How are Wages Determined? A Quasi-Experimental Test of Wage Determination Theories*

Marcelo Carvalho† Joao Galindo da Fonseca‡ Rogerio Santarrosa§

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Abstract

We use novel quasi-experimental variation to (i) test whether firm-specific demand shocks impact wages, and (ii) to disentangle predictions coming from wage bargaining and firm upward sloping labor supply curve (wage posting). We use a unique institutional feature of public procurement auctions in Brazil: the moment in which the auction ends is random. Under this setting, for close auctions in which firms are constantly outbidding each other by incremental amounts, winner and runner-up are as good as randomly assigned. Using this first variation, we find that winning a government contract increases wages. In addition, contract value is higher for auctions that (randomly) end earlier. We use these two sources of exogenous variation to disentangle the effect on wages that comes from changes in firm size (wage posting) and the part that comes from changes in contract value holding size constant (bargaining). We find evidence consistent with bargaining.

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†Vancouver School of Economics (UBC). Email: sdecarvalho.marcelo@gmail.com

‡University of Montreal. Email: ja.galindo.da.fonseca@gmail.com

§Insper. Email: rogeriobs2@insper.edu.br

1 Introduction

Growing evidence that wages respond to firm-specific demand or productivity shocks is at odds with perfectly competitive labor markets (e.g. Card et al., 2016; Kline et al., 2019; Garin and Silvério, 2023; Kroft et al., 2020; Amodio and de Roux, 2023), and is consistent with firms contributing substantially to wage dispersion across workers (Card et al., 2013; Barth et al., 2016; Card et al., 2016; Goldschmidt and Schmieder, 2017; Helpman et al., 2017; Sorkin, 2018; Abowd et al., 2018). This literature, however, has faced two major challenges. First, the identification strategy to estimate how wages respond to firm-specific shocks must rely on the assumption that workers in treated and non-treated firms would have earned the same wage in the absence of the shock. Second, and more importantly, rejecting competitive markets does not inform which non-competitive wage setting theory is the most relevant.

The two major theories of wage determination in non-competitive labor markets are wage bargaining and wage posting. Under the former, wages are bargained between employers and workers according to a bargaining rule, e.g., Nash Bargaining, Stole and Zwiebel (Mortensen and Pissarides, 1994; Cahuc et al., 2006; Elsby and Michaels, 2013; Acemoglu and Hawkins, 2014; Jarosch et al., 2019). The resulting wage depends on firm surplus and worker's outside options (e.g. the value of being unemployed, competing job offers). Importantly, the bargaining rule guarantees that for each additional dollar of surplus, a fraction, determined by worker bargaining power, goes to workers. In this context, a rise in firm demand boosts surplus, increasing wages directly via the bargaining rule. The larger surplus may also modify the firm's optimal size further changing wages. As a result, under bargaining, wage responses to firm demand can be decomposed into the direct effect of surplus and the variation coming from changes in firm size. As a result, bargaining implies that there should be an impact of firm demand on wages, even after we control for any variation in firm size.

Alternatively, under classic wage posting, firms make take-it-or-leave-it offers to workers. Furthermore, firms internalize the fact that a higher offer attracts a larger number of workers. As a result, each firm faces an upward-sloping labor supply curve (Robinson, 1933; Manning, 2003, 2011; Card et al., 2018; Kline et al., 2019; Kroft et al., 2020; Lamadon et al., 2022; Dube et al., 2022). Under posting, an increase in firm-specific demand leads the firm to increase wages to attract more workers. As a consequence, wage responses to firm demand are fully captured by variation in firm size. In other words, once we control for firm size there should be no wage variation left. Both theories predict that wages should respond to increases in firm-specific demand, but through fundamentally different mechanisms.

Importantly, these theories have different policy implications for relevant issues such as the gender wage gap and racial discrimination (Card et al., 2016; Lang et al., 2005). Policies of equal pay within a firm have different consequences under bargaining, where gaps may be driven by within-firm wage gaps (determined by differences in bargaining power and outside options), and under posting, where gaps arise from different sorting into firms. Another important distinction highlighted by Manning (2011) is that in wage bargaining models there is ex-post efficiency, while in wage posting some matches with positive surplus may not be consummated. As a result, policy interventions could have different implications for efficiency.

In an ideal experiment, one would increase the surplus of a firm and forbid it from hiring any additional workers. Wages would increase under bargaining, but not under wage posting. In contrast, we could force firms to hire workers and compensate them for any lost surplus. In this case, wages should increase under wage posting, but not under bargaining. The empirical challenge, however, is that increases in firm-specific demand or productivity raises both firm size and surplus – making it virtually impossible to distinguish the real mechanism behind the wage response with just one shock. Recent studies had to assume one model to estimate structural parameters, generally interpreting the rejection of competitive markets as evidence of wage posting (e.g. Kline et al. (2019); Kroft et al. (2020); Amodio and de Roux (2023)). On the other hand, a few papers have attempted to distinguish these two theories. Early research relied on survey data to document the incidence of these underlying practices in the market (Hall and Krueger, 2012). Recent studies test the relative importance of posting and bargaining, by verifying whether workers bargain up their current wage or change jobs when faced with competing job offers (Caldwell and Harmon, 2019; Lachowska et al., 2022). By focusing on outside options, they are unable to separately identify how firm demand shocks transmit to wages through higher firm growth and more surplus to be bargained over.

In this paper, we leverage quasi-experimental variation from procurement auctions where the winning firm sells goods to the government. A unique feature in these auctions generates randomness in the identity of the winner and on the contract value. We first test whether wages respond to increases in firm demand. Then, more importantly, we disentangle two major theories of non-competitive wage setting: wage bargaining and wage posting.

To do so, we obtained information on the universe of Brazilian public procurement auctions, by scraping the official federal government website for millions of HTML files and transforming these in usable data. In these auctions, firms repeatedly bid for a contract with the government, and all participants always observe the current winning (lowest) bid. The final (lowest) bid is the price the winning firm gets to sell to the government (descending first price auction).

Unlike other settings, these auctions have a unique feature: the moment in which the auction ends is random (chosen by a computer and unknown to participants). In particular, the duration of each auction comes from a uniform distribution, that is independent of any firm or auction characteristic, and bid behavior within the auction. Furthermore, they include products of all industries, from cleaning supplies to vehicle parts, medical equipment and computers. We merged this data with employer-employee matched data for the universe of formal workers in Brazil, *Relação Anual de Informações Sociais* (RAIS). In this data we observe both firm and worker characteristics, such as start and end of employment, earnings, contractual wages, education, occupation, gender and industry.

The random ending of the auction provides us with a natural experiment. For auctions in which winner and runner-up are constantly outbidding each other incrementally, winner and runner-up are as good as randomly assigned (Ferraz et al., 2015). For the entirety of the paper, we focus on close auctions - which we define to be when the two lowest bids are within 0.5% difference in value, and placed in the final 30 seconds of the auction. Intuitively, consider two firms, A and B, constantly outbidding each other by a few cents and placing their bids seconds apart. The random ending implies that the auction might end when either firm A or firm B is the lowest bidder. Then, both firms are in expectation similar in predetermined characteristics. As a result, we can use the runner-up as a natural counterfactual for the treated (winning) firm and credibly estimate the effect of firm-level demand shocks (winning a contract to provide goods to the government) on wages.

Second, the auction duration generates variation in the contract value won by the winner. Consider A' and B' also competing in a close auction that randomly lasted longer. Since each firm bids lower values as time goes by, this leads to a lower contract value won by firm A' relative to firm A. As a result, the surplus of firm A' relative to B' is (exogenously) smaller than the one received by firm A relative to B. By comparing the difference in outcomes of winner and runner-up across auctions that end late to those that end early we get an extra source of variation.

Wage bargaining implies that firms increase wages as a response to additional revenue, even after controlling for any change in firm size. Wage posting, on the other hand, implies that a firm only increases their wages when they need to increase employment. To empirically separate these competing theories, we consider an empirical specification in which wages are a function of the value of the contract won and the number of employees. We use two instruments to separately identify the effect of these two endogenous variables. Our first instrument is a dummy taking value one if the firm is the lowest bidder (and taking value zero if the firm is the runner-up). Our second instrument is the interaction between this same dummy and the (random) duration of the auction. Our sample consists of only winners and runners-up of close auctions. Importantly, for all our specifications, we include auction fixed effects to ensure we are comparing lowest bidder and runner-up of a same auction.

To formalize our intuition and guide our interpretation, we consider a tractable model in which both wage bargaining and wage posting are possible. The objective with the model is to show how the key elements of wage bargaining and wage posting map to a clear interpretation of our empirical results. As in Elsby and Michaels (2013), bargaining is over marginal product of labor. Similar to Card et al. (2018), from a worker's perspective, workplaces are imperfect substitutes which implies firms face an upward-sloping labor supply curve. The model shows that, holding the number of employees constant, firm revenue affects wages only via bargaining. Second, in the presence of an upward-sloping labor supply curve alone, wages should increase only through the number of employees. Finally, if both bargaining and an upward-sloping labor supply curve are present, the effect of number of employees on wages can be ambiguous. While the model helps to interpret our findings, it is not necessary for identification.

We find that winning a public procurement auction causes a 1.8% increase in wages one year later. Looking at treatment heterogeneity, we find that the effect is driven by young firms, with a wage increase of 2.7%. For the remainder of the paper we focus on young firms. We find that winning a contract leads to wage increases for both workers already present prior to the shock (stayers) and workers hired after the shock (new hires) but disappears for workers that leave the firm (separators). We also confirm that our results are robust to changes in composition.

Next, we estimate our main specification attempting to disentangle wage posting and wage bargaining. Our first-stage estimates show that winning an auction has strong effects on firm size and on contract value. As expected, winners of longer duration auctions earn a lower contract value. In particular, for each additional five minutes the auction lasts, the contract value decreases by 10%. The instrumental variable results show that a one standard deviation increase in contract value increases wages by 7.2%, while the effect of firm size is statistically insignificant. This result is consistent with the presence of bargaining. More precisely, our findings still allow for the presence of wage posting, but rejects its prevalence alone.

We provide further evidence on potential mechanisms associated to wage posting and wage bargaining. First, recent papers show that market concentration, due to firms not being atomistic (granular firms), is consistent with and has potentially important implications for both wage bargaining (Jarosch et al., 2019) and wage posting (Berger et al., 2022).[1] We investigate whether our estimates are different for firms with higher or lower labor market share and do not find any significant heterogeneity in terms of wage response. We find strong wage effects even for firms with minimal labor market share. In addition, wages in firms with larger shares respond to the demand shocks, even though their size remains unaffected, consistent with wage bargaining. For all samples, we consistently find wages responses coming from contract value, while firm size does not show any statistically significant effect. Second, Bhuller et al. (2022) document and discuss the widespread presence of collective bargaining and its implications for wage determination. Using data on collective bargaining agreements, we find larger wage responses in firms that had a collective bargaining agreement prior to the auction.

We have framed our analysis as disentangling between classic wage posting and wage bargaining models. For them, we obtain clear predictions regarding the effect of firm size and revenues. Of course, there are other models beyond them. It is beyond the scope of this paper (and perhaps of any paper) to test the predictions of every single wage-setting model in the literature. Nevertheless, we provide new empirical patterns that any model (or set of models) would have to satisfy. With this in mind, we also discuss to what extent other types of wage posting models (without a strict relationship between firm size and wage) would be able to rationalize our findings. Still, classic wage posting remains a widespread way to characterize labor markets – as evidenced by the large literature assuming wage responses to firm-specific shocks are fully accounted by labor supply elasticities (Ransom and Sims, 2010; Hirsch et al., 2010; Staiger et al., 2010; Falch, 2010; Depew and Sørensen, 2013; Matsudaira, 2014; Naidu et al., 2016; Vick, 2017; Card et al., 2018; Goolsbee and Syverson, 2019; Kline et al., 2019; Dube et al., 2019; Tortarolo and Zarate, 2020; Kroft et al., 2020; Dube et al., 2022; Lamadon et al., 2022; Amodio and de Roux, 2023). Overall, our findings cannot be explained entirely with a classic wage posting model (although it can still be present); are consistent with bargaining; and could be possibly (but not directly) accounted for by some (but not by many) other versions of more general wage posting models.

Our paper relates closely to the literature studying how firm-specific shocks impact wages (Christofides and Oswald, 1992; Blanchflower et al., 1996; Van Reenen, 1996; Abowd et al., 1999; Guiso et al., 2005; Card et al., 2014, 2016; Kline et al., 2019; Garin and Silvério, 2023; Kroft et al., 2020; Amodio and de Roux, 2023), improving on identification with the use of a novel quasi-experimental variation. Specifically, our setting resembles more closely an ideal experiment.

Recent literature uses patent winners (Kline et al., 2019) and firm-specific export

[1] Hence, when disentangling bargaining and posting we are not testing between firm granularity and atomistic firms. Instead, we are testing between two non-competitive wage setting procedures possible with both atomistic and granular firms.

demand shocks (Garin and Silvério, 2023). They require that workers in treated and non-treated firms are similar. Kroft et al. (2020) consider procurement auctions in which bidders do not observe the currently winning bid (sealed-bid auctions) and the ending of the auction is not random. They estimate structural parameters, having to assume one wage setting framework, interpreting rejection of competitive markets as evidence of wage posting. Instead, we use a setting in which the random duration of auctions generates random assignment in winner status. Furthermore, by using two sources of variation we disentangle wage bargaining from wage posting, finding evidence consistent with bargaining.

