbers for exposition purposes. Panel (b) shows the *excess mass* for each group of years to retirement. The *excess mass* is the ratio between the *true mass* and the *expected mass*. The former is based on the actual distribution. The *expected mass* is calculated by fitting a polynomial of degree 3. The red line shows the excess mass for the ceiling bin, while the blue line shows the excess mass of another bin (ten above the ceiling). We measure nominal wages in December for active contracts.

In addition, the ceiling has been updated annually since 2011.[16] This means that we can replicate Figure (8) for every year. We show results for the years 2016-2018 in Figure (9). Appendix 9 provides a table with the same exercise for all years in our sample.

[16] In the following link you can find the time series of both contribution rates and ceilings.

Figure 9: Bunching Across Years




This figure replicates the bunching pattern for years 2016, 2017, and 2018. We keep only workers with the highest incentives to bunch (less than 10 years to retirement). The ceilings are R$ 5,189, R$ 5,531, and R$ 5,645, respectively. Bin's bandwidth is R$ 10 (about US$ 2). We dropped bins containing rounding numbers for exposition purposes. We measure nominal wages in December for active contracts.

Finally, there is another prediction arising from the discontinuity, which is less straightforward. Note that, conditional on bunching, $\alpha^* = \frac{w-c}{w}$. Then $\frac{\partial \alpha^*}{\partial w} = \frac{c}{w^2} > 0$, meaning that higher-wage bunchers evade a higher fraction of their income. This prediction is consistent with the pattern found in Figure (2b). Although it is not possible that bunchers at the ceiling are driving this pattern by themselves, this prediction is generalizable to any kink that incentivizes workers to reduce PUT up to a certain kink. In Appendix 13.3, we show this prediction for the income tax threshold and the minimum wage, which is consistent with the findings in Bíró et al. (2022).

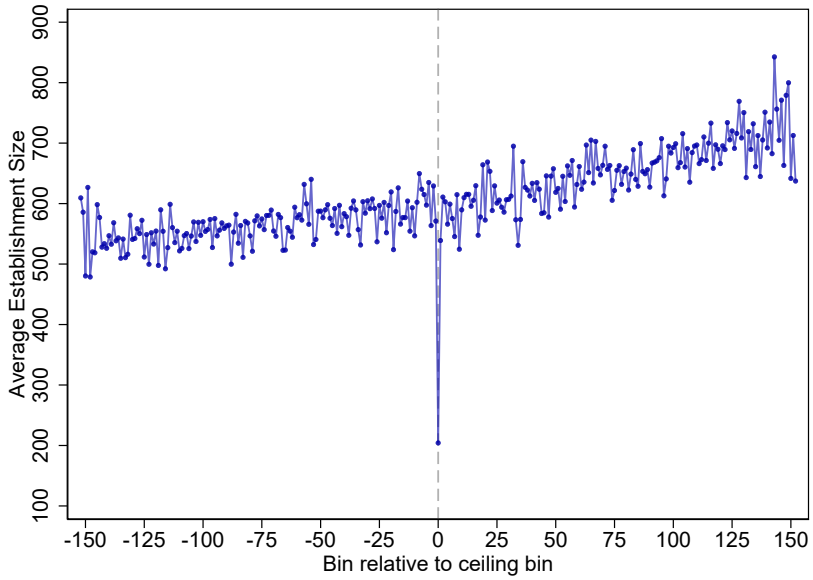
### 6.1.3 Ruling out alternative explanations

A potential concern with interpreting our results is that our model does not capture labor supply responses and that we cannot observe non-reported wages. It is worth remembering that Saez (2001) was developed to understand optimal non-linear income tax rate and, therefore, it is agnostic to whether the bunching is produced by real labor supply or evasion responses. While subsequent work has proved that real responses are small relative to evasion for both, individuals (Saez 2010, Chetty et al. 2011) and firms (Bachas et al. 2021, Garriga and Scot 2023), it is required to provide evidence in our setting as well.

We take advantage of the repeating bunching pattern across years for two main reasons. First, we can leverage a large sample that allows us to observe selection in observables around the ceiling. We compare such heterogeneity with our survey evidence, from which we collected direct evidence on *who* employees are more likely to engage in PUT. Second, we can study bunchers' wage dynamics across and within years to evaluate whether they are consistent with evasion behavior or not.

In Section (4), we learned that while PUTs are widespread, they are less likely to happen in large firms. Figure (10) shows that larger firms pay more, except at the ceiling. The average establishment size drops substantially for bunchers, consistent with the fact that PUT receivers are located in smaller firms.

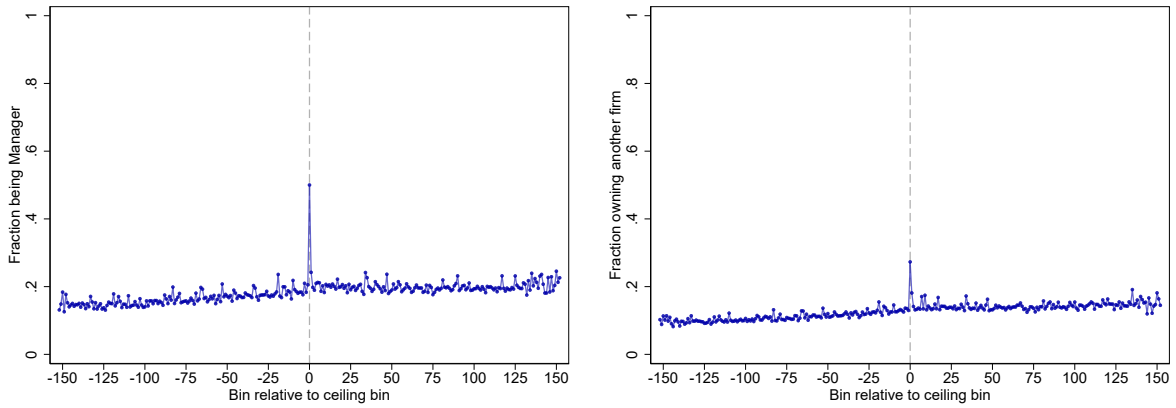
Figure 10: Firm Size across the Income Distribution




*Notes*: This figure shows the average establishment size where workers in each bin are employed. The sample includes the years 2015-2018. Bins are centered with respect to the ceiling for each year. Bin's bandwidth is R$ 10 (about US$ 2).

In addition, Figure (11a) shows that bunchers are twice as likely to hold managerial positions. On the other hand, Figure (11b) provides evidence that bunchers are more likely to own a firm that can be used to receive PUT, a more relevant payment method for high-income earners. This evidence is also consistent with the survey evidence (see Table (5) and Figure (5b), respectively).

Figure 11: Selection into Bunching




(a) Managerial Position

(b) Owning a Different Firm

*Notes*: Panel (a) shows the fraction of workers holding managerial positions in each bin. The sample includes the years 2015-2018. Panel (b) shows the fraction of employees in each bin that we find in the ownership data. While negligible, we make sure to drop cases in which the employee owns the firm where she is employed. Bins are centered with respect to the ceiling for each year. Bin's bandwidth is R$ 10 (about US$ 2).

Finally, we study bunchers' wage dynamics to document strategic reporting behavior that is consistent with evasion as opposed to real labor supply responses. We compare workers earning exactly at the ceiling with those earning a bit less and a bit more. In the absence of discontinuity in incentives, workers should behave identically as we get closer to the ceiling. More formally:

$$\lim_{w_i^- \to c} y(w_i) = y(c) = \lim_{w_i^+ \to c} y(w_i) \tag{6}$$

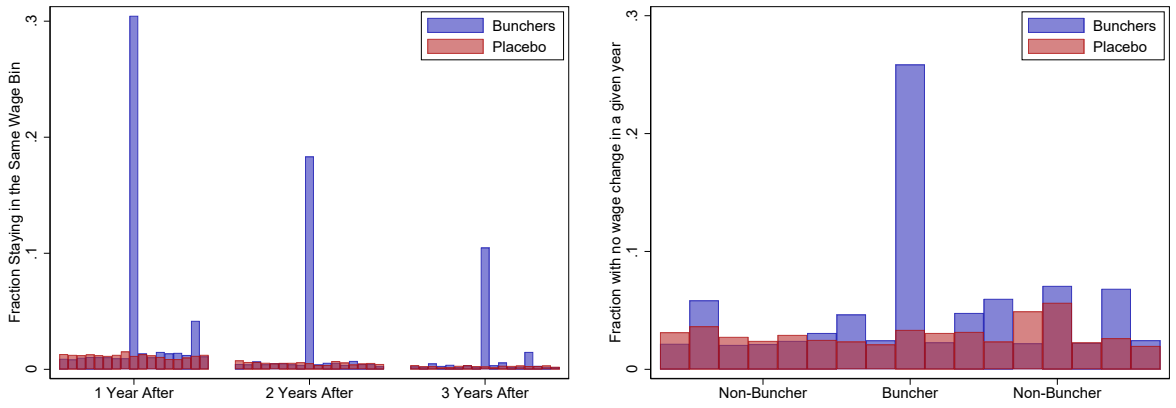
Therefore, we define as *bunchers* those workers earning exactly at the ceiling, and as *non-bunchers* those earning in eight bins above and five bins below the ceiling.[17] If Equation (6) doesn't hold, it provides evidence of strategic behavior for those who take advantage of the kink. To validate our approach, we construct a placebo test, where we replicate the analysis using a *fake* ceiling. For the placebo, there is no change in the incentives around the fake ceiling and Equation (6) should hold. Figure (25) in

[17] We don't consider those just below and above to avoid approximation problems.

Appendix 8 illustrates the methodology.

Figure (24c) shows that *bunchers* are extremely more likely to remain in the same wage bin than *non-bunchers*; one, two, and even three years after. Because bins are measured relative to the ceiling, this means that they update their wages to fit the new ceiling. For several decades now, the literate has recognized the rigidity of labor contracts to adjust labor supply to a specific level of earnings (Dickens and Lundberg 1985). It is even harder to imagine that workers can adapt real labor supply year by year such that they reach the exact level of earnings that maximizes pension. Moreover, Figure (24d) shows that within a given year, *bunchers* are much less likely to experience a wage change than *non-bunchers*. It is important to note that Brazilian employees receive a 13th salary in December that has to be reported by the employer because it pays taxes and contributions as the normal wage. Therefore, it is very common to have changes in reported wages between January and December, which would happen automatically if real responses explain the bunching. However, the evidence in Figure (24d) suggests that *bunchers* are also misreporting the 13th salary, consistent with the evasion explanation underlying the reporting responses.

Figure 12: Wage Dyamics




(a) Across Years (b) Within Years

*Notes*: Panel (a) shows wage dynamics across years, while Panel (b) shows wage dynamics within years. Blue bars refer to *bunchers* and *non-bunchers* around the true ceiling, while the red bars are the placebo (where we replicate the exercise for wage bins centered at a fake ceiling). The mid-bar always refers to the *bunchers'* bins (ceiling), and it has 8 bins to the right and to the left, which correspond to *non-bunchers*. Panel (a) contains observations from 2011 to 2018, and it measures wages in December of each year. For Panel (b), we keep from 2015 to 2018 because for these years we have monthly wages. In this case, we calculate the fraction of workers in each wage bin that has the same reported wage in January than in December of a given year.

Full table with all the descriptions and collusion story

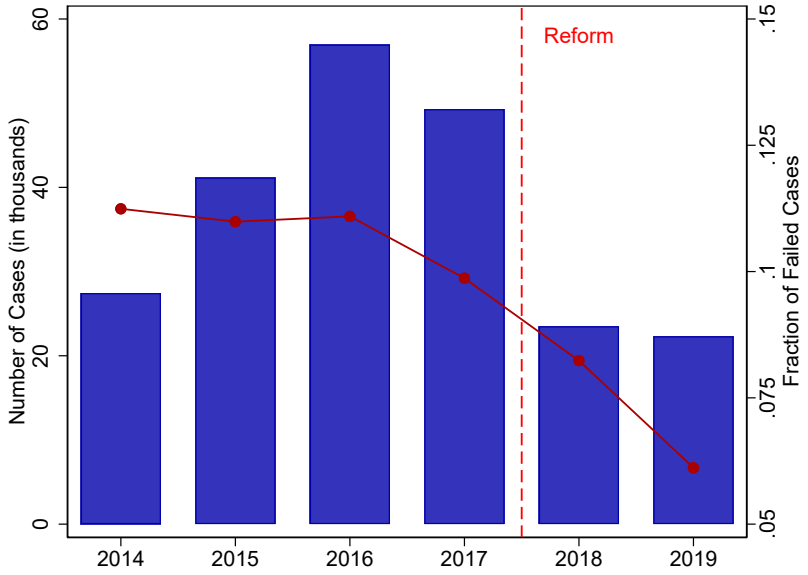
## 6.2 Employers' incentives to collude: changes in $C_F'(\alpha)$

In Section 5, we showed that collusive tax evasion demands that not only employees' marginal cost but also employers' marginal cost are relevant to determine the share of the wage paid under the table. Moreover, Figure (6b) reveals that labor lawsuits are firms' main risk when engaging in PUT. Therefore, we collected novel data on labor lawsuits related to PUT in Brazil to study how employers respond to them.

### 6.2.1 Institutional context

We partnered with Datalawyer[18], which is a company compiling all labor lawsuits in Brazil since 2014. Among all cases in Brazil, there is a particular category for *Pagos por Fora* (Payments under the Table, in English). We accessed the universe of PUT cases initiated between 2014 and 2019. This accounts for 220,669 cases, covering 207,848 unique employees and 132,787 unique firms. In 2017, Brazil passed a reform which made employees suing to pay for firms' lawyers in case of losing the lawsuit. Consistent with the cost increase for suing, Figure (13) shows a decrease in total number of cases for PUT. Moreover, the composition of cases changed. We observe a drop in the fraction of failed cases (defined as abandoned by the employee or not approved by the judge).

Figure 13: Number of Lawsuits




*Notes*: In the left y-axis, we show the number of cases by year. In the right y-axis, we plot the share of failed cases, measured as those abandoned by the employee or cases the judge did not find ground to continue with the lawsuit.

While labor lawsuits are widespread, and everyone recognizes them as the main risk, it is common for firm owners to underestimate their own chances of being sued. In

[18]Know more in their website.

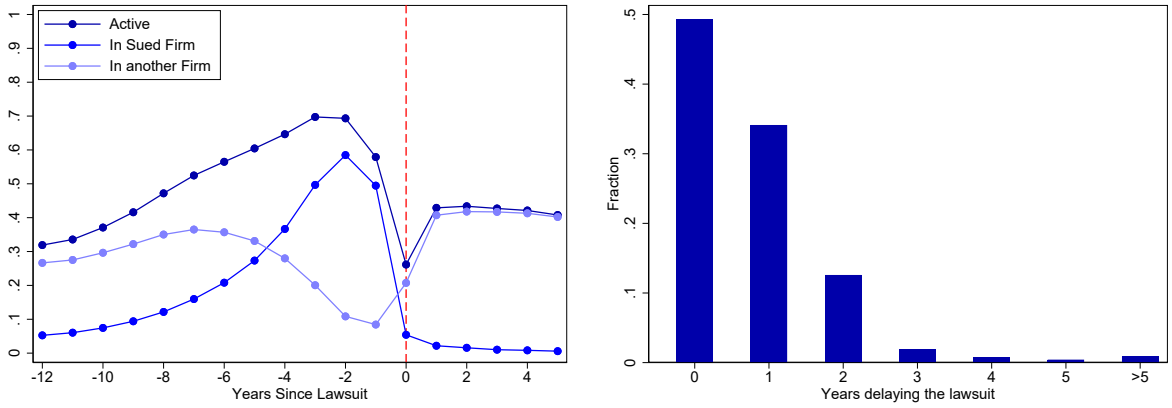
our interviews with accountants, we explicitly asked why employers engage in PUT if they can be sued afterward. Some accountants highlighted that it can still be profitable, since the penalties are restricted to the employee suing, without externalities on other wages paid under the table. However, most of them highlighted that firm owners underestimate the risks.

> *"Yes, lawsuit risks are underestimated, mostly for those who never went through a lawsuit. Sometimes, they are not aware of the damage PUT can cause."* (Accountant B)

> *"They underestimate the risks; they never think it will happen to them"* (Accountant C)

This points to the direction that lawsuits (and especially first-time firms are sued) can make owners update their beliefs about the probability of being sued.

Figure 14: Employees' Dynamics and Lawsuits




(a) Employment (b) Lawsuit delay

*Notes*: Panel (a) shows the employee's dynamics around the lawsuit. The x-axis is the years relative to when the lawsuit happened. The high-dark blue line plots the probability of having an active contract each year in December. The mid-dark blue line is the probability of being active in the firm that the employee sues. Finally, the low-dark blue line is the probability of employment in another firm. Panel (b) shows how many years pasted between the last time the employee appeared on the firm's payroll and the lawsuit happened.

### 6.2.2 Theoretical predictions of labor lawsuits

Table 6: Conflict at the Workplace

| | P(Fired = 1 if Separation = 1) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Suer | .235*** | .241*** | .19*** | .183*** |
| | (0.001) | (0.001) | (0.002) | (0.001) |
| Female | | -.107*** | -.0113*** | .000294 |
| | | (0.001) | (0.001) | (0.001) |
| Nonwhite | | .0418*** | .0301*** | -.00337*** |
| | | (0.000) | (0.000) | (0.001) |
| Less than High School | | .0621*** | .0535*** | .0442*** |
| | | (0.001) | (0.001) | (0.001) |
| High School | | .0166*** | .0418*** | .0316*** |
| | | (0.001) | (0.001) | (0.001) |
| Dep. Var Mean - Coworkers | .57 | .57 | .57 | .57 |
| Controls | | | | |
| Ind*Occ*Year*Age*Size FE | | | | |
| Firm FE | | | | |
| Observations | 5145771 | 4632597 | 4629831 | 4622854 |

This table shows key predictors of being fired from a job. The outcome variable take value 1 if the employee was explicitly fired, and it takes 0 if the employee stopped working in the firm for any other reason (quitting, retirement, etc.). Therefore, the sample in this regression are all employees who separated from their job in a given year. *Suer* is a dummy variable indicating if an employee will sue the firm in the following years. It takes value zero for all the coworkers who do not sue the firm at any point in our data.

### 6.2.3 Empirical Strategy and Results

We propose a *matching staggered difference in difference* to causally estimate the effects of a lawsuit on the wages of incumbent workers. To do so, we merged sued firms with the matched employer-employee, and we looked for them the year before being sued. Moreover, we condition that the firms survive three years before and after the lawsuit.

We classify these firms based on *industry, number of employees, legal form, state, and year of opening* cells. We then create a one-to-one matching, searching for firms that were never sued but correspond to the same cell and also survived the full period. Finally, we define incumbent workers as those who remain in the same firm for the six years around the lawsuit. [19]

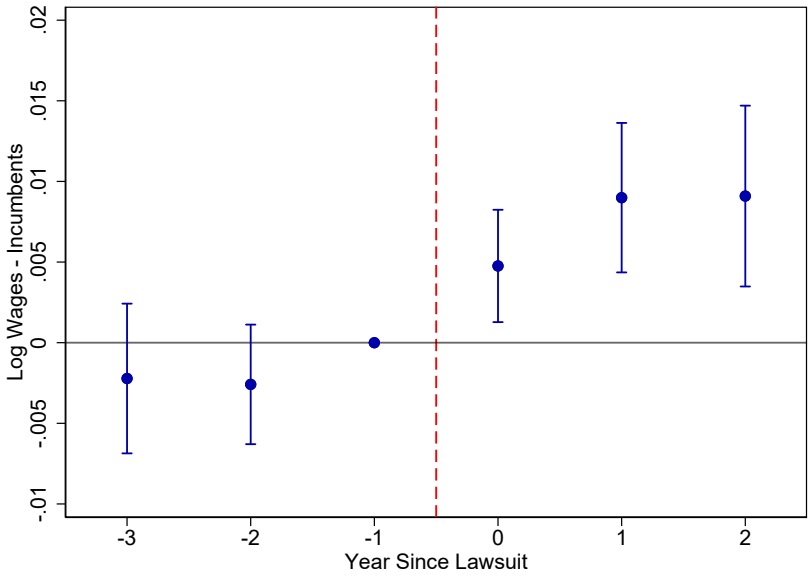
The key identification assumption is parallel trends in incumbent workers' wages for those in treated and nontreated firms. This rules out concerns related to survival bias, meaning that incumbent workers in sued firms are likely to be the most productive, and therefore high-wage employees. This average difference in levels between workers in treated and control firms would represent that the pretrends do not overlap. Fortunately, our identification assumption only requires parallel rather than overlapping pretrends. In addition, we add individual fixed effects to control for time-invariant individual characteristics. Equation (7) shows the exact regression.

$$\ln w_{i_{(j)}t} = \gamma_i + \delta_t + \sum_{k \neq -1} \beta_t \mathbf{1}(k = t)\mathbf{1}(j \in \text{treated}) + \varepsilon_{i_{(j)}t} \tag{7}$$

Here, the subindex $t$ refers to the year relative to the lawsuit (ranging from -3 to 3), and the subindex $(j)$ refers to a given firm $j$. As treatment is defined at the firm level, our coefficients of interest are $\beta_k$, which capture the interaction between the treatment and the time variable. $\gamma_i$ and $\delta_t$ capture individual and time-fixed effects, respectively. To avoid the problems of staggered dif-in-dif approaches when there may be heterogeneous treatment effects over time, we saturated unit- and time-fixed effects with indicators for dataset identifiers (Baker et al. 2022).

[19] We make sure that keeping only incumbent workers does not affect the one-to-one matching by dropping observations that loses their matching observation because that firm has no incumbent workers during the full period.

Figure 15: Average wages of incumbent Workers

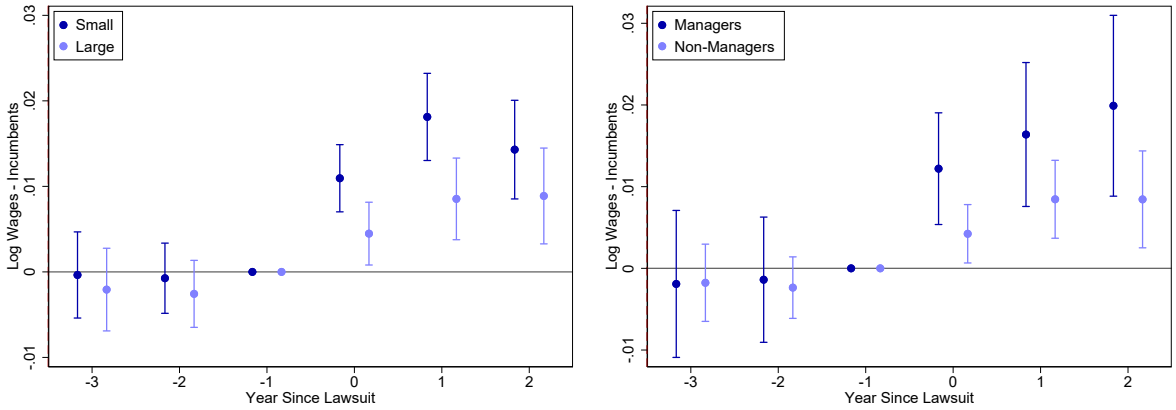



*Notes*: This Figure shows coefficients $\beta_t$ in Equation (7). The sample contains active employees who have worked in the same firm for the entire period but never appear in the lawsuit data. Treatment is defined at the firm level. The treated group contains firms that were sued for PUT. The control group contains firms that match the treated firms one-to-one based on their characteristics in the pre-period. A combination of *industry, number of employees, legal form, state, and year of opening* form a cell. If a cell has less control than treated firms, control firms are expanded randomly. If a cell contains less treated than control firms, we take a random subset of the latter. When keeping incumbent workers, we ensure that each treated firm remains matched with a control firm. Event time is centered in the lawsuit year. We include worker fixed effects and cluster standard errors at the firm level (treatment level).