We also contribute to a growing literature studying the prediction from bargaining that wages are impacted by variation in outside options due to industry spillovers (Beaudry et al., 2012; Bidner and Sand, 2016; Beaudry et al., 2018; Green et al., 2019), coworker networks (Caldwell and Harmon, 2019), firm granularity (Jarosch et al., 2019) or secondary jobs (Lachowska et al., 2022). We depart from this literature in two main directions. First, while they focus on the role of outside options under wage bargaining, we test the complementary prediction that, under bargaining, rents pass-through to wages even after controlling for firm size. Second, the nature of our variation is arguably less likely to correlate with any change in worker's productivity.

More specifically, we closely relate to recent papers attempting to shed some light on the role of wage posting and bargaining. Caldwell and Harmon (2019) and Lachowska et al. (2022) use the implied consequence of posting models that a better individual outside option increases wages only via job-to-job transition, while bargaining also leads to within-job wage growth. Caldwell and Harmon (2019) use this implication to identify the share of posting and bargaining firms through the estimation of a structural model. Lachowska et al. (2022) document the relevance of bargaining and posting for different types of dual jobholders depending on their reaction to wage shocks in a secondary job (higher wage versus separation rate). Here, we improve on their work by using quasi-experimental variation to disentangle posting and bargaining, directly identifying the mechanisms responsible for the wage response to higher firm demand. By using individual-level outside options they identify the role of individual-level bargaining but not collective bargaining. Meanwhile, our test allows us to disentangle any form of wage bargaining (collective or individual) from wage posting.

The paper is organized as follows. Section 2 describes our data. Section 3 describes our empirical design. Section 4 presents our results on how auction demand shocks impact wages and workforce composition. Section 5 goes over our tractable model and presents our results disentangling wage bargaining from wage posting. Section 6 discusses to what extent other forms of wage posting (without a tight connection between firm size and wage) would rationalize our findings. Finally, Section 7 concludes.

2 Data

We combine two large administrative data sets: matched employer-employee data from Relação Anual de Informações Sociais (RAIS) and online procurement auctions conducted by the government of Brazil in the ComprasNet platform. ComprasNet is the online environment where the government conducts its auctions, and where the auction records are stored.

2.1 Auctions Background and Data

In this section, we explain the features of the auctions in our data. The governmental branch interested in procuring goods publishes an announcement of the auction, specifying the product and quantity being procured, the date and time when the auction will be conducted, which documents should be provided by the winning firm, and the location and date where the goods should be delivered. In the data there are 3,264 purchasing governmental branches, which are relatively disaggregated governmental levels. These can be for example an Army battalion, a university or a hospital. After this announcement, interested firms submit a sealed bid before the time of the auction. When the auction begins, the sealed bids are revealed to all participants and firms may start placing new bids in a descending price auction. To do so, a bidder needs to type the bid value in the auction page.

At each moment, all firms observe the currently winning bid. The winner is the firm that has placed the lowest bid when the auction ends. The auction has two parts: there is a first phase when the auction cannot end, and a final, random phase that can end at any moment – and after which no more bids are accepted. After some time elapsed in the first phase, the auctioneer announces when the final, random phase of the auction will begin. The duration of the first phase is at the auctioneer's discretion. The final phase has a random duration between 0 and 30 minutes, drawn electronically by the platform from a uniform distribution (Appendix Figure A1).

No participant or auctioneer is able to interfere with the duration of the random phase, or to know it before the auction ends. When the random phase ends, no new bids are accepted and the firm that has placed the lowest bid at that moment has the chance of selling the procured good to the governmental branch. The auctioneer messages the lowest bidder and asks that it sends the required documentation, setting a deadline for this. This deadline is usually within a few hours after the random phase ends. If the lowest bidding firm doesn't send the documentation in time, the auctioneer eliminates this participant and asks the second-placed firm to send it. This continues until a firm successfully sends the required documents, or until all participants have been called. A firm that successfully sends the required documents wins the contract to sell the procured goods. If all firms are called and none is able to produce all needed documents the auction is canceled.

Each auction is automatically registered by the ComprasNet platform in an auction record, which contains detailed specifications and quantity of the products being procured, the government's reference price, the tax identification number (CNPJ) of each participating firm, all bids placed and their respective timestamps, the contract winner, and contract value. It also contains the timestamps of crucial moments in the auction, particularly the start and ending of the random phase. We have scraped each auction record from the government's website and complemented it with detailed product classification codes.[2] We process millions of auction reports into a data set with all 9.2 million ComprasNet online auctions conducted between 2011 and 2016. Auctions are not concentrated in any specific group of products (see Appendix Table A1 for a breakdown). See Appendix for a detailed description of the data construction.

2.2 Employer-Employee Data

Our labor market data comes from RAIS (Relação Anual de Informações Sociais), which contains the universe of formal jobs in Brazil. We take observations from 2009-2017 and merge it with the auctions data using the firm's tax identification number (Cadastro Nacional de Pessoa Jurídica, CNPJ). In RAIS, for each job we observe a unique worker identifier, contractual wage, hours, earnings, race, sex, age, schooling, occupation, hiring and separation dates. For each firm, we observe its CNPJ, the municipality where it is located and its industry. The level of observation in RAIS is a job, so to build an annual data set we take only jobs that existed at the end of each year. In 2017, there are about 56 million unique workers and 3.8 million firms in RAIS.

For our identification strategy, which is explained in detail in Section 3, we focus only on close auctions where it is reasonable the lowest and second lowest bidders are as good as randomly assigned. After imposing this restriction and merging the two data sets, we are left with 256,697 close auctions with two firms in each, the lowest and second lowest bidder (see Appendix Table A4 for contract value summary statistics in the merged data set).

[2] 6-digit product code based on the Federal Supply Classification (FSC), developed by the United States' Office of the Secretary of Defense. https://mn.gov/admin/assets/DISP_h2book[1]_tcm36-281917.pdf.

3 Empirical Design

In this section, we establish how we use a unique feature of Brazilian procurement auctions to obtain credible quasi-experimental variation in firm-specific demand shocks. Our main goal is to estimate the effect of demand shocks on firm wages. Clearly, simply comparing auction winners and losers raises several concerns. These firms are likely different in their production function, size, and worker composition, any of which could affect wages and be correlated with winning an auction.

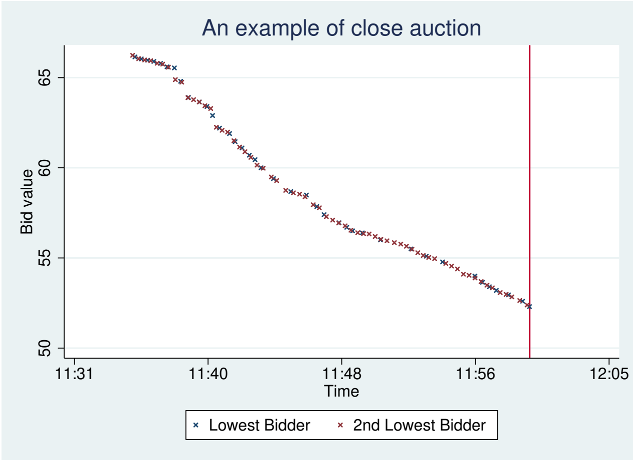
To overcome these endogeneity concerns, we use close auctions, relying on the practical frictions generated by the random ending and the manual time-consuming process for a firm to outbid a current winning bid. Figure 1 shows an example of a close auction. We plot the bid values of two competing firms: the first and the second placed bidder by the end of the auction. As time elapses each firm observes the lowest bid at the moment and decides whether to place a new bid. If it does, the firm must enter the bid manually on the auction page, which requires at least a few seconds. In the figure, we see how firms keep outbidding one another by incremental amounts until the end of the auction displayed by the vertical line. At this point, the lowest bidder wins the auction. Because the time the auction ends is not known, this creates randomness in the identity of the lowest bidder in close auctions. Had the auction ended a few seconds earlier or lasted a few seconds longer, the two lowest bidding firms would be switched. Since we observe each bid value and bid timestamp for each auction, we are able to verify that indeed the lowest bidder and runner-up identities switch if the auction had ended a few seconds earlier (see Appendix Table A2).

We use the time and value of each bid for all auctions and firms in our full data set to formulate our empirical definition of close auctions. We define these as auctions having at least two bids in the last 30 seconds and with a difference between bid values of at most 0.5%. After defining these auctions, we keep the firm that placed the lowest bid and the firm that placed the second lowest bid. By doing this, we ensure that we are on average looking at ex-ante identical firms. We also exclude auctions in which a firm has participated in more than two thousand close auctions during the 2011-2016 period.

We interpret each close auction as an experiment in itself. So for each auction, we follow the winner and runner-up and compare their main outcomes. We use job-level information from RAIS to construct firm-level earnings and worker composition variables for periods before and after the auction date. Our analysis uses annual earnings (main specification) and contractual wages (reported for robustness) as the main outcomes.

Our empirical design does not require any knowledge or assumption about the strategies of the firm. We are relying only on the practical frictions generated by the manual

Figure 1: Example of close auction



time-consuming insertion of the bid and the randomness of the auction end.[3] When the auction reaches the random phase, participants are not able to anticipate when it is about to end. Additionally, there is no automatic bidding in ComprasNet so it takes any participant a few seconds to react to a new bid placed by a competitor. See Figure 1 for example: it is clear that the second lowest bidder was about to place a new, incrementally lower new bid had it had a few more seconds. Additionally, had the auction ended a few seconds earlier the result would have been reversed. For that reason, as long as participants are outbidding one another frequently the identity of the lowest bidder is as good as randomly assigned (Appendix Table A3 shows exactly that: the average close auction's random phase lasts just under 15 minutes but it has more than 46 outbids).

The randomness in the identity of the lowest bidder is not the only quasi-experimental variation that can be exploited in our setting. The (random) *duration* of the auction also provides a useful shock. As it can be seen in Figure 1, firms naturally decrease their bid values as the auction period continues. Had the auction ended earlier, winners would hold a contract with a higher value for the same product and quantity. Since the duration of the auction comes from a uniform distribution that is independent of any firm or auction characteristic, and bid behavior within the auction, this provides an exogenous source of variation in the value of the contract won by the firm. The Appendix Figure A8 shows how the (final) contract value is decreasing in auction duration for the universe of auctions in our data.

[3] Szerman (2012) studies theoretically an auction model considering these features. The model generates two types of equilibria. In one, all bidders bid up to their true valuations before the random phase starts. In this equilibrium, firms do not bid during the random phase (and, therefore, would not be defined as a close auction in our design) and the winner is the one with highest valuation. The other equilibrium is where firms outbid each other by tiny amounts, trading off the probability of winning for a better selling price conditional on winning.

This second source of variation is crucial for us to identify how demand shocks are transmitted to wages through two different channels: (i) higher number of employees and (ii) higher revenue. A firm affected by a demand shock could potentially increase wages either because it decides to hire more workers or because, conditional on the number of workers, there is more revenue generated by the same output. It is impossible to separately identify these two channels with only one source of variation. However, in our setting we can estimate how wages are affected by the contract value and number of employees, using these two sources of variation as instrumental variables.

3.1 Validating the Empirical Design

Table 1: Balancing: Winner *versus* Runner-up

	Means		Difference
Variables at Year$_{t-1}$	Runner-up	Winner	Runner-up vs Winner
(Annual average) Wage (2018 R$)	1186	1194	7
	(692)	(746)	(8)
Contractual Wage (2018 R$)	1139	1148	9
	(618)	(618)	(7)
Employees	14.2	13.3	-0.9
	(163.1)	(132.3)	(0.9)
Firm age (years)	9.07	8.73	-0.34***
	(7.85)	(7.80)	(.11)
% College	15.7	16.2	0.5
	(26.4)	(26.9)	(0.4)
% High Skill	5.0	5.0	0.0
	(15.6)	(15.6)	(0.2)
% Intermediate Skill	6.1	6.1	-0.05
	(16.4)	(16.3)	(0.2)
% Low Skill	81.6	81.4	-0.3
	(27.3)	(27.6)	(0.4)
% Female	41.3	41.3	0.1
	(33.8)	(33.9)	(0.5)
Log(quality)	6.73	6.74	0.01
	(0.69)	(0.70)	(0.01)
Observations	105,668	105,668	211,336

Notes: Table shows means and standard deviations of selected pre-determined variables for winners and runners-up of close auctions. Difference is obtained from a regression with auction-fixed effects and standard errors clustered at the firm level. Standard errors are shown in parenthesis. All firm outcomes are measured at the year before the auction. "Log quality" represents predicted log wage based on worker demographics. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

In this section, we provide evidence that validates our empirical design. First, Table 1 compares winners and runners-up in the close auctions we use in our analysis. All outcomes are measured at the year before the auction. Firms are identical in our main outcome: the difference in annual average wages is 7 *Reais* (around 1.4 dollars), and not statistically significant. Furthermore, there are no significant differences across winner and runner-up with respect to the number of employees or worker composition. The share of female employees, employees with college, high skilled, low skilled, and management occupations are similar. Finally, the difference in firm age between winner and runner-up is only of 4.08 months. These patterns reinforce the intuition that winner and runner-up are as good as randomly assigned in our design.