We find that the reported wages of incumbent workers increase by about 1% due to the lawsuit. Furthermore, we do not find evidence of different pretrends between the treated and control individuals. It is helpful to use the results of Figure (1) in Section (4) to benchmark the effect of lawsuits. We know that about a quarter of formal employees admit to receiving PUT. Moreover, conditional on receiving PUT, they underreport about 20% of their total wages (25% of reporting wages). Taking these numbers at face value, if employers respond by reporting all the amount underreported, we cannot expect more than a 6.25% increase in reported wages. Therefore, a 1% increase represents about a sixth of the total reduction we could expect. Finally, Figure (16) shows that the heterogeneity is consistent with the survey and bunching shown

in previous sections. As smaller firms are more likely to have a higher share of PUT, we find larger effects on the reported wages of incumbent workers. Analogously, we find larger effects for incumbent workers in managerial positions. In Appendix (8), we also show the regression at the firm level rather than at the individual level, replacing individual-fixed effects with firm-fixed effects. We find similar results.

Figure 16: Event study plot - Average wages of incumbent Workers




(a) By Firm Size (b) By Managerial Position

*Notes*: This Figure shows coefficients $\beta_t$ in Equation (7). Panel (a) runs separate regression for incumbent workers in small and large firms. We define small firms as those in the bottom 25% of the firm size distribution in the year the matching is conducted. Panel (b) runs separate regressions for incumbent workers who hold managerial positions and those who do not. The sample contains active employees who have worked in the same firm for the entire period but never appear in the lawsuit data. Treatment is defined at the firm level. The treated group contains firms that were sued for PUT. The control group contains firms that match the treated firms one-to-one based on their characteristics in the pre-period. A combination of *industry, number of employees, legal form, state, and year of opening* form a cell. If a cell has less control than treated firms, control firms are expanded at random. If a cell contains less treated than control firms, we take a random subset of the latter. When keeping incumbent workers, we ensure that each treated firm remains matched with a control firm. Event time is centered in the lawsuit year. We include worker fixed effects and cluster standard errors at the firm level (treatment level).

One potential concern of our specification is that firms may modify workers' tasks to respond to the lawsuit. It should be noted that lawsuits can represent a major financial burden for firms. We observe that firms are more likely to close or reduce personnel after a lawsuit. Using incumbent workers eliminates the changes in the sample over

years that will arise from not conditioning on survival. However, it does not invalidate concerns about firms reorganizing activities for incumbent workers because of the lawsuit. Several responses could occur in this margin. First, consistent with the overall shrinkage in firms' activity that we observe, treated firms may reduce wages growth relative to control firms. This would lead to a downward bias of our estimates, suggesting that our current results are a lower bound. On the other hand, firms may reallocate incumbent workers to higher positions to cover the separation of other workers. They can also increase the hours worked by incumbent workers. This second response would translate into an increase in reported wages not due to reporting but due to task reallocation. We tested this hypothesis by examining the effects on occupation changes and hours worked using Equation (7). We find no effects, suggesting that our estimates are driven mainly by reporting changes and could be interpreted as a lower bound. Table (7) summarizes the main results.

Table 7: Effect of Lawsuit on Incumbent Workers

| | Log Wages | | | | Δ Occup | Hours Worked |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Treated x Post Lawsuit | 0.0108*** | 0.0180*** | 0.0103*** | 0.0182*** | -0.00235 | -0.0603 |
| | (0.002) | (0.003) | (0.002) | (0.004) | (0.003) | (0.038) |
| Sample | All | Small | Large | Manager | All | All |
| Obs (ind x time) | 6937602 | 487824 | 6449778 | 356427 | 5781335 | 6864310 |

This table shows the coefficient $\beta$ for the regression $\ln w_{i_{(j)}t} = \gamma_i + \delta_t + \beta \mathbf{1}(t > 0)\mathbf{1}(j \in \text{treated}) + \varepsilon_{i_{(j)}t}$. Columns (1) to (4) explore the heterogeneities shown in Figure (16). Columns (5) and (6) use as outcome variable changes in occupation and hours worked, respectively. As explained in the methodology, these regressions have saturated fixed effects at the unit x time.

### 6.2.4 Interpretation

The results presented in Table (7) are consistent with an increase in the marginal cost of employers for engaging in PUT with their employees. At the same time, it rules out alternative interpretations regarding adjustment in other margins (e.g. more hours worked, promotion, change in occupation). However, we can be more precise in un-

derstanding which the key drivers of the employer's marginal cost adjustment are. On the one hand, it is possible that employers had wrong perceptions of the probability of being sued, and they update after a lawsuit happens. On the other hand, when an employee sues, other employees in the firm can learn about this possibility or its benefits, leading to an increase in real (rather than perceived) risks. Our qualitative evidence from the survey of accountants and firms suggests that both margins may play a role.

To test for the *change in employers' perception*, we leverage the network of firms connected through ownership. We identify firms owned by someone who also owns a firm that was sued for PUT. Then, we study the reported wages of incumbent workers in these *connected* firms. Our preliminary findings suggest a positive and significant effect of about a third of the effect on directly affected firms. This suggests that employers are, at least to some extent, learning and changing their behavior beyond the employees in the sued firms.

Understanding how real risks are changing is tricky. We developed a strategy based on *suers-movers*. These are defined as employees who sued their firm and work for another firm later on. Then, we study the probability that the new coworkers sue for PUT in a *matching difference in difference* design. If it is true that employees learn from their coworkers about the possibility and/or benefits of suing, having a *suers-movers* as a coworker should increase their probability of suing. We find evidence that this effect is positive, suggesting that this margin may contribute to explaining results in Table (7)

Table 8: Effect of suer-mover on new coworkers

| | Probability of Suing (x100) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Treated x Post Move | 0.0140*** | 0.0205*** | 0.0227*** | 0.0329** | 0.0348** |
| | (0.003) | (0.004) | (0.006) | (0.010) | (0.011) |
| Sample | All | Gender + Race | G + R + Age | G + R + A + Occup3 | G + R + A + Occup5 |
| Dep. Var Mean | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| N | 61058258 | 28684048 | 6076800 | 2914959 | 2565962 |

# 7 Discussion

This paper reveals a significant presence of informal compensation practices within formal employment relationships, challenging the effectiveness of third-party reported income as a mechanism to ensure tax compliance. In Brazil, approximately 24% of formal employees acknowledged receiving PUT for about 20% of their wages. This widespread practice tends to be more prevalent among higher-income workers, implying a regressive aspect of PUTs. The consequences for government revenue and state capacity are considerable. Back-of-the-envelope calculations suggest that PUTs imply about 7% of income tax losses. These losses are larger than the analogous calculation for classic informal employment, calling for the special attention of policymakers and tax agencies in developing countries.

The evidence strongly points towards collusive behavior between the employer and the employee, which is captured in our conceptual framework. We propose a Nash bargaining determination for PUTs, in which employers and employees bargain over the share they take from the government. This model highlights that third-party reported income is only effective in increasing tax compliance as long as there is a conflict of interest between the agents involved. Regarding PUTs, the different tax rates faced by employers and employees can be seen as a potential benefit for both, since they can distribute the share evaded discretionary. However, they face different evasion costs, which brings conflict of interest. On the one hand, employees lose several social security benefits (e.g. pension, unemployment insurance), access to credit, income proof, etc. On the other hand, employers get exposed to higher audit and lawsuit risks, booking costs, etc.

We leverage quasi-experimental variation and rich administrative data to study changes in the marginal cost of participating in PUTs for the employee and the employer. Consistent with the model, we find strong evidence of workers closer to retirement bunching at the ceiling of the social security contributions, which was not previously documented in the literature. Furthermore, the model predicts that the size of the

bunching will increase as individuals approach retirement. Consistent with the survey evidence, bunchers are more likely to work in smaller establishments, hold managerial positions, own an external firm that can be used to receive the PUT, to exhibit strategic wage reporting behavior. Second, we show that firms increase by 1% the reported wages of incumbent workers who never sued the firm. Based on the evidence from our survey, this increase represents about a sixth of the total wages underreported, which makes the estimates quite sizeable. Consistent with the survey (and bunching) evidence, we find larger effects for smaller firms and managers. On the other hand, we show neither effects on task reallocation nor hours worked within the firm for incumbent workers, ruling out alternative explanations.

Our study presents, to our knowledge, the first attempt to produce a comprehensive picture of the practice of employees receiving part of their salaries off-the-books and its implications for the government's budget. Most of the existing literature on informality has focused on firm- and worker-level informality, with only some papers providing local evidence of the existence of unreported payments in response to particular policies. We also provide a conceptual framework to think through collusive tax evasion in settings with third-party reported income, allowing us to identify potential policy responses to reduce PUTs. Finally, we also provide the first attempt to investigate the consequences of PUTs related to distortions in economic activity.

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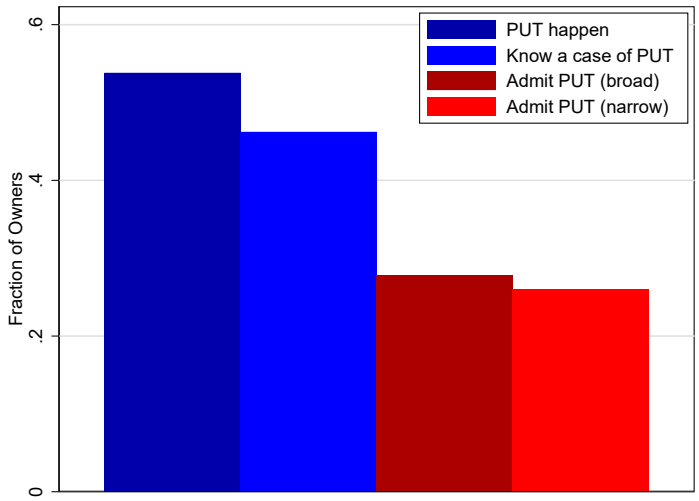
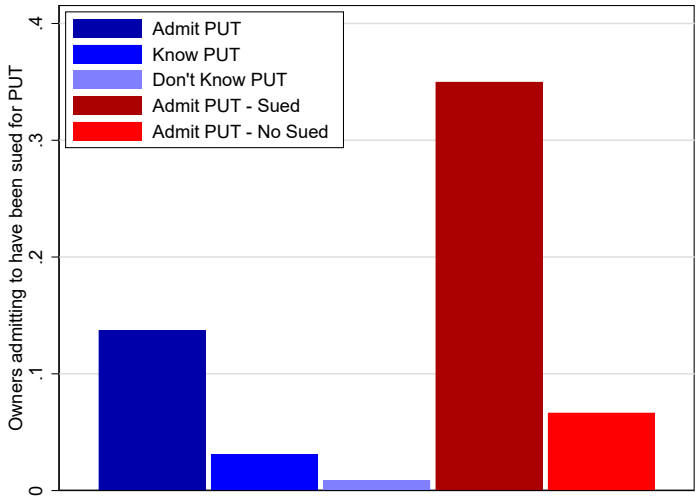
# 8 Figures

Figure 17: Fraction of Firm Owners Engaged in PUTs



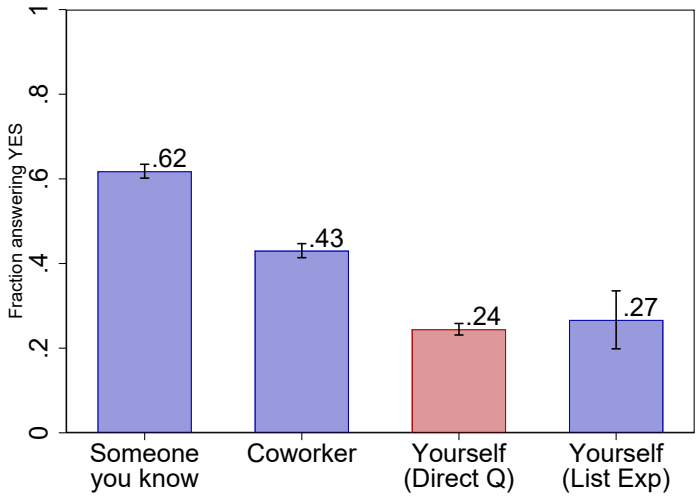

*Notes*: This figure shows

Figure 18: Validity Check: Firms sued for PUTs



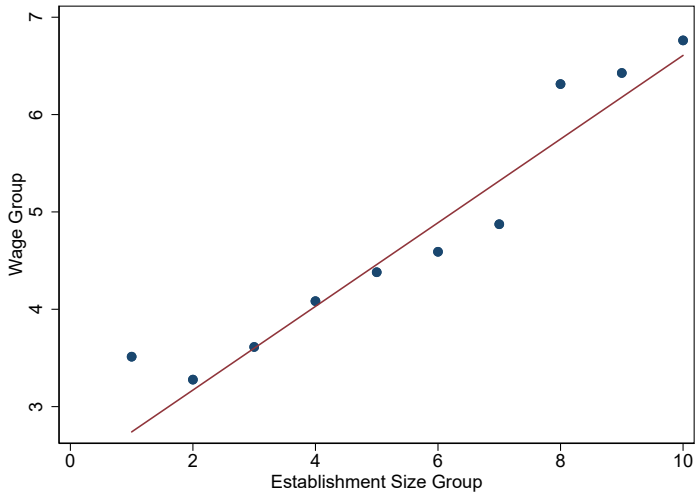

*Notes*: This figure shows

Figure 19: Proportion of Formal Employees Engaged in PUT



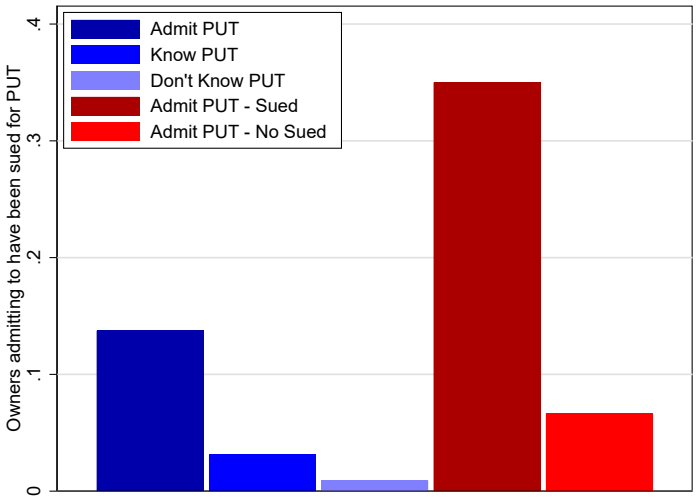

*Notes*: This figure shows the proportion of respondents in each category. "Yourself (List Exp)" is the proportion of workers that receive PUT derived from the list experiment. "Yourself (Direct Q)" is the proportion of respondents that report receiving at least some part of their salary as PUT. "Coworker" is the proportion of respondents that report that they know at least one coworker at their current establishment that receives part of their salary as PUT. "Someone you know" is the proportion of respondents that report that they know at least one person that receives part of their salary as PUT. Vertical bars represent 95% confidence intervals.

Figure 20: Correlation: Number of Coworkers and Wages



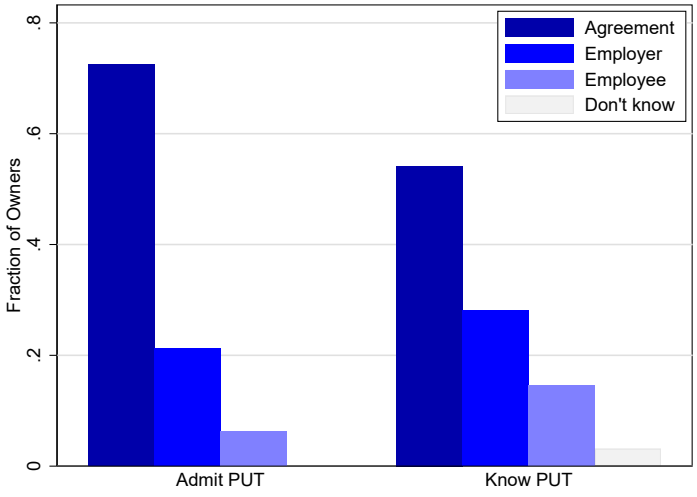

*Notes*:

Figure 21: Validation: Survey of Firm Owners



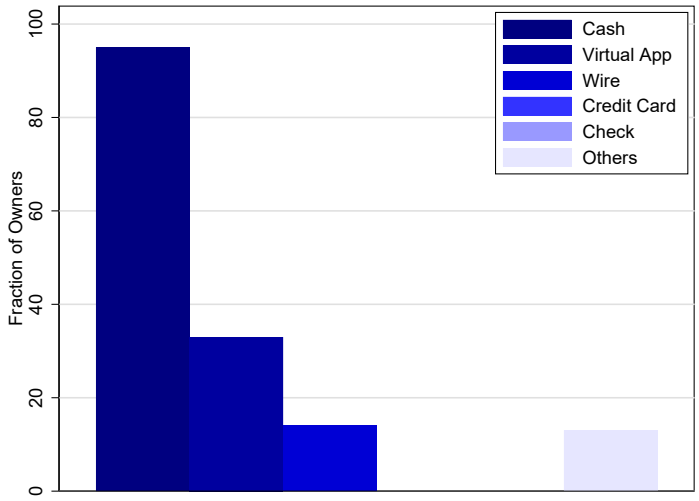

This plot shows

Figure 22: Who proposes PUT?



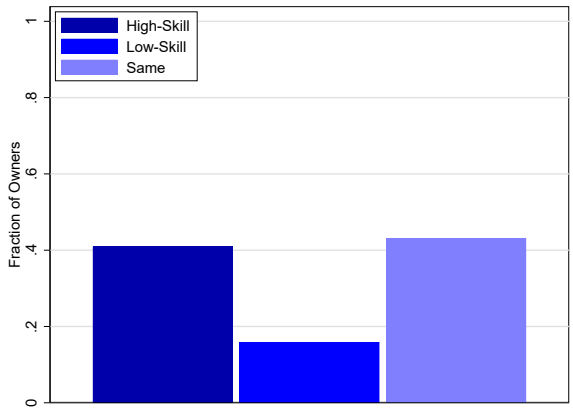

This plot shows

Figure 23: Payment Method (survey of firm owners?

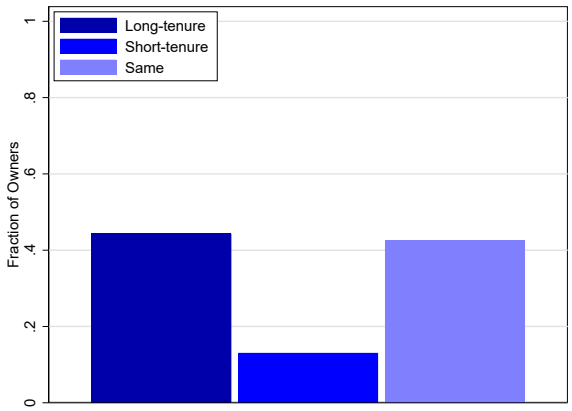



This plot shows

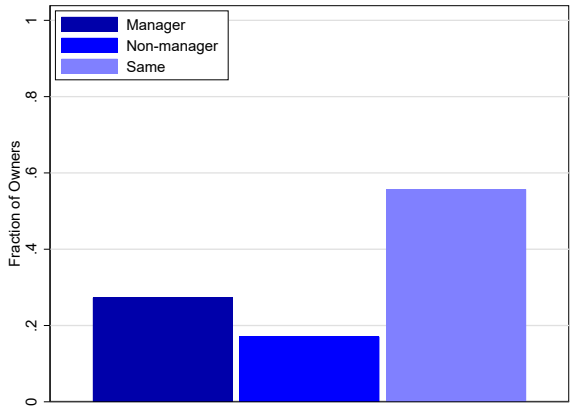
Figure 24: Survey to Firms: who to collude with