4 Identifying Rent-sharing

4.1 Empirical Estimation

Our first goal is to test whether a firm-specific demand shock affects wages. We test this by comparing winners and runners-up in close auctions, as defined above. For each competitive auction, we keep only winners and runners-up and discard all other firms. Then, we compare the average wages of each firm for several periods following the auction. To do that, we estimate the following reduced-form specification:

$$log(w)_{iat} = \beta_0 + \beta_1 Lowest\ Bidder_{ia} + \theta_a + \delta' X_{ia} + u_{iat} \tag{1}$$

Our main outcome $log(w)_{iat}$ is the logarithm of firm i's average wages that participated in an auction a. We run this specification separately for $t = 1, 2, 3, 4$ years after the auction. *Lowest Bidder* is a dummy with value equal to 1 if the firm had the lowest bid at the (random) end of the auction (equal to 0, otherwise). We add auction fixed-effects, θ_a, since the quasi-randomization is at the auction-level. Therefore, we are always comparing close winners and losers within the same auction. Finally, X_{ia} are additional firm-specific controls.[4]

In our setting, after winning an auction the lowest bidder must submit additional documentation confirming that the firm satisfies all conditions to produce the goods demanded by the government. In exceptional cases, if the documentation is not provided in a satisfactory way, the firm does not win the contract and the next firm (in final bid ascending order) is invited to do so. Following this logic, we estimate the effect of being the actual winner of the contract on wages. Given the endogeneity generated by the submission of documents, we use the lowest bidder indicator as an instrument for the winner of the contract. In fact, the lowest bidder becomes the contracted firm in around 75% of cases. Thus, the first and second-stage equations are:

$$Contract\ Winner_{ia} = \alpha_0 + \alpha_1 Lowest\ Bidder_{ia} + \lambda_a + \gamma' X_{ia} + u_{iat} \tag{2}$$

[4]We have included the lag of the number of firm employees as control. We do not include previous wages. In any case, we have shown winners and runners-up are similar in a wide range of pre-shock characteristics.

$$log(w)_{iat} = \beta_0 + \beta_1 Contract\ Winner_{ia} + \theta_a + \delta' X_{ia} + u_{iat} \quad (3)$$

Equation (2) is the first stage. Equation (3) is the second stage of our estimation. The parameter of interest is β_1. Therefore, we estimate the effect of winning a procurement contract using only the variation coming from the quasi-random assignment generated by the auction design.

4.2 Main Results

Panel A of Table 2 shows the results obtained from the estimation of equation (1). Wages in the lowest bidder firm are 1.4% higher compared to runners-up one year after the auction date. After two years, auction winners pay 1.6% higher wages. Results persist even three years later when wages are still 1.4% higher; and four years later when they are 1.6% higher for the lowest bidder. All of these estimates are significant at the 1% level.

Table 2: Results

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.014***	0.016***	0.014***	0.016***
	(0.004)	(0.004)	(0.004)	(0.005)
	Panel B. IV estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.018***	0.021***	0.019***	0.020***
	(0.005)	(0.005)	(0.005)	(0.006)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.745***	0.751***	0.758***	0.767***
	(0.005)	(0.005)	(0.006)	(0.006)
Auction FEs	✓	✓	✓	✓
Observations	247980	190570	131138	79376

Notes: Reduced form and IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Panels B and C of Table 2 report the IV and first-stage estimates. The lowest bidder is a strong instrument for the contract winner as expected (Panel C). In fact, around 75% of lowest bidders become the actual procurement contract holder. The magnitude of the coefficients in the IV estimation are larger than the reduced-form given they take into account the imperfect compliance. Results point to an 1.8% increase in wages driven by this exogenous firm-specific shock one year later. The effect persists (2.0%) four years after the auction. Finally, our results are unchanged when using either contractual or hourly wages, indicating results are not driven by changes in hours worked (see Appendix Tables A6 and A7).

The number of observations varies across our estimations for two main reasons. First, it is due to the overlap between our auction data (2011-2016) and RAIS (2009-2017). We are not able to follow firms for long periods for more recent auctions. For instance, to estimate the wage effects 4 years later, we can only use auctions conducted in 2013 or before. Second, firms may not be observed in future years in the data (firm survival or attrition). Together, these factors make our number of observations drop substantially across the years of analysis.

This is also the first reason why we are severely restricted to perform an event study. Second, an event-study analysis would also require to follow the same firms across years after and before the auction, when young firms - the ones that are driving the results - were not necessarily born. To give a perspective on the issue, 40% of young firms were born two years or less before the auction date. And among the young firms born more than two years before the auction, 52% are not observed at $t+3$ for the reasons stated in the previous paragraph. For all these reasons, an event-study sample would be significantly smaller and over represented by firms that are not likely affected by the shock.

Winning a competitive auction is not necessarily a meaningful demand shock for every firm. The incremental revenue is likely to be more substantial for younger firms. Indeed, Ferraz et al. (2015) show that procurement demand shocks are mostly relevant for young firms. Motivated by this, we run our analysis splitting the sample between young (age less or equal to 8 years) and old (9 years or older[5]) firms.

The effect of winning an auction is stronger for young firms. The reduced-form estimates (Table 3, columns 1-4) show that being the lowest bidder causes a significant effect of 2% on wages one year after the auction. This effect is amplified as time goes by reaching 2.9% after four years. As expected, the IV strategy produces larger coefficient estimates (Panel B). Winning the contract leads to 2.7% higher wages after one year and 3.8% higher wages after four years for young firms. All of these are significant at the 1% level. On the other hand, our point estimates for older firms are economically small and not statistically significant (Columns 5-8), while the first stage is strong. We also find similar results for contractual and hourly wages (see Appendix Tables A8 and A9).

These results are consistent with recent evidence that winning a procurement contract affects firm growth, specially among young firms. The impact on young firms is likely due to building reputation, learning-by-doing, and the overcoming of financial and

[5]We picked this number because the mean firm age in our data is 9 years (see Appendix Table A5).

Table 3: Results - Young *versus* Old Firms

	Young Firms				Old Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.020***	0.024***	0.023***	0.029***	-0.001	0.005	0.001	-0.005
	(0.005)	(0.005)	(0.006)	(0.007)	(0.008)	(0.008)	(0.008)	(0.010)
	Panel B. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.027***	0.032***	0.031***	0.038***	-0.002	0.006	0.001	-0.007
	(0.007)	(0.007)	(0.007)	(0.009)	(0.010)	(0.010)	(0.011)	(0.012)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.735***	0.743***	0.754***	0.765***	0.770***	0.771***	0.773***	0.770***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.012)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107674	82716	56990	33646	34186	25632	17638	11122

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm age. Columns (1) to (4) report results for young firms, defined as those with 8 years or less of existence. Columns (5) to (8) report results for firms with age of 9+ years. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

demand constraints (Ferraz et al., 2021; Lee, 2021). Importantly, under perfect competition, regardless of why firm-specific demand or productivity increases, wages are taken as given. Identical workers are always paid the same wage across firms. It follows that any response of firm-specific wages to a firm-specific increase in demand or productivity is evidence of rent-sharing. Therefore, the stronger effects on wages for young firms are consistent with the fact that these are the firms that had their productivity or demand affected by the procurement auctions.

As shown by Tables 2 and 3, the effects on wages are persistent for four years. Most of these contracts take between six months and a year to be executed. Therefore, the persistence of the effect reflects the dynamics induced by the auction. Ferraz et al. (2021) shows that winning a contract (exogenously) puts a firm in a different growth and productivity trajectory. They are more likely to participate and win other procurement auctions, exhibit higher employment, sales, investment, inventories, and value-added in the following years.

We also verify that winning firms grow relative to the runner-up in our sample. We find that being the lowest bidder causes the firm to have 1.9% more employees on average one year after the auction, an effect that is significant at the 1% level. Two years after the auction the effect is 1.2%, and is significant at the 10% level (see Appendix Table A10). The effect is present for both young and old firms (see Appendix Table A11). We investigate also if winners are more likely to be present in RAIS (ie, have at least one employee) after the auction: we find a small, but statistically significant effect (see Appendix Table A12). Motivated by the increase in both wages and firm size following increased firm demand, in section 5, we will decompose the effect on wages that comes from having more employees (wage posting) versus what comes from having more money to be bargained over (wage bargaining). Since our results are driven by young firms, in the remainder of the paper, we analyse the heterogeneity of the effects and its possible theoretical mechanisms only for this group of firms.

We would like to calculate the pass-through elasticity of wage to value added per worker. Unfortunately, we do not have firm-level information on profits, revenues or valued added. In the Appendix, we perform a back of the envelope calculation arriving at the elasticity of 0.1, inside the range found by the literature (0.07-0.25).[6] To do so we are forced to rely on national statistics on aggregate value added and total revenue.

4.3 Worker Heterogeneity

In the previous section, we saw that winning an auction leads to an increase in wages. It is possible that wages of newly and previously hired workers respond differently to the shock. To investigate this possibility, we run our analysis splitting between workers already present at the moment of the shock that remained employed with the firm (stayers) and workers hired after the shock (new hires). Finally, we also check whether the increase in wages persists for those individuals that had been present at the moment of the shock, but eventually left the firm after the shock (separators).

Table 4 shows the results separately for stayers, new hires and separators. Reduced form (RF) estimates indicate that wages are higher for the lowest bidder, both for stayers (Panel A) and new hires (Panel B) by, respectively, 2.3% and 1.9% one year later (Column 1), 2.5% and 2.1% two years later (Column 3), 1.6% and 2.7% three years later (Column 5).[7] As expected, the IV strategy produces higher coefficient estimates. Winning a contract leads to higher wages for both stayers (Panel A) and new hires (Panel B) by, respectively, 3.1% and 2.5% one year later (Column 2), 3.4% and 2.9% two years later (Column 4), 2.1% and 3.6% three years later (Column 6). We do not show results for four years after the shock since the number of observation for stayers drops significantly. In practice, turnover is high in Brazil (as in many other developing countries), which makes it less likely that we find workers staying for several years in the same firm. Overall, these results tell us that winning an auction leads to wage increases for both stayers and new

[6] Van Reenen (1996), Card et al. (2014), Bagger et al. (2014), Card et al. (2016), Card et al. (2018), Kline et al. (2019), and Garin and Silvério (2023)

[7] For new hires we are looking at the effect of shock on wages of individuals hired 1, 2, 3 years after shock respectively.

hires, and that the effects are not substantially different between these groups.

Table 4: Stayers vs New hires vs Separators

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	log(w)$_{t+1}$	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**Stayers**			
Lowest Bidder	0.023***		0.025***		0.016*	
	(0.007)		(0.009)		(0.009)	
Contract Winner		0.031***		0.034***		0.021*
		(0.009)		(0.013)		(0.012)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	39,998	39,998	24,294	24,294	13,520	13,520
R-squared	0.592	0.015	0.584	0.014	0.608	0.025
Panel B						
Type of worker:			**New hires**			
Lowest Bidder	0.019***		0.021***		0.027***	
	(0.006)		(0.005)		(0.006)	
Contract Winner		0.025***		0.029***		0.036***
		(0.008)		(0.007)		(0.008)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	82,928	82,928	68,718	68,718	48,816	48,816
R-squared	0.557	0.017	0.558	0.012	0.556	0.008
Panel C						
Type of worker:			**Separators**			
Lowest Bidder	0.002		0.001		0.004	
	(0.009)		(0.007)		(0.006)	
Contract Winner		0.003		0.001		0.006
		(0.013)		(0.010)		(0.009)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	21,126	21,126	25,876	25,876	24,886	24,886
R-squared	0.559	0.003	0.560	0.003	0.558	0.009

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. Panel A shows results for stayers. Panel B shows results for new hires. Panel C shows results for separators. Stayers are workers who were employed in the firm before and keep employed at the period for which the regression is run. New hires are workers who were admitted after the auction date. Separators are workers who were employed in the firm before the auction but left the firm. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Finally, the results for separators (Panel C) show that the increase in wages does not persist for individuals that leave the firm. This last result rules out the possibility that wage changes are driven by increases of worker's human capital generated by the shock.

Next, we verify how wage responses vary by worker skill, education, ethnicity, and gender.[8] We find that wages of white and male workers rise in response to the firm winning a contract, while the wages of females and non-white individuals are less responsive (see Appendix Tables A13 and A14). We also find that wages respond to winning a contract

[8] We classify workers into low and high skill groups based on occupation.

regardless of education with effects one year after stronger for college graduates (see Appendix Table A15). We find that wages respond to winning a contract for both low skill and high skill workers, with effects one year and two years after stronger for high skill workers (see Appendix Table A16). We find no effect for managers. Since our firms are representative of the aggregate economy, the majority of workers in our sample are not in management positions. As a result, we lack power to identify the effect separately for managers. Finally, we also consider separating workers into those with tenure below or above the firm median, and into those with wages below or above the firm median. We find wages respond to the firm winning a contract regardless if workers have below or above median tenure, and regardless if workers have below or above median wages, with stronger effects for workers with above median wages (see Appendix Tables A17 and A18).

4.4 Worker Composition

A potential obstacle to interpreting firm-level aggregates is that firms may alter the composition of their employees in response to shocks. In that case, impacts on average wages could reflect compositional changes rather than changes in the wages of similar employees. At the same time, in a non-competitive labor market as firms increase worker wages, they may potentially attract better workers – an effect not fully investigated by the literature.

Upon investigation, we find that winning an auction leads to small changes in composition starting two years after the auction. Average education increases by half a month, average age increases by six months, and our measure of worker "quality", constructed following Kline et al. (2019), increases by 1.24%.[9] These patterns are driven by an increase in the quality of new hires. We find no effect on the quality of stayers.[10] See Appendix Tables A19, A20.