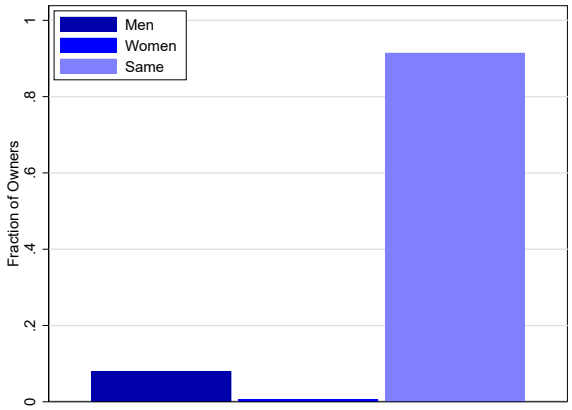

(a) Skill




(b) Tenure



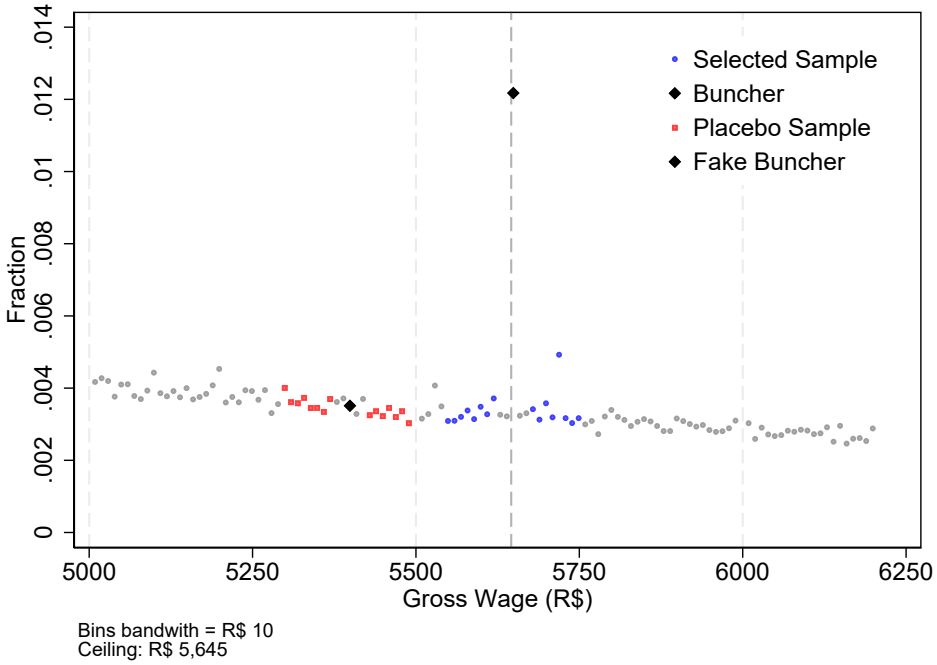

(c) Manager




(d) Gender

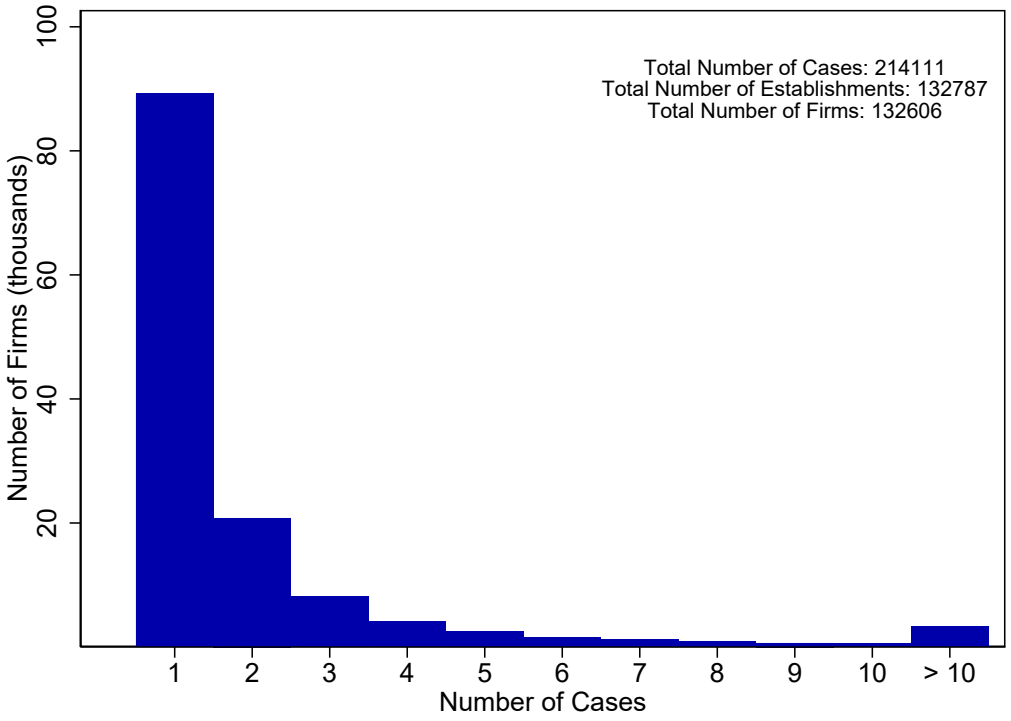
*Notes*:

Figure 25: Sample Selection



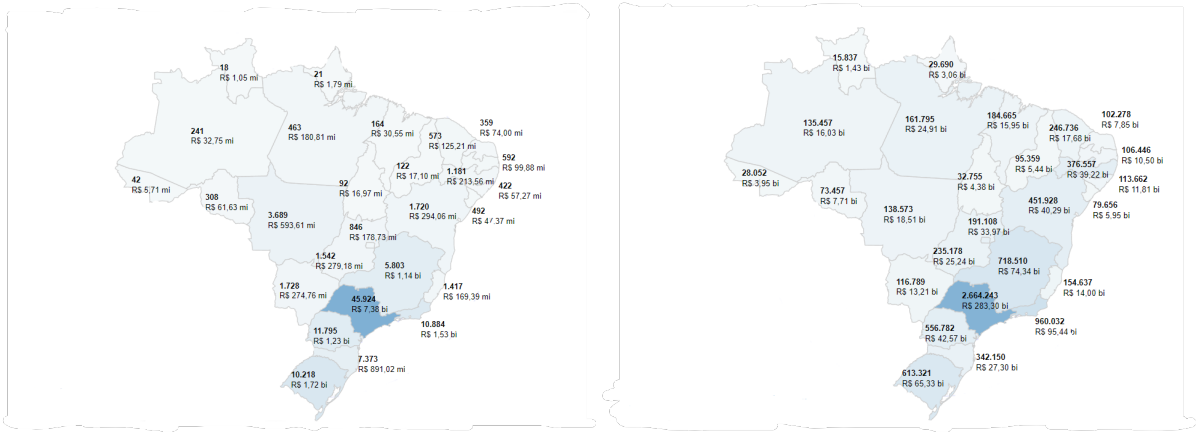

*Notes*: This figure shows the frequency of observations in each wage bin around the ceiling for the year 2017 for workers closer to retirement age. Selected bins for the buncher analysis are highlighted in blue. Non-selected bins are shown in red.

Figure 26: Histogram: Number of Cases by Firm




*Notes*: This figure shows the histogram of cases faced by each establishment. Most establishments only experienced one or two lawsuit between 2014 and 2019.

Figure 27: Labor Lawsuits in Brazil



(a) PUT-related (b) All

*Notes*:

# 9 Tables

# 10 Data

## 10.1 Employees Survey Data

### 10.1.1 Reweighing

explain reweight

### 10.1.2 List Experiment

explain reweight

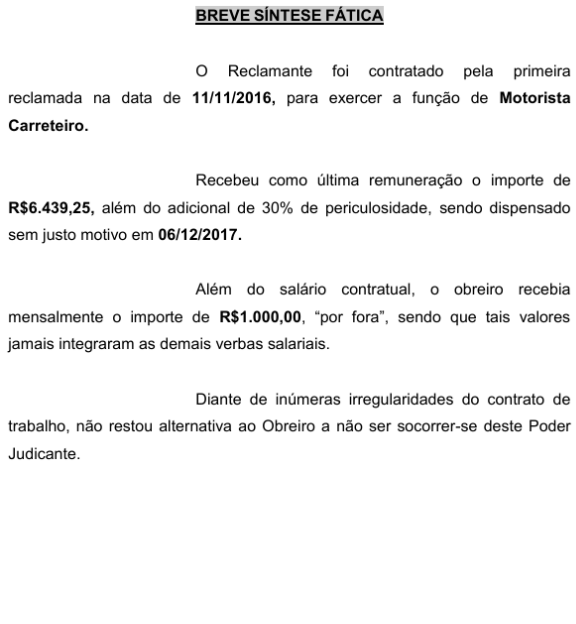
## 10.2 Labor Lawsuit Data

### 10.2.1 Administrative Records

### 10.2.2 AI Generated Data

In addition to the administrative records on PUT-related labor lawsuits, we processed a random subsample of 100,000 PDFs of the lawsuits. These PDFs are the initial claim made by the employee's lawyer to the judge, where they describe the events that took place in the workplace related to all labor law violations and the corresponding compensations. However, the PDFs are not structured in a common format, and each lawyer writes the information in their own way. The following examples illustrate information related to PUTs contained in two different PDFs.

Figure 28: PDF Examples



**BREVE SÍNTESE FÁTICA**

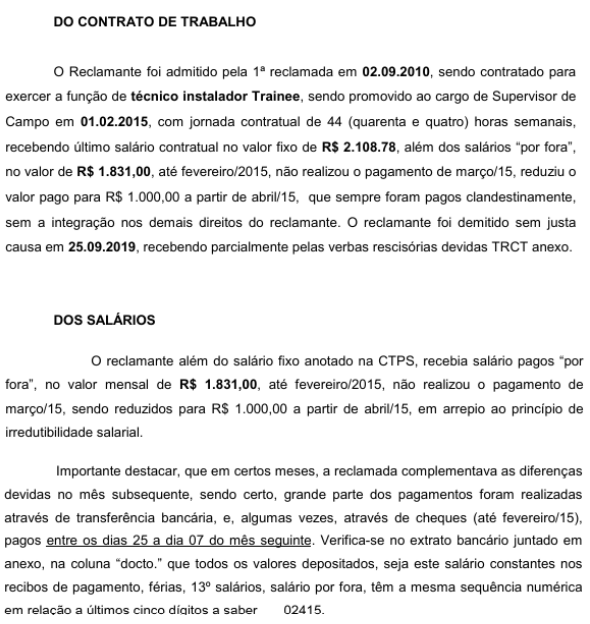
O Reclamante foi contratado pela primeira reclamada na data de **11/11/2016,** para exercer a função de **Motorista Carreteiro.**

Recebeu como última remuneração o importe de **R$6.439,25,** além do adicional de 30% de periculosidade, sendo dispensado sem justo motivo em **06/12/2017.**

Além do salário contratual, o obreiro recebia mensalmente o importe de **R$1.000,00**, "por fora", sendo que tais valores jamais integraram as demais verbas salariais.

Diante de inúmeras irregularidades do contrato de trabalho, não restou alternativa ao Obreiro a não ser socorrer-se deste Poder Judicante.

(a) Example 1



**DO CONTRATO DE TRABALHO**

O Reclamante foi admitido pela 1ª reclamada em **02.09.2010**, sendo contratado para exercer a função de **técnico instalador Trainee**, sendo promovido ao cargo de Supervisor de Campo em **01.02.2015**, com jornada contratual de 44 (quarenta e quatro) horas semanais, recebendo último salário contratual no valor fixo de **R$ 2.108.78**, além dos salários "por fora", no valor de **R$ 1.831,00**, até fevereiro/2015, não realizou o pagamento de março/15, reduziu o valor pago para R$ 1.000,00 a partir de abril/15, que sempre foram pagos clandestinamente, sem a integração nos demais direitos do reclamante. O reclamante foi demitido sem justa causa em **25.09.2019**, recebendo parcialmente pelas verbas rescisórias devidas TRCT anexo.

**DOS SALÁRIOS**

O reclamante além do salário fixo anotado na CTPS, recebia salário pagos "por fora", no valor mensal de **R$ 1.831,00**, até fevereiro/2015, não realizou o pagamento de março/15, sendo reduzidos para R$ 1.000,00 a partir de abril/15, em arrepio ao princípio de irredutibilidade salarial.

Importante destacar, que em certos meses, a reclamada complementava as diferenças devidas no mês subsequente, sendo certo, grande parte dos pagamentos foram realizadas através de transferência bancária, e, algumas vezes, através de cheques (até fevereiro/15), pagos entre os dias 25 a dia 07 do mês seguinte. Verifica-se no extrato bancário juntado em anexo, na coluna "docto." que todos os valores depositados, seja este salário constantes nos recibos de pagamento, férias, 13º salários, salário por fora, têm a mesma sequência numérica em relação a últimos cinco dígitos a saber 02415.

(b) Example 2

*Notes*:

Lack of

## 10.3 Ownership Data

### 1) Ownership Information for Brazilian Firms

*Cadastro Nacional de Pessoa Jurídica (CNPJ)*: consists of a registry of all formal establishments in the country. This includes for-profit businesses, public sector establishments, and non-profit organizations [20]. For every firm in the CNPJ, we have their unique firm

[20] In Brazil, these organizations are legally considered public entities that should disclose ownership, address, and information on the activity. Nevertheless, this was not easily tracked by researchers. Before 2018, one would have to ask for individual information of each organization to the *Receita Federal* (Brazilian Tax Authority), making it virtually impossible to obtain information on the universe of firms. After a long judiciary process, in 2018, the *Receita Federal* started to release files containing the information of all formal firms. Those files are publicly available at the tax authority website and used in our analysis.

identifier, name, legal form, date of entry, date of closure (if closed), industry defined at the 7-digit CNAE level, initial capital, and address. Ownership information in the publicly available CNPJ dataset is only recorded for firms with more than one legal owner. Additionally, when owners are identified, it only releases 6 out of 11 digits from the owners' CPF[21], full name, and date of entry into the partnership.