In order to fully control for any change in composition, we analyze the impact of winning a contract on the wages of a fixed cohort of workers. Specifically, we define this cohort by identifying the incumbent workers at the firm just before the auction, which is equivalent to pooling stayers and separators. The difference between the fixed cohort and stayers groups is that the latter may change in composition due to workers leaving the firm over time (therefore ceasing to be stayers) whereas the former is robust to any movement in and out of the firm. We then study the impacts on this group of

[9] We construct this index as firm-level average predicted wages, obtained from a regression of log wages on demographic characteristics of workers.

[10] We also find that quality, measured by pre-auction wages increases for new hires but not for stayers (Appendix Table A21).

workers regardless of whether they remained in the firm in the following years. Table 5 documents that being the lowest bidder leads to 2.3% higher wages one year later, 1.8% higher wages two years later, and 1.6% higher wages three years later, for workers present prior to the auction taking place (Columns 1, 3, and 5). Similarly, winning a contract increases wages by 3.2% one year later, 2.5% two years later, and 2.2% three years later (Columns 2, 4, and 6). All of these are significant at the 1% level. These estimates are of similar magnitude relative to our baseline results (Table 2). Our results are robust to using contractual wages (see Appendix Table A22).

Table 5: Fixed-Cohort

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+4}$
Lowest Bidder	0.023***		0.018***		0.016**		0.008	
	(0.006)		(0.006)		(0.006)		(0.006)	
Contract Winner		0.032***		0.025***		0.022***		0.011
		(0.008)		(0.008)		(0.009)		(0.008)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	58,974	58,974	49,080	49,080	38,920	38,920	28,362	28,362
R-squared	0.579	0.021	0.570	0.018	0.565	0.024	0.575	0.010

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on lowest bidder and contract winner. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. Firm outcomes are measured using a fixed-cohort comprised of incumbent workers at the firm before the auction. the same workers are kept regardless of remaining or not in firm. All regressions include auction fixed effects. Columns (1), (3), (5) and (7) are the reduced-form estimates. Columns (2), (4), (6) and (8) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

5 Disentangling Wage Determination Theories

In the previous sections, we saw that firm-specific shocks have an important effect on wages. However, even if we rule out competitive markets, that still does not narrow down the different possibilities of how wages are determined non-competitively.

On the one hand, we might think that firms post wages, facing upward-sloping labor supply curves. In such a context, following a positive shock, firms increase wages to attract more workers. On the other hand, we might think that, even controlling for firm size, any increase in firm surplus leads to increases in wages. This prediction arises in the context of bargaining between workers and firms. In this section, we leverage the unique variation at our disposal and the richness of our data to disentangle these two families of theories.

In order to formalize these two channels and microfound our estimating equation, we first go over a stylized model containing both channels. We chose to keep the bare minimum ingredients to obtain these two channels. The objective is to show how in the presence of both bargaining and a upward-sloping labor supply curve (posting), we can derive an empirical specification to disentangle the two. Then, using our unique data set, we show how to identify and estimate the parameters of this equation. Once that is clear, we go over our results. It is important to highlight that our identification does not depend on the model, instead relying on the key institutional features of our rich data.

5.1 Model

We consider a simple static model. There are many ways to generate a firm-specific upward sloping labor supply curve. Here we chose one with the purpose of formalizing our intuition and deriving a tight connection between theoretical predictions and empirical moments. In our model, firms can have both wage posting and wage bargaining, containing each of these wage setting procedures as particular cases. Since in our empirical strategy we will have exogenous variation in both firm production, y, and the price the product is sold for, p, we do not solve for these in the model. Instead, we consider y to be the exogenous demand for the firm and p the exogenous demand price faced by the firm. As a result, we can work with a simpler model that makes it easier to highlight the key intuition. We consider the problem of wage setting for a firm, for a given p and y. Profits of a firm j are given by

$$p_j y_j - W_j$$

where p_j is the price the firm sells their products, y_j is product demand and W_j is the wage bill. Production of y_j output is done according to

$$y_j = f(n_j)$$

Let f be such that $f(n) = n^{\alpha}$.

We define the utility a worker i derives from working in a firm j paying wage w as

$$u_{i,j}(w) = w - b + a_j + \epsilon_{i,j}$$

where b is the worker's outside option to working, a_j are firm-specific amenities common to all workers, and $\epsilon_{i,j}$ captures idiosyncratic preferences for working at firm j.[11]

Firms differ in the amenities they provide to workers. Firms post wages to attract workers. After matching, workers can bargain with the firm for a higher wage. This bargaining comes from the fact that once employed, the worker can always threaten the firm to lose their marginal product of labor. Firms fully commit to paying the worker at

[11] Card et al. (2018) consider a model where the utility a worker i derives from working at firm j depends on wage w but also on idiosyncratic preferences for working at firm j, $\epsilon_{i,j}$. Lamadon et al. (2022) and Kroft et al. (2020) generalize this framework to allow for a firm-specific amenity common to all workers, a_j.

least the wage that was posted. However, ex-ante, workers do not know the p faced by the firm (e.g. workers do not know if the firm will randomly win a close auction). As a result, workers do not know the marginal product of labor the firm will have and hence the wage they can get from bargaining. They do, however, have beliefs about what that wage might be.

Timing is as follows, first firms post wages without observing each worker's individual idiosyncratic preferences $\epsilon_{i,j}$ but with knowledge of the distribution of ϵ in the population. Second, workers do not observe the p_j of the firm but observe the posted wage from each firm j and form expectations about the (ex-post) wage they expect to earn from each firm j (after bargaining). Then, based on these expectations, firm-specific amenities a_j, and their privately observed $\epsilon_{i,j}$, they choose which firm to work for. Once the match is formed, firms observe the worker's idiosyncratic preference $\epsilon_{i,j}$ and workers observe the firm's p_j. Finally, firms and workers bargain over wages given each worker's $\epsilon_{i,j}$, with firms commmitting to paying at least the wage that was posted in the hiring stage.

Let w_j^p be the wage posted by a firm j. Define $w^E(w_j^p, a_j, \epsilon_{i,j})$ as the wage the worker i expects to earn in a firm j posting wage w_j^p. Workers are rational in that their expectation coincides with the actual realized average wage conditional on w_j^p. Once we solve for the worker's wage it will become clear that

$$\frac{\partial w^E(w_j^p, a_j, \epsilon_{i,j})}{\partial w_j^p} > 0,$$

workers expect to earn more from firms that post higher wages. As a result, the ex-ante utility a worker i derives from working in a firm j is

$$u_{i,j} = w^E(w_j^p, a_j, \epsilon_{i,j}) - b + a_j + \epsilon_{i,j}. \tag{4}$$

Then, the probability that individual i chooses to work for firm j is given by

$$P(\text{choose to work for firm } j) = Prob(u_{i,j} \geq u_{i,j'}, \forall j' \neq j) \tag{5}$$

$$= Prob(w^E(w_j^p, a_j, \epsilon_{i,j}) + a_j + \epsilon_{i,j} \geq \max_{j' \neq j}(w^E(w_{j'}^p, a_{j'}, \epsilon_{i,j'}) + a_{j'} + \epsilon_{i,j'})) \tag{6}$$

As in Card et al. (2018), to simplify the analysis we abstract from strategic wage setting. This modelling choice is consistent with our empirical results that our findings are present even for firms with close to zero labor market share. In particular, we assume the number of firms is very large, in which case

$$\Lambda_{i,j} \equiv \max_{j' \neq j}(w^E(w_{j'}^p, a_{j'}, \epsilon_{i,j'}) + a_{j'} + \epsilon_{i,j'}) \tag{7}$$

does not depend on the wage posted by firm j. As a result, the above probability can be written as

$$P(\text{choose to work for firm } j) = Prob(w^E(w^p_j, a_j, \epsilon_{i,j}) + a_j + \epsilon_{i,j} \geq \Lambda_{i,j}) \tag{8}$$

As a result, the number of workers, n, firm j posting wage w^p attracts is given by

$$n_j(w^p_j) = Prob(w^E(w^p_j, a_j, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a_j) \tag{9}$$

From the above expression we see that

$$\frac{\partial w^E(w^p_j, a_j, \epsilon_{i,j})}{\partial w^p_j} > 0 \Rightarrow \frac{\partial n_j(w^p_j)}{\partial w^p_j} > 0. \tag{10}$$

Once the worker is hired by the firm they can engage in bargaining. As mentioned, bargained wages, w^{bg}, are not observed by outsiders to the firm and, hence, do not affect hiring.

We follow recent literature departing from constant returns to scale and the corresponding modifications in the bargaining protocol (Acemoglu and Hawkins, 2014; Elsby and Michaels, 2013; Taschereau-Dumouchel, 2020; Green et al., 2022). Workers can only threaten the firm into losing their marginal product of labor. As done by the literature, we follow Stole and Zwiebel (1996) by considering that the value for the firm of negotiations breaking down corresponds to the loss of one individual worker (and the indirect effect the removal of one worker has on the wages bargained by others). It can be shown that the marginal effect of firm size on the bargained wage does not depend on a worker's idiosyncratic preference parameter $\epsilon_{i,j}$ or the firm-specific amenity a_j, i.e., $\frac{\partial w^{bg}_{i,j}(p,z,\epsilon_{i,j},a_j)}{\partial n} = \frac{\partial w^{bg}_{i,j}(p,z)}{\partial n}$.[12]

Then, the bargaining of a firm j with a worker i is the solution to

$$\max_{w^{bg}} (w^{bg} - b + a_j + \epsilon_{i,j})^\beta (p\frac{\partial f(n)}{\partial n} - w^{bg} - \frac{\partial w^{bg}}{\partial n}n)^{1-\beta} \tag{11}$$

$$\text{subject to} \quad w^{bg} \geq w^p(n). \tag{12}$$

[12]We first guess that the solution of w^{bg} is such that $\frac{\partial w^{bg}_{i,j}(p,z,\epsilon_{i,j},a_j)}{\partial n} = \frac{\partial w^{bg}_{i,j}(p,z)}{\partial n}$. Then, after solving for the bargained wage, we verify this guess. More generally, the independence of $\frac{w^{bg}_{i,j}}{\partial n}$ from $\epsilon_{i,j}$ and a_j is also implied by a more general result of Cahuc et al. (2008). The authors show that under homogeneous production functions of degree $0 < \alpha < 1$ with k type of workers $F(N_1, N_2, ..., N_k)$ and equal bargaining power amongst workers, the bargained wage for worker of type i always takes the form w_i = preference/outside option factors$_i$ + $\frac{\beta}{1-\beta(1-\alpha)} \frac{\partial F_(N_1,N_2,...,N_k)}{\partial N_i}$ (see equations (13) and (16) of the paper).

The term $\frac{\partial w^{bg}}{\partial n}n$ captures the fact that if a negotiation with a worker breaks down, wages are renegotiated with all workers remaining in the firm. Solving for w^{bg} gives

$$w^{bg}_{i,j} = \tilde{\beta} p \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}) \tag{13}$$

where $\tilde{\beta} \equiv \frac{\beta}{1-\beta(1-\alpha)}$.[13] See Appendix Section E for derivation of $w^{bg}_{i,j}$.

The wage $w_{i,j}$ paid by the firm j to individual i is

$$w_{i,j} = w^{bg}_{i,j} = \tilde{\beta}\alpha \frac{py}{n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}) \quad \text{if} \quad w^{bg}_{i,j} > w^p_j \tag{14}$$

$$w_{i,j} = w^p_j \quad \text{if} \quad w^{bg}_{i,j} \leq w^p_j. \tag{15}$$

Given the expression for the bargained wage $w^{bg}_{i,j}(z, p, a_j, \epsilon_{i,j})$ and the posted wage w^p_j, the expected wage of a worker i has of working for firm j is

$$w^E(w^p_j, a_j, \epsilon_{i,j}) = \int \max(w^{bg}_{i,j}(p, z_j, a_j, \epsilon_{i,j}), w^p_j) m(p) dp.$$

where $m(p)$ is the distribution of p which coincides with the beliefs of workers about p.[14]

From this expression we see that

$$\frac{\partial w^E(w^p_j, a_j, \epsilon_{i,j})}{\partial w^p_j} > 0.$$

Taking a first order Taylor approximation of wages leads to the following expression

$$log(E[w])_j = \zeta_0 + \zeta_1\xi_0 + \zeta_2 log(py) + (\zeta_3 + \zeta_1\xi_1) log(n) + (\zeta_4 + \zeta_1\xi_2) log(a)_j \tag{16}$$

where $\zeta_1 > 0, \zeta_2 > 0,\ \zeta_3 = -\zeta_2 < 0, \zeta_4 < 0,\ \xi_1 > 0$ (see Appendix Section G for derivation). Proposition 1 below relates this linear equation to the particular cases of our model with only bargaining or only posting (Proof in Appendix Section H).