*Cadastro Nacional de Empresas (CNE)*: it used to be organized by the Ministry of Industry and Commerce (MDIC) to create state-level business registers. It was collected until 2017, and its access is restricted and was obtained through direct contact with MDIC. Every business establishment in Brazil must register in federal and state business entities. These state-level entities are called *Juntas Comerciais* and collect information similar to that reported to the Federal Tax Authority. The CNE complements the CNPJ data set by providing us with the name and full CPF of firms with one single owner.

*Firm Records from Junta Comercial do Estado de Sao Paulo (JUCESP)*: is an autarchy of the state government that is responsible for organizing and keeping firm records. According to the Brazilian constitution, every formal business must register in its state's *Junta Comercial*[22]. In Brazil, firm ownership information is, in theory, public. All states' Trade Boards are obliged to make all information they collect public but can charge for it[23]. JUCESP is the only Trade Board that allows Brazilian Citizens to access information for free. However, they do not make it easy. To recover firm records, it is necessary to have a Brazilian Social Security Number (CPF) and registration on JUCESP's website. Each citizen has access to 799 firm records per day. We have collected over 3 million identified firm records for the last four years, covering all formal firms created in Sao Paulo between 2003 and 2023. These records contain full ownership information. Notably, they include the name and total social security number of all founders[24].

[21] They are always the six digits in the middle, as the data comes in a format *.XXX.XXX-** where we observe the Xs but not the asterisks.

[22] We translate *Junta Comercial* to Trade Board. Still, it can be translated to the commercial registry or business board.

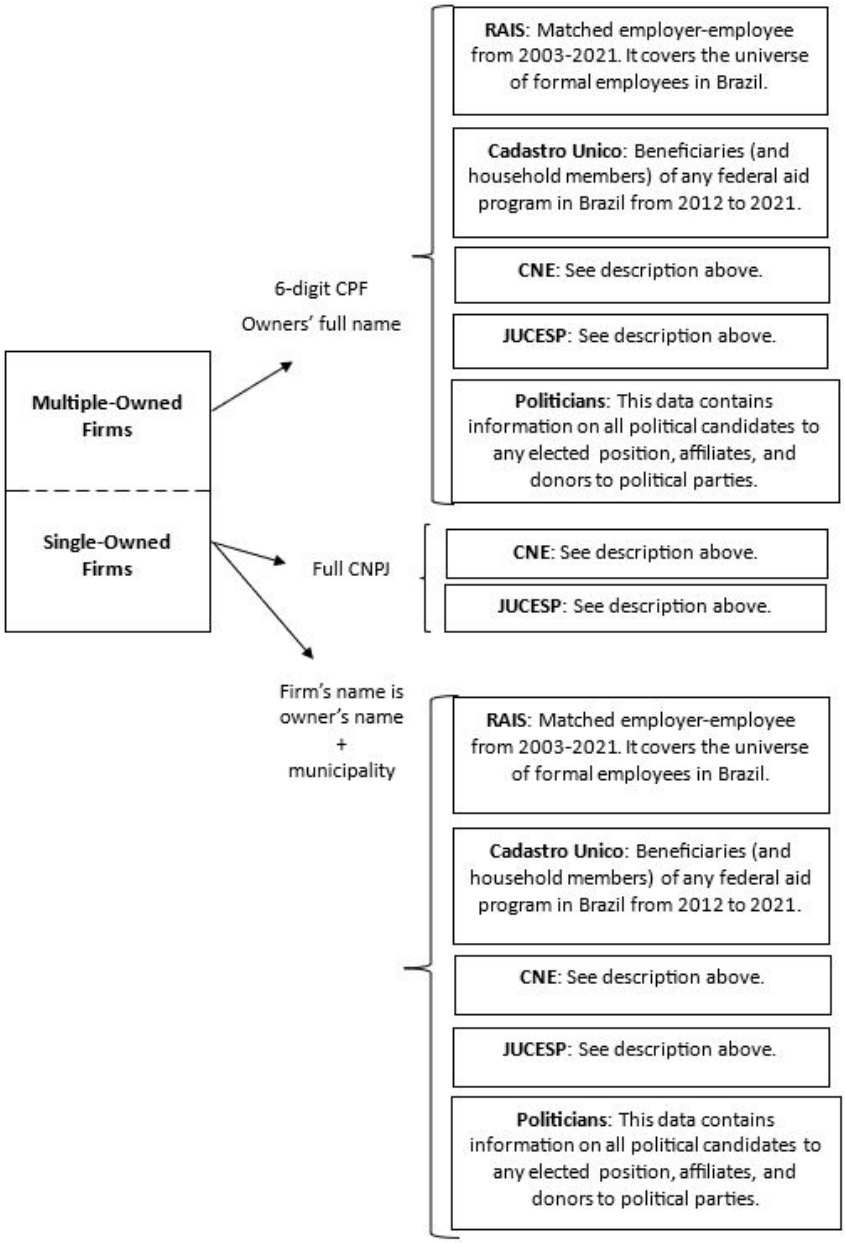
[23] Almost all states in the country charge exorbitant price rates for firm records stating who are the owners or who created each firm.

[24] If another firm founded the firm, the records contain the firm identifier of the founding firm.

See Appendix B for an example of this data. In addition to extending the CNE data for Sao Paulo after 2017, these PDFs track the full history of the firm from creation to closure (if closed). CNE, on the other hand, is a snapshot of ownership in 2017. We developed a text analysis code that reads these standardized PDFs and systematizes the information.

**From input data sets to master ownership data set**

Figure 29: Building blocks of ownership master data




*Note: This diagram illustrates how we go from the full list of firms in Brazil (CNPJ data) to the identifiers of their owners. As illustrated, the correct way to do it depends on whether the firm is multiple or single-owned.*

Figure (29) displays how we use our data sets as building blocks of a master ownership data set. We can divide the universe of firms (CNPJ data) into single and multiple-owned firms. These two groups of firms have different rules for ownership reporting. For multiple-owned firms, the data contains one row for each owner, perfectly identified by identification number plus full name. When the owner is a person, the identification number is the CPF. Instead, the identification number corresponds to the CNPJ when the owner is another firm. The caveat is that we never observe the full CPF or CNPJ, just six digits.[25] To merge firms' owner information to other data sets identified at the CPF level (as the education data), we need to recover the full CPF of the owners. Therefore, we sharply merge those six digits and the full names of the owners with our additional data sources listed in the diagram. This allows us to recover the full CPF of *90%* of all owners. This translates into finding that for 95% of all firms with multiple owners, we can recover at least one of their owners. Note that although for some firms, we cannot find the full CPF of all its owners, we can still know how many owners that firm has. This will become very important when classifying the type of entrepreneurial activity that we use as the outcome variables in our regression because the number of owners is a good proxy of the complexity of the firm and the actual economic activity.

The second group of firms is those owned by a single individual. In this case, the CNPJ data does not report ownership information. Fortunately, CNE does. While CNE does not cover the population of single-owned firms in Brazil (especially after 2017), it allows us to recover *67%* of them. Additionally, several single-owned firms register the owner's name as the firm's name. Given that we also know from CNPJ data which municipality each firm is located in, we conduct a sharp merge using complete owners'/firms' names plus municipality with all our extra data sources. This increases the finding rate by *10pp* more. The following Table illustrates the coverage and representative of our final ownership data.

[25] Full CPF has 11 digits and CNPJ 14 digits.

# 11 Back of the Envelope Calculations

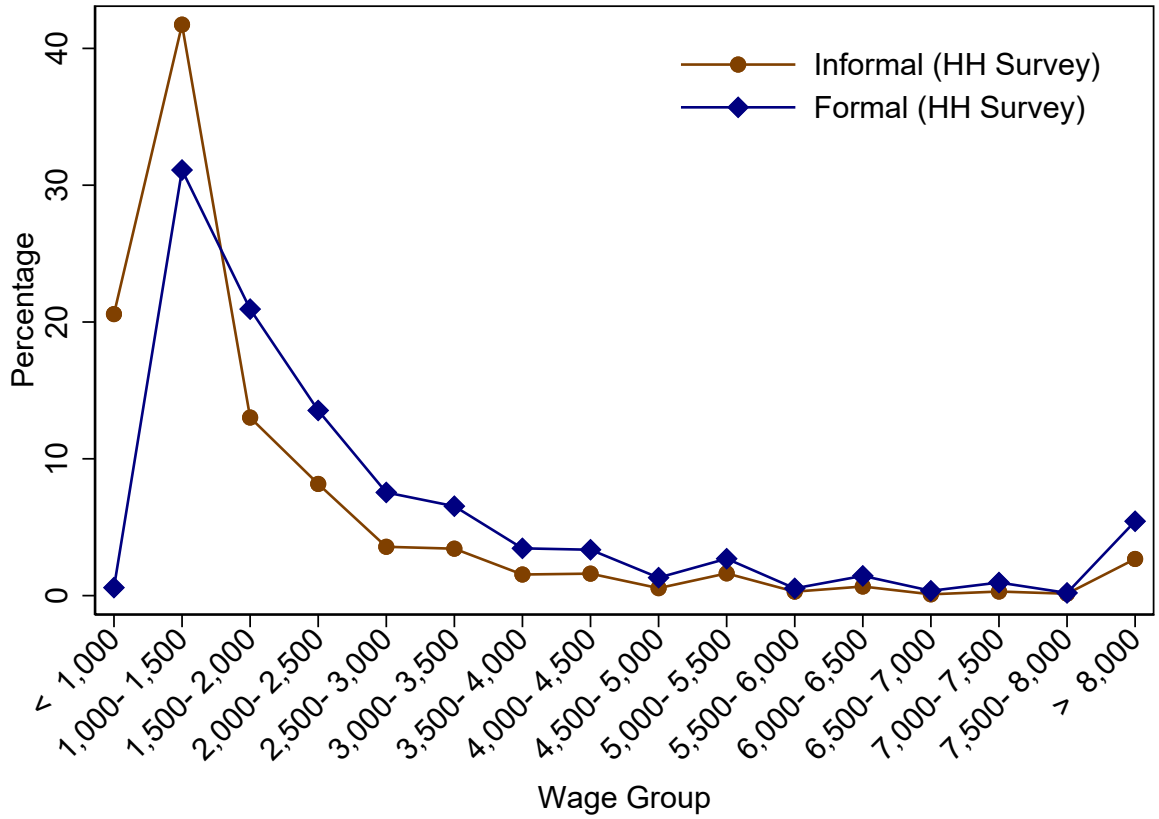
The inputs for the back of the envelope calculation are:

1. Income distribution of informal workers and PUT receivers
2. Proportion of formal workers receiving PUT
3. Fraction of the wage paid under the table for PUT receivers for each wage group
4. Marginal tax rate and tax brackets for income tax and contributions
5. Total number of informal, private, public and formal workers

**Income distribution of informal workers and PUT receivers**

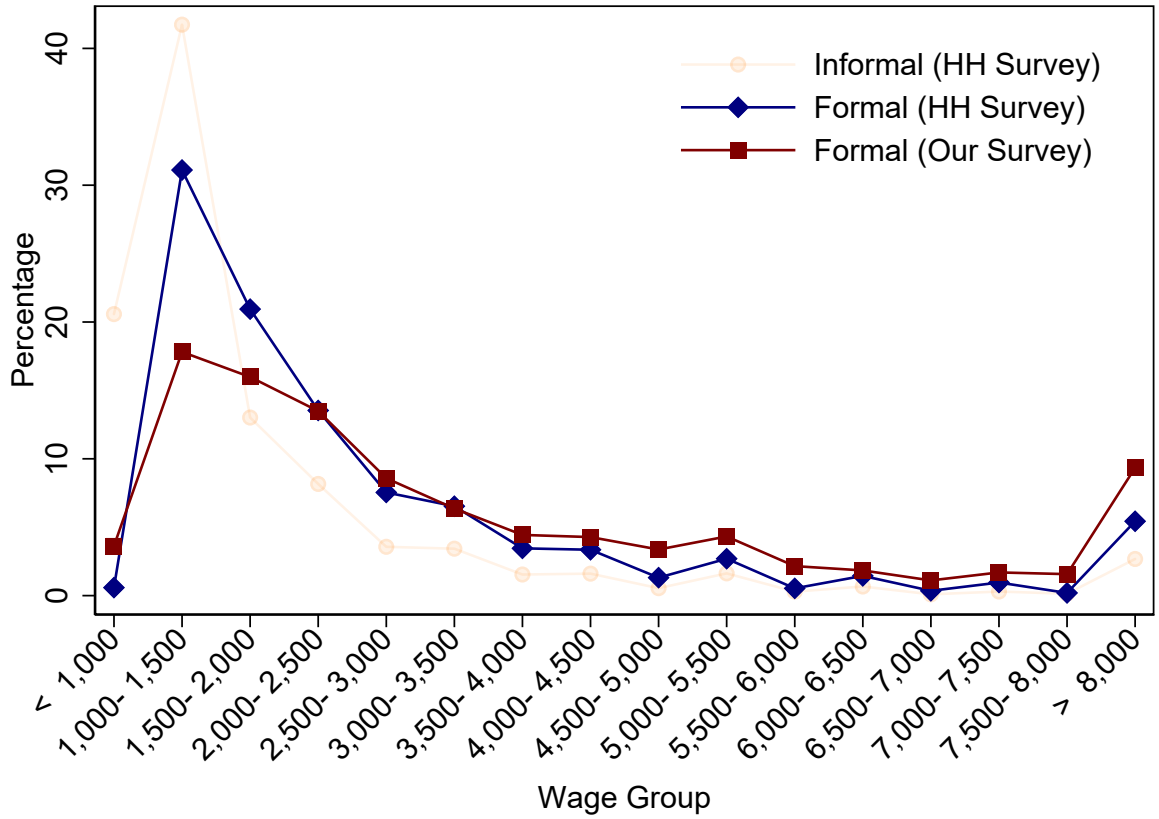
We recover the income distribution of informal workers from PNAD-C. On the other hand, we recover PUT receivers income distribution from our survey. However, our survey over-sample educated people and therefore it contains a higher fraction of high income earners. To make the comparison fair, we reweight our survey using the formal workers' income distribution from PNAD-C. From that, we recover the re-weighted PUT receivers' income distribution.

Figure 30: Income Distribution
(Informal v.s. Formal Employees)




*Notes*: this figure shows the percentage of respondents in each earnings bin. Red indicates all formal workers in our survey. Black indicates PUT receivers in our survey. Orange indicates informal workers in the PNAD-C survey. Blue indicates formal workers in the PNAD-C survey.

Figure 31: Income Distribution
(Our Survey v.s. PNAD-C Formal Employees)




*Notes*: this figure shows the percentage of respondents in each earnings bin. Red indicates all formal workers in our survey. Black indicates PUT receivers in our survey. Orange indicates informal workers in the PNAD-C survey. Blue indicates formal workers in the PNAD-C survey.

**Proportion of formal workers receiving PUT** is recovered from Figure (19)

**Fraction of the wage paid under the table for PUT receivers for each wage group** is recovered from Figure (**??**)

**Marginal tax rate and tax brackets for income tax and contributions**

Table 9: Income Tax (2022)

| Tax Base (R$) | MTR |
|---|---|
| $<$ *R*$ 1,903.98 | 0 |
| 1,903.98 - 2,826.65 | 0.075 |
| 2,826.65 - 3,751.05 | 0.15 |
| 3,751.05 - 4,664.68 | 0.225 |
| $>$ *R*$ 4,664.68 | 0.275 |

Table 10: Private Employee's SSC (2022)

| Contribution Base (R$) | MTR |
|---|---|
| $<$ *R*$ 1,212 | 0.075 |
| 1,212 - 2,427 | 0.09 |
| 2,427 - 3,641 | 0.12 |
| 3,641 - 7,087 | 0.14 |
| $>$ *R*$ 7,087 | 0.00 |

Table 11: Public Employee's SSC (2022)

| Contribution Base (R$) | MTR |
|---|---|
| $<$ *R*$ 1,212 | 0.075 |
| 1,212 - 2,427 | 0.09 |
| 2,427 - 3,641 | 0.12 |
| 3,641 - 7,087 | 0.14 |
| 7,087 - 12,136 | 0.145 |
| 12,136 - 24,273 | 0.165 |
| 24,273 - 47,333 | 0.19 |
| $>$ *R*$ 47,333 | 0.22 |

Additionally, employer's contributions are flat and equal to 20% of gross salary.[26] Additionally, the minimum wage is *R*$ 1,212 in 2022.

**Total number of informal, private, public and formal workers** are recovered from PNAD-C.

[26] Public sector is less clear in this point.

# 12 Questionnaires

## 12.1 Survey to Employees (online survey)

Hello!

We are a group of economics students, and we are studying the experience of workers in Brazil. We invite you to answer some questions about your own experiences as a worker, which will help us better understand the reality of the Brazilian labor market.

This survey lasts approximately 15 minutes, and your responses will be of great help to our project.

**Confidentiality: This survey contains some sensitive questions. Individual responses will be combined with those of other respondents and will never be submitted individually. Also, your responses will never be revealed outside this research group and will only be used for this project.**

We really appreciate your honesty in your answers.

Thank you for your participation!

**Do you currently work?**

- Yes
- No

In your main job, does your employer deduct your social security contributions from your paycheck?[27]

- Yes
- No

[27] The version in Portuguese ask for whether the respondent holds a *carteira de trabalho assinada*, which is a card that allows you to access social security benefits.

Is which sector is your main job?

- Private establishments
- Public sector
- Mixed company
- Self-employed (including both MEI and CNPJ)
- Other

**Change of Section**

**(List Experiment)**

**We present four (three) statements about possible work experiences. You must indicate how many of these statements correspond to your experience. In this way, if you indicate, for example, that two cases correspond to your experience, we are not going to identify which of these cases in particular are.**

- In the last 12 months, you thought about changing jobs because you are frustrated with the relationship with your chief and/or coworkers.
- Although you are offered a 10% higher salary in a position with similar obligations and the same location, you would prefer to continue in your current job.
- Your current salary is made up of two parts: one part that is declared in the payment sheet and the labor card (on which you pay taxes and contributions) and another part that is not declared on the payment sheet (on which you do not pay taxes or contributions)
- Since you started your current job, you have witnessed at least one situation of discrimination based on gender, race, religion or physical handicap.

**Change of Section**

How old are you?

What is your gender?

What is your education level?

- Incomplete primary school
- Complete primary school
- Incomplete high school
- Complete high school
- Incomplete college
- Complete college
- Post-graduate degree

What was your total labor earnings last month? *Bins of $R 500 from $R 1,000 to $R 10,000*

**Change of Section**

In addition to you, how many people work at the establishment where you have your main occupation?

- 0
- 1-4
- 5-9
- 10-19

- 20-49
- 50-99
- 100-499
- 500-999
- 1000-5000
- $>$ 5000

Is the establishment where you work at a family business?

- Yes
- No

How long (in years) have you been at this job?

Which of the following sectors best fit the activities carried out in your workplace? *See CNAE 2 digit classification*

Do you perform management or board roles in your workplace?

- Yes
- No

Do you have direct contact with the owners of the establishment where you work at?

- Never
- Very few times
- Very frequently
- Every day

**Change of Section**

In Brazil, **some formal workers (with a formal contract) receive part of their salary "off-the-books," that is, without it being declared on the company's payroll.**

Thus, the remuneration of these workers has two parts: **A part declared on the payroll** (for which taxes and contributions to the INSS are paid), and **another part outside the payroll** (for which taxes or contributions to the INSS are not paid).

The following questions refer to this informality: *formal employees with a formal contract, but who receive part of their salary outside the payroll*.

**It is worth remembering that the answers are 100% anonymous and will only be used for our research project. Under no circumstances will the content of these responses be used in addition to our academic research. We appreciate your collaboration.**

What proportion of all total workers do you think are receiving payments under the table?
*Slider from 0% to 100%*

Do you know **any formal employees** who receive part of their salary outside the payroll declared by the employer?

- Yes
- No

**In your current job, do you know any formal employees** who receive part of their salary outside the payroll declared by the employer?

- Yes
- No

**In your current job, do you** receive part of their salary outside the payroll declared by the employer?

- Yes
- No

**Change of Section**

You replied that you receive a portion of your salary outside the payroll declared by your employer. **Our research is about understanding how common these types of payments are.**

In the following questions, we will ask you how these payments work.

Thank you so much for helping us!

What percentage of your total labor income is paid off the books?

- 0-5%
- 6-10%
- 11-20%
- 21-30%
- 31-40%
- 41-50%
- $>$ 50%

When we started the survey we asked about your total labor earnings last month. What did you think about when answering?

- I answered thinking about total wage (reported and non-reported)

- I answered thinking only about reported wage
- Other

When did the proposal for paying part of the salary under the table come up? Was it your idea or your employer's?

- At the beginning of the employment relationship and suggested by the employer
- At the beginning of the employment relationship and suggested by you
- Sometime after the job started and suggested by the employer
- Sometime after the job started and suggested by you

How are the off-the-books wages paid?

- Cash
- Check
- Virtual Apps
- Good and service (like firm's credit card)
- Through a firm as a contractor
- Other

Since you started the job, what part of the salary has grown the most?

- The reported wages
- The non-reported wages
- Both grew at about the same rate
- I don't know

With regard to the thirteenth salary and paid vacation. Do you receive the equivalent of your total salary or only the part declared on the payroll?

- The equivalent of the total salary
- The equivalent of the salary reported on the payroll
- Other

On many occasions, employees and employers decide the amount non-reported based on laws, taxes, benefits, regulations, etc. In your case, which of the following obligations are relevant in deciding how much is not declared in the payroll?

- Income tax
- Minimum wage
- Employer payroll-taxes
- Social security contributions
- Audits to establishments
- Trash collection tax
- Minimum wage negotiated by unions
- None of the above (other)

## 12.2 Survey to Firm Owners (phone survey)

Hi, we are a group of researchers from the University of California, Berkeley. We are calling to invite you to participate in a survey about payment practices. Are you the firm's director or owner? If not, may I talk to him/her?

We are interested in understanding how taxes, contributions and regulations may affect how firms pay to employees, and the embedded risks. Would you like to participate?

**Do you have knowledge on how wages are paid in the firm?**

- Yes
- No

How many years have you been in the firm?

How many employees there are in the firm?

What is the firm's industry?

What is the firm's tax regime?

**Change of Section**

**We are interested in understanding the following practice: employees with *carteira assinada*, but who receive part of their wages outside the paycheck. This practices can be carried out in several ways. We highlights that we are not interested in informal employees (without *carteira assinada*) or contractors. This survey is 100% anonymous, and we have no connection with any governmental institution.**

Do you think it is common to pay under the table?

- Yes
- No

What is the share of firms that you think pay under the table?

- 0%
- 1% - 10%
- 11% - 25%

- 26% - 50%
- 50% - 75%
- More than 75%
- I don't know/ I prefer not to say

Among the firms relevant for your market/industry, what is the share of firms that you think pay under the table?