Proposition 1. *If the worker has no bargaining power, $\beta = 0$, all workers are payed the posted wage. This is what we call having only wage posting in our model. Then, $\zeta_0 = 0$, $\zeta_1 = 1$, $\zeta_2 = 0$, $\zeta_3 = 0$, $\zeta_4 = 0$, so,*

$$log(E[w])_j = \xi_0 + \xi_1 log(n) + \xi_2 log(a)_j. \tag{17}$$

In contrast, if we shut down heterogeneous worker preferences over firms, i.e., all

[13]Note that the above solution confirms our guess that $\frac{\partial w^{bg}_{i,j}}{\partial n}$ does not depend on $\epsilon_{i,j}$ or a_j.
[14]See Appendix for the explicit expression for $w^E(w^p_j, a_j, \epsilon_{i,j})$.

workers value each firm the same way ($\epsilon_{i,j} = \epsilon_j, \forall j$), a firm does not face an upward-sloping labor supply. In this case, all workers are paid the bargained wage. This is what we call having only wage bargaining in our model. Then, $\xi_0 = 0$, $\xi_1 = 0$, and $\xi_2 = 0$, so

$$log(E[w])_j = \zeta_0 + \zeta_2 log(py) + \zeta_3 log(n) + \zeta_4 log(a)_j. \quad (18)$$

Note that our error term in all three equations is $log(a)_j$, the firm-level amenities offered by the firm. The implications of the above proposition are the following:

1. Effect of revenue, py, only present if there is bargaining.
2. If the coefficient on $log(n)$ is positive and the coefficient on $log(py)$ is zero, then, there is only wage posting and no wage bargaining.

Intuitively, in a posting world regardless of any variation in py, the firm is always on its labor supply curve (which is fully accounted by n). To be clear, firm revenues (and its effect on labor demand) matters in a wage posting model. However, it will only imply a movement along the labor supply curve. That is, all effect of py must come through changes in firm size. In contrast, under bargaining, variation in py leads to changes in the bargained wage even for a given firm size (while the effect of firm size is ambiguous[15]). As a result, we can test whether the empirical evidence is consistent with bargaining or posting.

Manning (2011) and Card et al. (2018) show that under either wage posting or wage bargaining models, it is possible to write wages as a function of firm surplus.[16] Under wage posting, the coefficient on firm surplus depends on the elasticity of labor supply. Under bargaining, it depends on worker bargaining power. This equation for wage posting is derived from the optimal posting wage problem, where the authors replace firm size by its expression given by the elasticity of labor supply. Here, we do not replace firm size by its expression coming from labour supply. Instead, we decompose the effect of the shock through the mediating effect of firm size (movement along the labor supply curve) and any effect beyond that. Under posting, however, the mediating effect of firm size captures all wage variation. On the other hand, under bargaining, there is an effect beyond the mediation of firm size.

5.2 Discussion and Empirical Estimation

In the previous sections, we saw that wages respond to increases in firm demand. Given that previous papers only had one firm-specific shock, they have been unable

[15]The reason is that, under bargaining over marginal product, firm size might also affect wages, possibly in a negative way.

[16]Equation 12 on page 992 of Manning (2011) for the equation of wage posting.

to test between bargaining and posting. Instead they have had to assume one model to estimate structural parameters, often interpreting wages responses to firm shocks as evidence of wage posting.[17] Under such a setting, firms increase wages in order to hire more workers, and increase production. As a result, a firm demand shock leads to wage increases exclusively via increases in the number of employees. This has led the literature to often estimate equations of the form

$$log(n)_{it} = B_0 + B_1 log(w)_{it} + \epsilon_{it} \tag{19}$$

where $w_{i,t}$ is the wage paid by firm i at time period t and $n_{i,t}$ is the size of firm i at time period t. Intuitively, since under wage posting firms face an upward-sloping labor supply, B_1 is expected to be positive.[18] Conversely, we can invert this equation to write it as

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \upsilon_{it} \tag{20}$$

where $\gamma_0 = -\frac{B_0}{B_1}$, $\gamma_1 = \frac{1}{B_1} > 0$, and $\upsilon_{i,t} = -\frac{\epsilon_{i,t}}{B_1}$.

The literature has consistently found that firm-specific shocks pass-through to wages, a result that is inconsistent with labor markets being perfectly competitive (Card et al., 2018). However, ruling out competitive markets does not correspond to validating firm-specific upward-sloping labor supply curves (wage posting). There are other non-competitive wage setting procedures that lead to firm shocks affecting wages but where wages are set differently. For example, under wage bargaining, as firm output increases, wages increase according to the worker's bargaining share, leading to pass through of firm shocks to wages. Furthermore, under wage bargaining, even after controlling for changes in firm size, an increase in revenue leads to higher wages. Intuitively, each additional unit of revenue is passed partially to workers. As a result, the effect of firm revenue on wages goes beyond the effect only via changes in number of employees. In that case, the corresponding equation to equation (20) would be

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(pq)_{it} + \upsilon_{it} \tag{21}$$

where $pq_{i,t}$ represents the revenue of firm i at time period t. Whether one of these two groups of theories or a combination of both are an adequate description of the labor market is an empirical question.

[17] For example, Kline et al. (2019); Kroft et al. (2020); Lamadon et al. (2022); Amodio and de Roux (2023)

[18] Berger et al. (2022) show that under firms employing a large share of the workforce (granular firms), even in a world of wage posting, knowledge of B_1 is not enough to derive the structural labor supply elasticity as it will also capture changes in strategy by competing firms. However, even in Berger et al. (2022), we expect B_1 above to be positive.

Comparing equations (20) and (21) highlights how we can test between these two wage setting procedures. Crucially, we want to verify whether γ_2 is positive and significant as predicted by bargaining and if it is not, whether γ_1 is positive and significant as predicted by wage posting theories. The challenge is to obtain two sources of variation to separately identify $log(n)_{i,t}$ and $log(pq)_{i,t}$.

Our unique institutional setting gives us two different sources of variation that allow us to estimate equation (21). First, we can use the fact that winners and runners-up of close auctions are as good as randomly assigned. Second, we can use the fact that the (random) duration of the auction generates variation in the contract value the winner gets. In fact, we empirically observe an approximately linear negative relationship between contract value and auction duration (Appendix Figure A8) in our setting. Importantly, in order to separately identify $log(n)$ and $log(pq)$ we just need that our two sources of variation affect these two variables by different amounts.

Ideally, we would like to use firm revenues (or total value added) for the variable pq. Unfortunately, this data is not available. We use instead the contract value faced by the firm. The key assumption here is that for a given auction, an exogenously higher contract value is always desirable for the firm (firms always prefer to sell their goods to the government for the highest price). Therefore, conditional on firm size, a more favorable contract must be strongly associated with higher pq. The same applies when comparing a winning firm (positive contract value) against a losing firm (that obtained zero contract value from that auction). Furthermore, if higher contract values obtained by firms affect wages beyond firm size, this is already evidence of wages being affected by a second factor – inconsistent with posting. Under bargaining, this second factor must be necessarily higher surplus. In Appendix Section D we prove that using contract value as opposed to firm revenue delivers the same predictions. The only assumption needed is that contract value and firm revenue are positively correlated. In fact, the estimated parameter will suffer from attenuation bias (biased toward zero).

Let w_{iat} be the wage paid by a firm i at period t that participated in close auction a. Let $value_{ia}$ denote the contract value for firms that won the contract and 0 for runners-up and n_{it} be the number of employees of the firm. Given our quasi-experimental variation is at the auction level, similar to Section 4, we add auction fixed effects. In line with this argument, our estimating equation is

$$log(w)_{iat} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(value)_{ia} + \delta' X_{ia} + \mu_a + \epsilon_{iat}, \tag{22}$$

where $log(n)_{i,t}$ and $log(value)_{ia}$ are two endogenous variables (we add one to $value_{ia}$ so that $log(value)_{ia}$ is always well defined). They are instrumented by two instrumental variables: (i) *Lowest bidder*, a dummy equal to 1 if the firm bid the lowest value at the end of the auction and 0 for the runners-up, and (ii) *Lowest bidder · random t*, the interaction between *Lowest bidder* and the random time elapsed in the auction, *random t*.

Intuitively, finding $\gamma_2 > 0$ tells us that more firm revenue leads to higher wages, even after we control for firm size, consistent with bargaining. If, on other hand, $\gamma_2 = 0$ and $\gamma_1 > 0$, then, firms only increase wages to hire more workers, consistent with wage posting.

Our model in the previous section allowed us to microfound equation (22). However, it is important to highlight that our identification does not depend on the model, instead relying on the key institutional features of our data.

The duration of the final phase of the auction is a random draw from a uniform distribution, independent of all bidding behaviour and any characteristic of participants. However, even with a pure exogenous ending, since these are descending price auctions, we do not necessarily expect firms in low duration and high duration auctions to be similar. This is because we only keep firms that place the two lowest bids in the auction, when these have been placed in the last 30 seconds. On the one hand, we expect only firms with low cost of production to continue bidding in auctions that lasted for a longer time. As a result, we would expect firms participating in longer auctions to have lower production costs. On the other hand, firms might decide to continue bidding based on the alternative contract they can get if they exit the auction. In that case, we expect more productive firms to have better outside options and to drop out from auctions that last too long. For this reason, we never use *random t* as an instrument alone (in other words, comparing firms across auctions of different duration).

Importantly, when using both the variation in duration and winning an auction, we are always comparing the difference between winner and runner-up across auctions of different duration. It follows that to identify equation (22) all we need are restrictions on the heterogeneity of the treatment effect of winning an auction. More precisely, our key identifying assumptions to estimate equation (22) are that: (1) any variation in the treatment effect of winning across different auctions comes exclusively from variation in either number of employees or contract value and (2) duration gives us different variation in number of employees and contract value relative to the effect of winning an average auction.

At this point, it is worth considering the case of borrowing constraints. A financially constrained firm that wins an auction of lower duration can use the extra revenues to hire more workers. In this case, it is plausible that our instrument *Lowest bidder · random t* can affect both $log(n)_{i,t}$ and $log(value)_{ia}$. For identification, we require that wages are affected by no other channel beyond firm size and the extra revenue (these variables might be affected exactly, or partially, because the firm was financially constraint). This is already a less restrictive assumption compared to the previous literature where firm-specific demand shocks are allowed to affect wages only through movements along the labor supply curve. Furthermore, to identify the effects of $log(n)_{i,t}$ and $log(value)_{ia}$ separately, we only need that winning auctions that end earlier have a differentiated effect on $log(n)_{i,t}$ and $log(value)_{ia}$ compared to auctions that end later. It is not necessary that each instrument affects one of the endogenous variables and not the other.

Therefore, borrowing constraints is one channel among possibly many that can make a winning firm more productive. Now, the way wages are affected by this higher productivity depends on the wage setting model one considers. The two main classes of models in the literature, and considered in this paper, are wage bargaining and wage posting. Under wage posting, firms are always placed on their labor supply curve. Therefore, if a firm faces a productivity shock, regardless if it was due to relaxing of borrowing constraints, wages increases are completely captured by changes in firm size. In contrast, under bargaining, there is an effect on wages beyond firm size (through extra revenues). In this sense, the presence of borrowing constraints, does not affect our capacity to test wage determination theories.

5.3 Results

Table 6 (Panel B) shows the first-stage results for $log(\text{value})_{ia}$. Column 1 shows results for an IV specification where the outcome in the second stage is the wage in the following year $log(w)_{iat+1}$. Column 2 shows results for an IV specification where the outcome in the second-stage is the wage two years later $log(w)_{iat+2}$. Finally Columns 3 and 4 shows results for an IV specification where the outcome in the second stage is the wage three years and four years later $log(w)_{iat+3}$ and $log(w)_{iat+4}$. Across columns, we see that as predicted our instrument $IV_2 = \textit{Lowest bidder} \cdot \textit{random } t$ is significant and negative. The table shows that winning an auction that ended (randomly) ten minutes later decreases contract value by $17\% - 20\%$.

Table 6 (Panel B) also shows first-stage results for $log(n)$. Similarly, Column 1 shows results for an IV specification where the outcome is the wage in the following year $log(w)_{iat+1}$. Column $2, 3$ and 4 show results for an IV specification where the outcome is the wage two years ($log(w)_{iat+2}$), three years ($log(w)_{iat+3}$), four years ($log(w)_{iat+4}$) later . We see in Column 1 that as predicted by our intuition, $IV_1 = \textit{Lowest bidder}$ has a positive and significant effect on number of employees $log(n)$. Winning an auction leads to a 3% increase in firm size. Column 2, 3 and 4 show similar results once we consider as dependant variable in the second stage: $log(w)_{iat+2}$, $log(w)_{iat+3}$ and $log(w)_{iat+4}$.

Finally, Table 6 (Panel A) shows our second-stage results. Columns 1 to 3 show

Table 6: Effects of Contract Value and Firm Size on Wages

	(1)	(2)	(3)	(4)
	Panel A. IV estimates			
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+4}$
log(value)	0.004***	0.004***	0.004***	0.007***
	(0.001)	(0.001)	(0.001)	(0.003)
log(n)	-0.217	-0.224	-0.271	-0.348
	(0.345)	(0.301)	(0.551)	(0.378)
	Panel B. First-stage estimates			
Dep Var	log(value)			
Lowest Bidder	5.987***	6.039***	6.040***	6.001***
	(0.067)	(0.072)	(0.082)	(0.101)
Lowest bidder x random t	-0.020***	-0.019***	-0.017***	-0.017***
	(0.003)	(0.003)	(0.004)	(0.005)
F-stat (excluded instruments)	6476.930	5600.175	4435.244	3219.531
p-value (F-stat)	0.000	0.000	0.000	0.000
Dep Var	$\log(\mathrm{n})_{t+1}$	$\log(\mathrm{n})_{t+2}$	$\log(\mathrm{n})_{t+3}$	$\log(\mathrm{n})_{t+4}$
Lowest Bidder	0.030**	0.025*	0.017	0.059***
	(0.013)	(0.015)	(0.015)	(0.017)
Lowest bidder x random t	-0.001*	-0.001*	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
F-stat (excluded instruments)	2.687	1.752	0.746	6.874
p-value (F-stat)	0.068	0.173	0.474	0.001
Auction FEs	✓	✓	✓	✓
Observations	107674	82716	56990	33646
Underidentification Test:				
Kleibergen-Paap LM stat	5.031	6.676	2.443	4.700
p-value	0.025	0.010	0.118	0.030
Weak-instrument-robust inference:				
Anderson-Rubin Wald test (F)	9.168	13.252	9.206	9.995
p-value	0.000	0.000	0.000	0.000
Anderson-Rubin Wald test (χ^2)	36.681	53.021	36.834	39.998
p-value	0.000	0.000	0.000	0.000

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n). Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

that the wage response to higher number of employees is statistically insignificant. Since the estimates for the effect of number of employees are noisy, it is difficult to infer the sign or magnitude of the effect. The standard errors for the coefficient of the number of employees are so large that we cannot reject effects driven by plausible labor supply elasticities.

However, and more importantly, columns 1 to 3 also show that, even after controlling for number of employees, an increase in the contract value increases wages for up to 3 years after the auction. For completeness, we report conventional F-statistics for both first-stages. The F-statistics for $log(n)$ are generally small, and in fact this might be a reason why our estimates are imprecise. Given this imprecision, one concern would be whether we have power to identify the effects of $log(value)$ and $log(n)$ separately.

We reject the hypothesis that they are underidentified (Kleibergen-Paap LM statistics). That is, despite the imprecision around the estimates of $log(n)$, we are able to identify the effect of contract value conditional on firm size. Finally, we report Anderson-Rubin Wald statistics that are robust to weak instruments. Results confirm that the (second-stage) coefficients of the endogenous variables are jointly significant. Overall, our findings are not conclusive about the direct effects of firm size on wages, but strongly supports an effect beyond firm size coming from the contract value.

Our results indicate that a firm demand shock impacts wages strongly via contract value beyond any effect via firm size. These results are consistent with a presence of bargaining in wage determination. We do not reject the presence of wage posting (firm-specific upward-sloping labor supply curve). According to our model, the effect of firm size on wages (conditional on firm revenues) is ambiguous in the presence of both bargaining and wage posting. In particular, our results tells us that a one standard deviation increase in contract value increases wages by 7.12%.[19]

Unfortunately, we do not observe firm revenues. One concern would be that winning a specific auction simply allows the firm to take on fewer projects in the future, and that higher contract value does not necessarily imply higher revenues to the firm. To address this concern, we computed the total firm revenue obtained from all procurement auctions in that year. Our results are unchanged once we replace contract value with this alternative variable (Appendix Table A23). Our findings are also robust to considering contractual wages (Appendix Table A24), indicating our estimates are not driven by changes in hours worked.

Next, we verify to what extent the effects of contractual value and firm size on wages vary by worker skill and education. We find that, regardless of skill, higher contract value increases wages, and increases in number of employees are not associated to higher wages (Appendix Table A25). The effect of contract value is less precisely estimated but stronger for high skill individuals. We find that for both high school dropouts and high school graduates, higher contract value increases wages, and increases in number of employees are not associated to higher wages (Appendix Table A26). Since our data set is representative of the aggregate economy, the majority of firms employ individuals without a college degree. As a result, we lack power to identify the effect separately for college graduates.

Our results indicate that wages increase following the auction demand shock, even after we control for firm size. While wages do increase with contract value, number of employees has no impact on wages. Through the lens of our model, our results confirm

[19]In our data, the contract value standard deviation is 17.8 times the mean. Multiplying 17.8 by 100 and our regressions estimate, $17.8 \cdot 100 \cdot 0.004$, gives us our desired result of 7.12%.

the presence of bargaining.

Some caveats are in order. Informal workers comprise a significant share of the Brazilian economy. In our administrative data, we observe formal workers only. One concern with our results is that winning a contract leads to more hiring of informal workers. However, this is unlikely given the evidence that informality is decreasing in firm size (Ulyssea, 2018). Second, winning a contract with the government leads to more scrutiny which makes growth via informality less likely. In fact, Brazilian procurement law (*Lei de Licitações*, L8666) establishes that all contract winners must prove they are up to date with their labor and fiscal obligations. An alternative concern with our results is that our variation in number of employees is actually firms formalizing previously informal workers, hence not actually growing. As shown by Ferraz et al. (2015) this is unlikely the case: firms in fact grow in several dimensions including employment, sales, investments and inventories. Furthermore, even if that was the case, then, our results indicate that winning a contract would lead to wage increases without increases in number of employees. Such a mechanism would be also consistent with wage bargaining which is what we find. Finally, we also verified that our results on identifying rent-sharing (Section 4) and on disentangling wage theories are robust to only using winner and runners-up in municipalities with high labor legislation enforcement (Appendix Tables A27 and A28). Following Almeida and Carneiro (2012) and Ulyssea and Ponczek (2018), we use the distance to the closest labor office as our source of variation in labor legislation enforcement.

5.4 Further Evidence

In this section, we investigate different mechanisms capable of generating wage posting and wage bargaining. First, firm-specific upward sloping labor supply curves (wage posting) can arise due to labor market power. In section 5.4.1, we split the data in two halves: firms above and below the in-sample median labor market share. We show that wage responses to firm demand are similar between these groups, and are significant even for firms with negligible labor market share. Second, wage bargaining theories predict that larger bargaining power leads to higher wage responses to increased firm demand. In section 5.4.2, we show that wage responses to firm demand are larger for firms with collective agreements prior to the auction taking place.

5.4.1 Labor Market Shares

Market concentration, inducing labor market power, can be present under both wage bargaining (Jarosch et al., 2019) and wage posting (Berger et al., 2022). Motivated by this recent literature, we investigate how our results vary when looking at firms with different labor market shares. Following Berger et al. (2022) and Baumgartner et al. (2022), we use firm payroll share as a measure of a firm's labor market share. We define a local labor market based on the combination of five-digit industry and municipality. Then we construct a firm payroll share as the sum of all firm employees' earnings divided by the sum of all workers' earnings in the firm's local labor market.

Table 7: Results - Heterogeneity by Payroll Share

	Low payroll share				High payroll share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.020*	0.011	0.026*	0.035**	0.016***	0.024***	0.024***	0.019**
	(0.012)	(0.009)	(0.013)	(0.016)	(0.005)	(0.006)	(0.006)	(0.009)
	Panel B. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.028*	0.015	0.034*	0.046**	0.021***	0.032***	0.033***	0.025**
	(0.016)	(0.013)	(0.018)	(0.020)	(0.006)	(0.007)	(0.008)	(0.011)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.727***	0.735***	0.755***	0.765***	0.751***	0.749***	0.752***	0.756***
	(0.011)	(0.011)	(0.012)	(0.015)	(0.012)	(0.013)	(0.014)	(0.016)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Average Payroll share	<0.01%	<0.01%	<0.01%	<0.01%	12.6%	12.6%	12.6%	12.6%
Observations	23764	18162	12760	7444	35450	26716	17558	10272

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm level payroll share. Payroll share is measured with respective to the local labor market. Local labor market is the combination of municipality and five-digit industry. Columns (1) to (4) report results for firms with payroll share below the median. Columns (5) to (8) report results for firms with payroll share above median. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table 7 shows the effect of winning an auction on wages by firms below and above the median according to their payroll shares. Wages responses are generally meaningful and significant for both groups. Crucially, firms below the median have an average payroll share of less than 0.1%. Even with negligible market power, wages strongly respond to demand shocks in these firms. This result suggests that our observed increases in wages cannot be driven exclusively by market concentration. Berger et al. (2022) and Jarosch et al. (2019) show that firms with higher labor market share are expected to have higher markdowns. As a result, while we expect firms with lower market share to have less market power, their lower markdown leads to strong wage responses to firm shocks.

In Table 8, we attempt to disentangle the mechanisms behind these wage responses between contract value and firm size, using our two instrumental variables. The instruments *Lowest bidder* and *Lowest bidder · random t* have strong effects on both contract value and firm size for low payroll share firms (Panel B: first-stage estimates). However, consistent with our previous findings, the effect on wages are mostly driven by contract value (bargaining) and not firm size. The results for high payroll share firms are also enlightening (columns 5 to 8). These firms have on average significant payroll share (around 12%). If we focus on the top 10% in the payroll share distribution we obtain similar results to our high payroll share group (see Appendix Table A30). Even though wages respond strongly to demand shocks, firm size is virtually unaffected (Panel B). This confirms once more the role of bargaining in this setting.

Table 8: Effects of Contract Value and Firm Size on Wages
by Payroll Share

	Low Payroll share				High Payroll share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
log(value)	0.004	0.002	0.005**	0.010**	0.003***	0.010	0.002	0.014
	(0.003)	(0.002)	(0.002)	(0.004)	(0.001)	(0.069)	(0.007)	(0.037)
log(n)	-0.049	-0.070	0.156	-0.349	-0.327	9.107	1.573	-1.703
	(0.317)	(0.328)	(0.232)	(0.440)	(0.634)	(102.566)	(4.420)	(5.824)
	Panel B. First-stage estimates							
Dep Var	log(value)							
Lowest Bidder	5.985***	6.097***	6.208***	6.249***	6.027***	6.079***	6.025***	5.993***
	(0.125)	(0.139)	(0.163)	(0.190)	(0.101)	(0.114)	(0.135)	(0.176)
Lowest bidder x random t	-0.022***	-0.021***	-0.021***	-0.026**	-0.017***	-0.020***	-0.019***	-0.022**
	(0.006)	(0.007)	(0.008)	(0.010)	(0.005)	(0.006)	(0.007)	(0.009)
F-stat (excluded instruments)	1984.411	1669.623	1360.614	962.992	2861.369	2162.041	1808.643	1122.950
p-value (F-stat)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest Bidder	0.066***	0.047*	0.055*	0.088***	0.011	-0.005	0.002	0.044
	(0.022)	(0.028)	(0.031)	(0.034)	(0.014)	(0.016)	(0.020)	(0.027)
Lowest bidder x random t	-0.002*	-0.002	-0.003**	-0.003*	-0.001	0.000	0.000	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
F-stat (excluded instruments)	4.397	1.441	2.107	3.668	0.586	0.076	0.233	2.649
p-value (F-stat)	0.012	0.237	0.122	0.026	0.557	0.927	0.792	0.071
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Average Payroll share	<0.01%	<0.01%	<0.01%	<0.01%	12.6%	12.6%	12.6%	12.6%
Observations	23764	18162	12760	7444	35450	26716	17558	10272
Underidentification Test:								
Kleibergen-Paap LM stat	5.936	4.298	7.748	4.894	2.359	0.016	0.270	0.190
p-value	0.015	0.038	0.005	0.027	0.125	0.900	0.604	0.663
Weak-instrument-robust inference:								
Anderson-Rubin Wald test (F)	1.705	0.874	1.926	3.731	5.421	11.564	7.900	3.192
p-value	0.182	0.418	0.146	0.024	0.004	0.000	0.000	0.041
Anderson-Rubin Wald test (χ^2)	6.823	3.497	7.713	14.947	21.694	46.280	31.622	12.782
p-value	0.033	0.174	0.021	0.001	0.000	0.000	0.000	0.002

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n) by firm level payroll share. Payroll share is measured with respective to the local labor market. Local labor market is the combination of municipality and five-digit industry. Columns (1) to (4) report results for firms with payroll share below the median. Columns (5) to (8) report results for firms with payroll share above median. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

5.4.2 Collective Bargaining Agreements

Our previous findings indicate that contract value affects wages for a variety of workers and firms, even after we control for number of employees. These patterns are at odds with wage posting and are consistent with wage bargaining. In such a context, we expect the presence of collective bargaining agreements to interact with our results. In this section, we investigate how the effect of winning a contract on wages varies by firms with collective agreements prior to the auction taking place.

To investigate this, we incorporate data from *Sistema Mediador*, an online registry in which all collective bargaining agreements in Brazil are recorded. The data includes a unique agreement identifier, their starting dates, and the tax identification number (CNPJ) of all firms covered by each of them. A thorough description of this data can be found in Lagos (2022).

Collective agreements can either be at the industry level or at the firm level. In our data 15.8% of firms had at least one collective agreement of any type in the year before the auction. Almost all of these (98.8%) are at the industry level. Importantly, industry-level collective agreements in our data are not concentrated in specific industries but occur in every major industry group.

Table 9 shows results separately for firms with and without collective agreements prior to the auction taking place. The reduced form estimates (Panel A, Columns 1-4) indicate that, among firms with a collective agreement in the year before the auction happened, wages in the lowest bidder firm are 3.4% higher compare to runners-up one year after the auction (significant at the 10% level). This persists even four years later when wages are 5.9% higher for the lowest bidder (significant at the 1% level). The IV strategy produces larger coefficient estimates (Panel B). Winning a contract leads to 4.5% higher wages after one year and 7.5% after four years for firms with a collective agreement one year before the auction. For firms that did not have a collective bargaining agreement, the effect is smaller and more precisely estimated (Columns 5-8). Among these firms, reduced form estimates (Panel A) indicate that lowest bidders pay 1.3% higher wages 1 year after the auction. This effect is 2.4% four years after the auction. The IV estimates (Panel B) indicate winning a contract has an effect of 1.8% higher wages one year later, and 3.1% after four years for firms that did not have a collective bargaining agreement. For this group of firms, all reduced form and instrumental variables estimates are significant at the 1% level.