- 0%
- 1% - 10%
- 11% - 25%
- 26% - 50%
- 50% - 75%
- More than 75%
- I don't know/ I prefer not to say

**This question is very important for us. Do payments under the table happen in your firm?** (remember: these are formal employees receiving part of their wages outside the paycheck)

- Yes
- No

**Change of Section**

# 13 Conceptual Framework: details and extensions

## 13.1 Collusion Model

$$\{\beta^*; \alpha^*\} = \text{argmax}\left[\beta R(\alpha) - C_W(\alpha)\right]^{\theta}\left[(1-\beta)R(\alpha) - C_F(\alpha)\right]^{(1-\theta)} \tag{8}$$

FOC ($\beta$):

$$R(\alpha)\theta[\beta R(\alpha) - C_W(\alpha)]^{(\theta-1)}[(1-\beta)R(\alpha) - C_F(\alpha)]^{(1-\theta)} =$$
$$R(\alpha)(1-\theta)[(1-\beta)R(\alpha) - C_F(\alpha)]^{-\theta}[\beta R(\alpha) - C_W(\alpha)]^{\theta}$$

$$\theta[(1-\beta)R(\alpha) - C_F(\alpha)] = (1-\theta)[\beta R(\alpha) - C_W(\alpha)]$$
$$\theta[R(\alpha) - C_F(\alpha)] - \theta\beta R(\alpha) = (1-\theta)\beta R(\alpha) - (1-\theta)C_W(\alpha)$$
$$\theta[R(\alpha) - C_F(\alpha)] + (1-\theta)C_W(\alpha) = R(\alpha)\beta$$
$$\frac{\theta[R(\alpha) - C_F(\alpha) - C_W(\alpha)] + C_W(\alpha)}{R(\alpha)} = \beta$$

Implying

$$\beta^* = \frac{\theta[R(\alpha) - C_F(\alpha) - C_W(\alpha)]}{R(\alpha)} + \frac{C_W(\alpha)}{R(\alpha)} \tag{9}$$

FOC ($\alpha$):

$$\underbrace{\theta[\beta R'(\alpha) - C'_W(\alpha)][(1-\beta)R(\alpha) - C_F(\alpha)]}_{(A)} = \underbrace{-(1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)][\beta R(\alpha) - C_W(\alpha)]}_{(B)}$$

Working with (A):

$$\theta[\beta R'(\alpha) - C'_W(\alpha)][R(\alpha) - C_F(\alpha)] - \beta R(\alpha)\theta[\beta R'(\alpha) - C'_W(\alpha)]$$

Working with (B):

$$-(1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)]\beta R(\alpha) + (1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)]C_W(\alpha)$$

Putting the expressions together and reorganizing the terms we get:

$$\underbrace{\theta[\beta R'(\alpha) - C'_W(\alpha)][R(\alpha) - C_F(\alpha)]}_{(C)} - (1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)]C_W(\alpha) =$$
$$\beta R(\alpha)\left[\theta[\beta R'(\alpha) - C'_W(\alpha)] - (1-\theta)[(1-\beta)R'(\alpha) - C'_F(\alpha)]\right]$$

Note that (C) can be re-write it as:

$$\theta[\beta R'(\alpha) - C'_W(\alpha)][R(\alpha) - C_F(\alpha) - C_W(\alpha)] + C_W(\alpha)\theta[\beta R'(\alpha) - C'_W(\alpha)]$$

Using this version of (C) and $R(\alpha)\beta^*$ found in the FOC for $\beta$:

$$[\beta R'(\alpha) - C'_W(\alpha)][R(\alpha) - C_F(\alpha) - C_W(\alpha)]\theta(1-\theta) =$$
$$-(1-\theta)\theta[(1-\beta)R'(\alpha) - C'_F(\alpha)][R(\alpha) - C_F(\alpha) - C_W(\alpha)]$$

Implying

$$R'(\alpha^*) = C'_W(\alpha^*) + C'_F(\alpha^*) \tag{10}$$

## 13.2 Functional Forms

## 13.3 Extensions

### 13.3.1 Employees

The following framework is a simple way to capture patterns we see in the data. In particular, this model generates that, conditional on receiving PUT, the proportion evaded is increasing on total labor earnings. Moreover, it rationalizes a simple way the bunching patterns we see in section (**??**).

Here, we look only at the worker's side as the determinant of how much to under-report. This can be thought of as shifting the full bargaining power to the employee. She chooses, based only on her personal incentives, what proportion of her total earning to report ($\alpha$). We abstract from the employer's incentives that have been studied in other papers (Kleven et al. 2016), recovering, consistent with the evidence in our paper, that larger firms are less likely to engage in collusive tax evasion. Therefore, we also set the gross wage ($w$) paid by the firm as exogenous.

$$\max_{\alpha_i} \left\{ \alpha_i w_i + (1-\alpha_i)w_i - \underbrace{T\left((1-\alpha_i)w_i\right)}_{\text{Total taxes}} + \underbrace{\phi\left((1-\alpha_i)w_i\right)}_{\text{Benefits of reporting}} \right\} \tag{11}$$

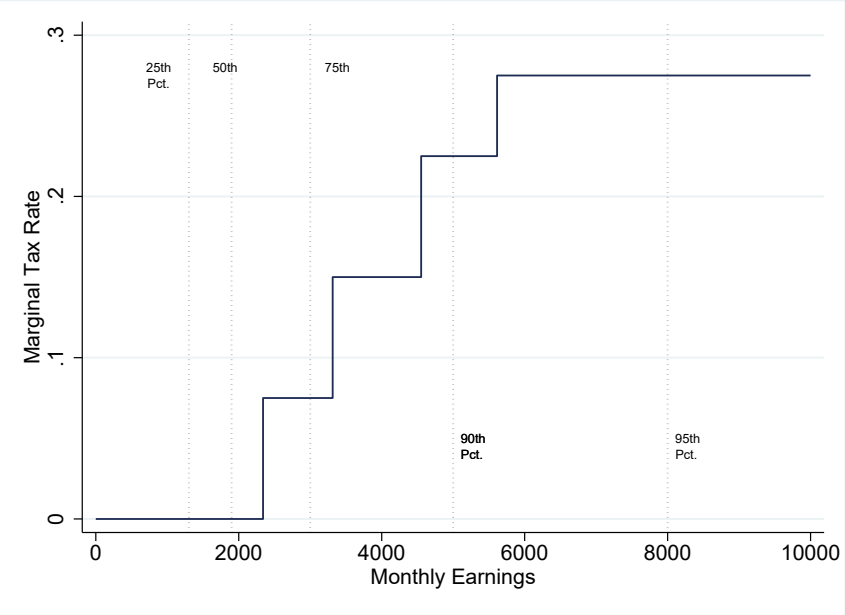
Each worker $i$ chooses $\alpha_i$ to maximize equation (11). Intuitively, the workers can choose what part of the wage to report and then pay taxes and receive benefits for only the amount reported. The only source of heterogeneity across workers is the gross wage $w_i$.

Then, each worker is trading tax payments and benefits off when deciding whether or not to increase the reported wage marginally.

$$(\alpha): \quad T'((1-\alpha)w) = \phi'((1-\alpha)w) \tag{12}$$

Most countries have non-linear income tax schemes. Brazil is not the exception, as seen in Figure (32).

Figure 32: Non-linear Income Tax Scheme




*Notes*: This figure shows the marginal income tax rate scheme (IFRS) for 2023.

Moreover, when marginal benefits ($\phi'(\cdot)$) have discontinuities, it is mainly in the opposite direction, meaning a drop. A clear example is the ceiling to SSC, studied in section (6.1.2), where the pension depends on the minimum between your reported wages and the ceiling. This means that the reported dollar above the ceiling has no impact on your retirement. In some situations, it also mirrors a drop in contributions rate. Therefore, the key is to think about the difference between marginal tax/contribution rate versus benefits.

In what follows, we present the simplest non-linear income tax case, where there is only one discontinuity in the income tax scheme, keeping constant the marginal benefits. The analogous problem is to consider a drop in the marginal benefits when crossing the ceiling of SSC. Even when it comes together with a decline in contribution rates, for those workers who had positive net benefits of reporting, crossing the threshold makes such incentives disappear.

**Simple Case: Non-linear Income Tax**

$$T((1-\alpha)w) = \begin{cases} 0 & if \quad (1-\alpha)w < \bar{w} \\ \\ \tau[(1-\alpha)w - \bar{w}] & if \quad (1-\alpha)w \geq \bar{w} \end{cases} \tag{13}$$

$$\phi((1-\alpha)w) = b(1-\alpha)w \tag{14}$$

**Proposition** (1). *Let $\tilde{\alpha}$ be the $\alpha$ such that $(1-\tilde{\alpha})w = \bar{w}$. Then, if $w \geq \bar{w}$, $\tau > b$ and $b > 0$, $\tilde{\alpha} = \alpha^* = argmax_\alpha[U]$*

*Proof.* Suppose $\alpha^* < \tilde{\alpha}$ (lower evasion). Then $\exists \epsilon > 0$ and $\alpha^* + \epsilon < \tilde{\alpha}$ such that: $U(\alpha^* + \epsilon) - U(\alpha^*) = (\tau - b)\epsilon w > 0$. Then, $\alpha^*$ was not the optimal

Suppose $\alpha^* > \tilde{\alpha}$ (higher evasion). Then $\exists \epsilon > 0$ and $\alpha^* - \epsilon > \tilde{\alpha}$ such that: $U(\alpha^* - \epsilon) - U(\alpha^*) = wb\epsilon > 0$. Then, $\alpha^*$ was not the optimal

■

**Corollary** (1). Since $\tilde{\alpha} = \frac{w-\bar{w}}{w}$, then $\tilde{\alpha}'(w) > 0$

### 13.3.2 Employers - Profit Taxes and Labor Costs Deductability

This part provides a simple exercise showing that higher profit taxes may reduce PUT. We abstract from the employer-employee collusion and focus on how different tax rates may interact in employers' incentives to engage in PUT. Firms are typically taxed on profits or revenues. Typically, the share of firms taxed on revenues is larger in developing countries. Best et al. (2015) shows that revenue taxation reduces corporate income evasion by 60-70% in Pakistan, a setting with limited tax capacity. This is a very important result because it shows that even when revenue taxes reduce production efficiency, these effects are more than compensated for large cost elasticities related to evasion. However, looking only at corporate income evasion misses a (potentially large) cross-elasticity related to revenue collection due to the reporting of those costs.

In settings where PUTs are prevalent, reporting more labor costs implies more taxes. In fact, most of the accountants we interviewed mentioned that PUTs would be more minor if firms in Brazil would pay profit taxes rather than revenue taxes.

To illustrate how the interaction between profit taxes and other labor costs (for simplicity, we only consider payroll taxes), let us assume that a given firm $j$ maximizes profits based on how much wages to report (we fix firm's hiring decisions).

$$\max_{\alpha} \left[F(L) - (1-\alpha)wL(1+\tau_l)\right](1-\tau_p) - \alpha wL \tag{15}$$

Where $\alpha$ is the share of the wages to pay under the table, $\tau_l$ and $\tau_p$ are the payroll and profit tax rate, respectively. The first order condition to this problem is

$$\tau_l = \frac{\tau_p}{(1-\tau_p)} \tag{16}$$

This means that if the payroll taxes are higher ($\tau_l > \frac{\tau_p}{(1-\tau_p)}$), then evasion is desirable and vice versa. If we expand the setting to add a quadratic cost of evasion, as is typically done[28], the FOC becomes:

$$\alpha^* = \frac{(1+\tau_l)(1-\tau_p)}{\kappa_j(wL)} \tag{17}$$

This expression makes explicit that the relevant tax rate in an employer's decision to evade depends on the *effective* tax rate paid for an extra dollar reported, which depends both on the labor costs and the possibility of deducting it from profit taxes.

[28] We add $-\frac{k_j}{2}(\alpha wL)^2$ at the end of Equation (15)