Taken together, these results indicate a stronger wage effect at firms that had a collective bargaining agreement prior to the auction. Since 98.8% of collective agreements are at the industry level, the presence of collective agreements does not directly explain our evidence of wage bargaining. Instead, we view previously existing industry-level

Table 9: Heterogeneity by Participation in Previous Firm- or Industry-Level Collective Bargaining Agreement

	CBA: Yes				CBA: No			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.034*	0.035**	0.038**	0.059***	0.013***	0.020***	0.017***	0.024***
	(0.020)	(0.016)	(0.017)	(0.018)	(0.004)	(0.005)	(0.005)	(0.006)
	Panel B. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.045*	0.046**	0.049**	0.075***	0.018***	0.027***	0.022***	0.031***
	(0.026)	(0.021)	(0.022)	(0.023)	(0.006)	(0.007)	(0.007)	(0.008)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.756***	0.770***	0.767***	0.783***	0.732***	0.739***	0.750***	0.771***
	(0.020)	(0.019)	(0.025)	(0.032)	(0.008)	(0.008)	(0.009)	(0.010)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	6334	4964	3590	2254	65450	49856	33794	19762

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by participation in any (firm- or industry-level) collective bargaining agreement (CBA) in the year before the auction. Columns (1) to (4) report results for firms that were part of a CBA in the previous year. Columns (5) to (8) report results for firms that were not part of any CBA. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level.* represents 10% significance, ** represents 5% significance and *** represents 1% significance.

agreements as catalysts to wage bargaining after the firm wins a government contract. Our evidence is consistent with workers already covered by collective agreements being more used to bargaining or having stronger unions, and therefore being more likely to bargain for a higher wage once their employer wins a new government contract.

We also run the same specification with two IVs as in Table 6, separately for firms with and without a previous collective agreement (see Appendix Table A31). The estimates are qualitatively similar to what we find when the full sample is used: positive wage effect of contract value and statistically zero effect of number of employees. It is harder to disentangle the two effects for firms with previous collective agreements, since the number of observations is substantially smaller. Even so, it is suggestive that point estimates for the effect of contract value on wage are always higher for firms with prior agreements, than in the ones without.

6 Discussion

Overall, our findings show that wages respond to a demand shock, and that these responses are consistently driven by the extra revenues earned by these firms and not by firm growth. These results are relevant to evaluate the performance of wage-setting models. Our first contribution is to reject competitive labor markets using a unique empirical strategy. Now, there are a multitude of non-competitive wage-setting theories explored in the literature. Obviously, it is unfeasible in a single paper to derive precisely the predictions (and define conditions for them) of every wage-setting model in the literature and analyse how they account for our empirical findings. Our key contribution here is that we provide new empirical patterns that can discipline any (existing or forthcoming) model of wage determination. Our final contribution then is to start this journey by examining two largely encompassing set of models (classic wage posting and wage bargaining), for which we obtain clear predictions concerning the effects of firm size and revenue.

In what follows we conjecture on possibilities beyond the versions of the models we have presented. First, there are other bargaining style models in which *contemporaneous* wages do not respond to firm-specific shocks. For instance, Postel-Vinay and Robin (2002) and Cahuc et al. (2006) predict that workers in more productive firms will eventually earn higher wages, but that occurs over time when they can threaten their employers with outside offers from competitors. Alternatively, wage renegotiation may not always be possible, happening at every period only with certain exogenous probability (Gertler and Trigari, 2009). Regardless, these models still hold the prediction that wages will eventually increase as a response to a firm-specific shock beyond the effect due to firm size. We do estimate and find significant wage responses to firm-specific shocks for up to 4 years. In this sense, our findings are consistent with more general models of bargaining, and is not a by-product of our modelling choice.

Second, when considering wage posting we have focused on classic wage posting models that exhibit a one-to-one relationship between wages and employment. Nevertheless, there are also classes of generalized wage posting models where this is not necessarily the case. For instance, under strategic interaction among granular firms, a firm-specific demand shock can lead to a shift in the supply curve due to a change in strategy by competing firms (Bhaskar et al., 2002; Berger et al., 2022). While representing an important departure from classical wage posting, these models are unable to rationalize our finding that, even for firms with close to zero labor market shares, wages respond to firm-specific demand. It is also possible that atomistic firms interact strategically due to search frictions, in which case firm size is fully determined by the wage posted and the wage offer distribution of the economy, taken as given by any single firm (Burdett and

Mortensen, 1998).[20] Such a setting would unlikely fit our empirical patterns. To do so, the increase in posted wage by one, small (almost zero measure), firm needs to change the wage offered by competitors. And even in this case, the wage posting strategy by competitors only changes if the firm receiving the shock adjusts its number of employees. More generally, under strategic interaction, there is a structural labor supply faced by the firm – which dictates the relationship between firm size and wages taking into account the strategic response of competitors. Therefore, the implication that wages are only affected via firm size remains in this type of model, except that we cannot interpret this reduced-form relationship as determined solely by one firm's labor supply.

Adjustments costs can also be considered and added to the marginal cost of hiring a worker (e.g. Chan et al. (2023)). In such models, wages are a function of the elasticity of labor supply and the marginal adjustment cost of labor (i.e., the derivative of adjustments costs relative to firm size). In general, these models also imply that variations in wages come exclusively through changes in firm size, except that optimal firm size depends on both the elasticity of labor supply and the adjustment costs faced by the firm. As in classical wage posting, regardless of why the firm expands, it is always on its labor supply curve. We have also abstracted from the ability of firms to choose the amenities (compensating differentials) offered to workers (Sorkin, 2018). In order for such margin to generate our finding that larger firm revenue increases wages even after controlling for firm size, firms would need to worsen their amenities following a firm-specific demand increase (therefore requiring them to increase wages to attract the same number of workers).

Alternatively, there are models where firms can attract workers not only through higher wages, but also by increasing recruitment expenditure (Manning, 2006). Another alternative is to assume that workers are heterogenous in quality and firms also choose the cut-off quality level among its applicants (Manning, 2011). Katz (1986) also surveys "efficiency wage models". In these models, firms may raise wages after a shock to encourage more effort from their workers. Different from bargaining, our empirical patterns do not follow directly from these models. However, they can be accounted for under some conditions (e.g. if revenue windfall increases the optimal effort level firms want to induce from their workers).

Although there is a variety of possible extensions, the stylized wage-posting model presented in this paper is not just a particular case of wage-setting models considered in the literature. It is actually the way labor markets are described by a vast share of recent papers. In particular, our findings raise concerns with their attempt to outline non-competitive labor markets exclusively through labor supply elasticities (Ransom and

[20] See equation (10) in Burdett and Mortensen (1998) which applies to both the case of homogenous and heterogeneous firms.

Sims, 2010; Hirsch et al., 2010; Staiger et al., 2010; Falch, 2010; Depew and Sørensen, 2013; Matsudaira, 2014; Naidu et al., 2016; Vick, 2017; Card et al., 2018; Goolsbee and Syverson, 2019; Kline et al., 2019; Dube et al., 2019; Tortarolo and Zarate, 2020; Kroft et al., 2020; Dube et al., 2022; Lamadon et al., 2022; Amodio and de Roux, 2023). We show that the wage effects of demand shocks cannot be fully accounted by these elasticities, and that bargaining should be considered as part of the wage protocol.[21]

These theoretical distinctions have important implications for our understanding of the effects of labor market concentration, for instance. As emphasized in Hemphill and Rose (2017), and shown in Jarosch et al. (2019), changes in market structure can affect wages through changes in bargaining leverage (rather than supply elasticities). Our results help rationalize recent evidence that sometimes market concentration affects prices but not quantities, at odds with the prediction from wage posting that both employment and wages should be affected. For example, Prager and Schmitt (2021) and Guanziroli (2022) find evidence of mergers that decreased wages without having an effect on employment. Our results are also consistent with recent evidence showing that wages respond to outside employment opportunities, as implied by a bargaining wage-setting procedure (Beaudry et al., 2012; Caldwell and Harmon, 2019). Furthermore, the fact that our results are consistently driven by firms with collective bargaining agreements and workers with arguably more bargaining power provides additional suggestive evidence in favor of a bargaining protocol.

Examining which set of theories best describes the data is fundamental. Wage posting and wage bargaining models have different policy prescriptions for pressing issues of our days. For example, in order to confront gender and racial discrimination, there have been proposals to limit a potential employer's ability to ask and receive information on an applicant's salary history. Under bargaining, workers with different past salaries can have different wages as these are informative about their respective outside options. Similarly, policies of equal pay trying to address the gender wage gap or racial discrimination may be effective in a bargaining world, but not so much in a posting world where gaps arise primarily from different sorting into firms. For instance, some papers find that differences in bargaining power contribute to the gender wage gap (Dittrich et al., 2014; Flinn et al., 2020; Biasi and Sarsons, 2022). Finally, these models also have different implications for the efficiency of the labor market equilibrium. Under posting, minimum wage policies might induce gains of efficiency and even employment increase in some contexts. Meanwhile, under bargaining it can destroy some matches but improve overall worker's wages.

[21] See Flinn and Mullins (2021) for recent progress on models exhibiting both wage bargaining and wage posting in equilibrium.

More generally, our clear empirical results show that wages respond to increased firm revenue even after controlling for firm size. Even though this evidence is consistent with bargaining and not fully accounted by classical wage posting models, it invites future theoretical developments. Future research can explore other mechanisms in which this phenomenon occurs. For instance, firm and workers might engage in different types of bargaining procedures, such as collective bargaining (Bhuller et al., 2022). Alternatively, workers and firms might have preferences that account for fairness or reference points that can respond to firm performance (e.g. Mas (2006); Breza et al. (2018)). Research on other forms of generalized wage posting models, or extension to current ones, is also welcome.

7 Conclusion

How are wages determined? Can we distinguish between different wage theories? We use quasi-experimental variation to test how firm-specific demand shocks impact wages and to disentangle predictions coming from wage bargaining and wage posting. To obtain a quasi-experimental design, we exploit an institutional feature of Brazilian public procurement auctions: the moment in which the auction ends is random. We show that under this setting, for close auctions, winner and runner-up are as good as randomly assigned. Furthermore, the (random) duration gives us variation in the value of the contract won.

We find that winning a close auction increases wages by about 1.8% one year later. For young firms, this effect is about 2.7%, and it persists for four years. We also focus only on workers present at the firm before the auction and verify that our results are not driven by the selection of workers into or out of the winning firm. This result is consistent with non-competitive labor markets where firms have power to set wages.

Second, for each additional five minutes the auction lasts (randomly), the contract value decreases by 10%. We then instrument contract value and firm size using variation in the identity of the winner and its interaction with the duration of the auction. Our results show that a one standard deviation increase in contract value increases wages by 7.2% while the number of employees has no significant effect. Guided by a theoretical model encompassing both posting and bargaining features, we interpret our results as evidence of bargaining. Importantly, we do not reject the presence of wage posting, but clearly reject it as a unique framework to explain the labor market.

Overall, our findings show that wages respond to a demand shock across a multitude of markets and in firms with varying degrees of labor market shares. These responses are consistently driven by the extra revenues earned by these firms and not by firm growth.

Such results are at odds with theories of firms only posting wages (facing an upward-sloping labor supply curve), and are consistent with bargaining being a relevant aspect of non-competitive labor markets. Our results provide novel empirical patterns that invite and must guide future research on wage determination theories, including bargaining models and more general forms of wage posting.

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Appendix for Online Publication

Appendix A Data Construction

To build the auction data set, we first obtained a list of all online auctions conducted in the ComprasNet platform, from the government's open data website. This gives us a unique identifier for each auction report, composed of the governmental branch's code and a serial number. We then insert these two numbers in ComprasNet's home screen (Figure A2). The query returns a page (Figure A3), from which we can access that specific report. Each auction report is an HTML page containing 4 main parts. First, we have a list of goods being procured (Figure A4), their quantity, a paragraph-long description of the procured goods, the government's reference value, the auction result (e.g., whether it was canceled or a contract was signed), the contracted firm and contract value. The second part is a list of proposals (Figure A5), containing for each procured lot the unit and total values each firm submitted as their first bid, which are made public at the start of the auction. Third, the HTML file gives us a list of event timings (Figure A6), which contains the timestamps of the auction start , the start of the random phase, and its ending. The fourth part is a table with all bids placed in the auction, their timestamps, and the bidder's tax ID (Figure A7). With this information we can rank each participant based on how low their last bid was.

We supplement this data with more information from the government's open data website. For each auctioned lot we obtained a 6-digit product code based on the Federal Supply Classification (FSC), developed by the United States' Office of the Secretary of Defense.[22] We process millions of HTML auction reports into a data set with all 9.2 million ComprasNet online auctions conducted between 2011 and 2016. Auctions are not concentrated in any specific group of products (see Table A1 for a breakdown).

[22] https://mn.gov/admin/assets/DISP_h2book[1]_tcm36-281917.pdf

Appendix B Figures

Figure A1: Random Phase Duration (Histogram)

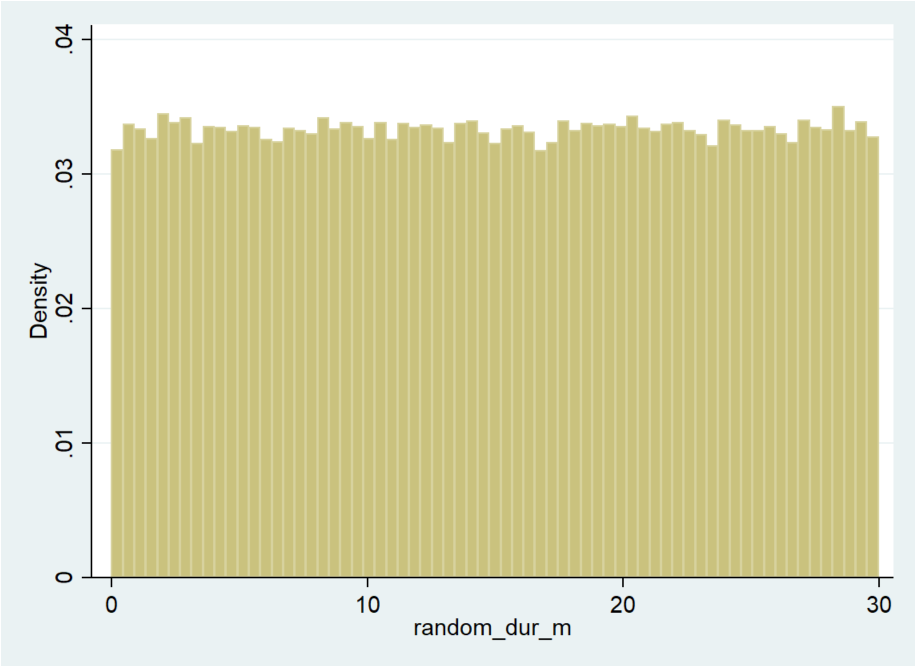


Figure A2: ComprasNet Platform - Home Screen

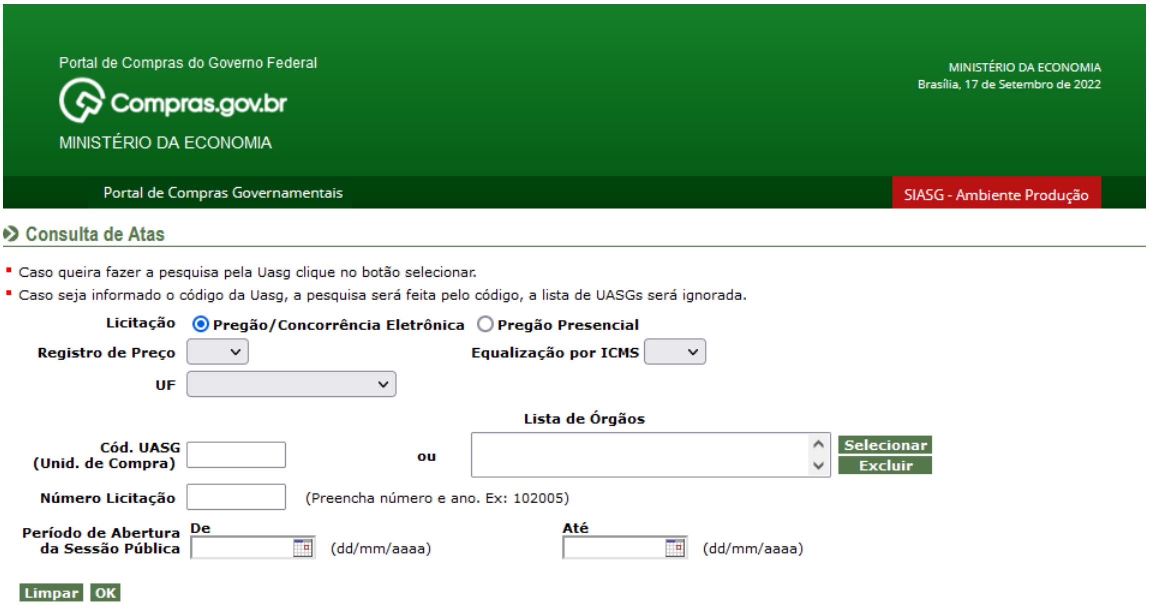


Figure A3: ComprasNet Platform - Query Result

Portal de Compras do Governo Federal

Compras.gov.br

MINISTÉRIO DA ECONOMIA

MINISTÉRIO DA ECONOMIA
Brasília, 17 de Setembro de 2022

Portal de Compras Governamentais

SIASG - Ambiente Produção

Consulta de Atas

- Clique no número da licitação para ver a ata

Licitações Eletrônicas

Nº da Licitação	Cód. UASG (Unid. de Compra)	Nome da UASG (Unid. de Compra)	Data de Realização
312012 (Pregão)	170394	CORPO DE BOMBEIROS MILITAR DO DF	18/02/2013

Voltar

Figure A4: ComprasNet Auction Report - Procured Auction Specifications and Summary Information

Portal de Compras do Governo Federal

Compras.gov.br

MINISTÉRIO DA ECONOMIA

MINISTÉRIO DA ECONOMIA
Brasília, 17 de Setembro de 2022

Portal de Compras Governamentais

SIASG - Ambiente Produção

CONSULTA ATA DE PREGÃO

170394.312012.5923.4950.12582994977.567

Ata de Realização do Pregão Eletrônico
Nº 00031/2012 (SRP)

Às 13:11 horas do dia 18 de fevereiro de 2013, reuniram-se o Pregoeiro Oficial deste Órgão e respectivos membros da Equipe de Apoio, designados pelo instrumento legal Portaria nº 02/2013 de 02/01/2013, em atendimento às disposições contidas na Lei nº 10.520 de 17 de julho de 2002 e no Decreto nº 5.450 de 31 de maio de 2005, referente ao Processo nº 053.002.317/2012, para realizar os procedimentos relativos ao Pregão nº 00031/2012. Objeto: Objeto: Pregão Eletrônico - Registro de Preços de viatura do tipo Unidade Tática de Emergência - UTE para o CBMDF. Veículo tipo furgão, monobloco com integração cabina e carroçaria unificados, adaptada para serviço de emergência médica; original de fábrica.. O Pregoeiro abriu a Sessão Pública em atendimento às disposições contidas no edital, divulgando as propostas recebidas. Abriu-se em seguida a fase de lances para classificação dos licitantes relativamente aos lances ofertados.

Item: 1
Descrição: VEÍCULO ESPECIAL
Descrição Complementar: VEÍCULO ESPECIAL, NOME VEÍCULO ESPECIAL. Veículo tipo furgão, monobloco com integração cabina e carroçaria unificadas, adaptada para serviço de emergência médica; tipo UTE (Unidade Tática de Emergência); original de fábrica; construído em aço; longo com teto alto; zero Km, de ano e modelo 2012 ou do ano da entrega, com emplacamento e IPVA em nome do Corpo de Bombeiros Militar do Distrito Federal, com tração 4x2, com rodado simples, as portas terão travas e dispositivo para abertura por dentro e por fora, porta lateral de correr no lado direito, original de fábrica, trava de segurança e dispositivo para abertura por dentro e por fora, retrovisores externos em ambos os lados e demais equipamentos de série de acordo com as normas do CONTRAN. [...] Estas e demais especificações deverão estar de acordo com o constante no Termo de Referência, constante no anexo I ao edital.
Tratamento Diferenciado: -
Aplicabilidade Decreto 7174: Não
Aplicabilidade Margem de Preferência: Não
Quantidade: 40
Valor estimado: **R$** 188.200,2500
Unidade de fornecimento: unidade
Situação: Aceito e Habilitado com intenção de recurso

Aceito para: DIVENA LITORAL VEICULOS LTDA., **pelo melhor lance de** R$ 148.000,0000 **e a quantidade de** 40 **unidade** .

Figure A5: ComprasNet Auction Report - Proposals

Item: 1 - VEÍCULO ESPECIAL

Propostas Participaram deste item as empresas abaixo relacionadas, com suas respectivas propostas.
(As propostas com * na frente foram desclassificadas pelo pregoeiro)

CNPJ/CPF	Fornecedor	Porte ME/EPP	Declaração ME/EPP/COOP	Quantidade	Valor Unit.	Valor Global	Data/Hora Registro
02.990.234/0001-59	DIVENA LITORAL VEICULOS LTDA.	Não	Não	40	R$ 188.000,0000	R$ 7.520.000,0000	29/01/2013 09:10:33
	Marca: MBB SPRINTER 415 **Fabricante:** MERCEDES-BENZ **Descrição Detalhada do Objeto Ofertado:** Furgão, carroceria monobloco todo em aço estampado original de fabrica, Mercedes-Benz, modelo Sprinter 415 CDI, 0KM, ano/modelo 2012/2013, adaptado para Viatura tipo UTE (Unidade Tática de Emergencia), motor diesel, tração traseira e rodagem simples p/uso em todo terreno em conformidade c/PROCONVE P-7; Motor: Mercedes – Benz modelo OM-651, Turbocompressor: Bi Turbo (2 estágios) intercooler, 4 cilindros em linha, 146 CV de potência; Torque máximo: 33,6 mkgf; Cilindrada Total: 2.143 cm³; Freio: Sistema hidráulico de duplo circuito, servo depressão, a disco nas 04 rodas e válvula sensível à carga; Suspensão: Dianteira: tipo independente, c/conjunto de mola parabólica transversal, amortecedores hidráulicos de duplo efeito; Traseira: rígido com molas parabólicas, amortecedores hidráulicos de duplo efeito e barra estabilizadora dianteira e traseira; Rodas: Aço 6,5J; Pneus: 225/75 R 16C; Embreagem e Direção: Hidráulicas; Câmbio: Sincronizado 5 marchas à frente e 1 ré; Tanque de Combustível: 75 litros; Distancia entre - eixos: 3.665mm. Dimensões: Comprimento total 5.910mm, Largura (sem/com espelhos) 1.993/2.426mm; Altura 2.716mm. Interna: Compartimento carga Altura 1.940mm; Largura 1.780mm; adaptado para UNIDADE TATICA DE EMERGENCIA conforme Anexo I do Termo de Referencia nº 060/2012 – DIMAT do Pregão Eletrônico 31/2012 . Prazo de Entrega em até 150 (cento e cinquenta) dias , Local de entrega: Centro de Manutenção de Equipamentos e Viaturas (CEMEV) do CBMDF – localizado no setor Policial – SAIS Area Especial 3 – CEP 70.602-600. Garantia do veiculo adaptado 12 meses ou 60.000 (sessenta mil) quilometros . Assistência Técnica através de nossa rede de concessionaria Mercedes-Benz em todo território nacional. E com todos os itens de segurança exigidos pelo Código Nacional de Transito. Atenderemos plenamente ao solicitado no edital e seus anexos. Os Veiculos serão entregues com Manual de Operação e Manutenção Preventiva em Língua Portuguesa para cada Viatura. Declaramos que nos preços cotados estão incluídos todos os custos e despesas, tais como e sem se limitar a: custos diretos e indiretos, custos do veículo, custos da transformação do veículo, tributos incidentes, taxa de administração, materiais, serviços, encargos sociais, trabalhistas, seguros, lucro, frete e outros necessários ao cumprimento integral do objeto deste Termo de Referência e seu Anexo.						
00.913.443/0001-73	RENAULT DO BRASIL S.A	Não	Não	40	R$ 188.000,0000	R$ 7.520.000,0000	29/01/2013 09:41:26
	Marca: RENAULT MASTER **Fabricante:** RENAULT **Descrição Detalhada do Objeto Ofertado:** Veiculo modelo MASTER FURGAO 2.3 DCI 16V, marca RENAULT, monobloco com integração cabina e carroçaria unificadas, adaptada para serviço de emergência médica; tipo UTE (Unidade Tática de Emergência); original de fábrica; construído em aço; longo com teto alto; zero Km, de ano e modelo 2012 ou do ano da entrega, com emplacamento e IPVA em nome do Corpo de Bombeiros Militar do Distrito Federal, com tração 4x2, com rodado simples, as portas terão travas e dispositivo para abertura por dentro e por fora, porta lateral de correr no lado direito, original de fábrica, trava de segurança e dispositivo para abertura por dentro e por fora, retrovisores externos em ambos os lados e demais equipamentos de série de acordo com as normas do CONTRAN. Motor 130 CV, 31 mkgf, freios ABS, ar condicionado, air bag duplo, cambio de 6 marchas a frente e 1 a ré, peso bruto total de 3.500 kg, carga util dr 1.530 kg, distancia entre eixos de 4.332 mm, comprimento de 6.198 mm, com as devidas adaptações para Unidade Tatica de Emergencia.						

Figure A6: ComprasNet Auction Report - Event Timings

Eventos do Item

Evento	Data	Observações
Aberto	18/02/2013 14:00:27	Item aberto.
Iminência de Encerramento	18/02/2013 14:35:16	Batida iminente. Data/hora iminência: 18/02/2013 14:45:16.
Encerrado	18/02/2013 15:00:29	Item encerrado
Aceite	18/02/2013 15:17:40	Aceite individual da proposta. Fornecedor: DIVENA LITORAL VEICULOS LTDA., CNPJ/CPF: 02.990.234/0001-59, pelo melhor lance de R$ 148.000,0000. Motivo: A proposta está em conformidade com a especificação.
Abertura do prazo de Convocação - Anexo	18/02/2013 15:30:19	Convocado para envio de anexo o fornecedor DIVENA LITORAL VEICULOS LTDA., CNPJ/CPF: 02.990.234/0001-59.
Encerramento do prazo de Convocação - Anexo	18/02/2013 15:32:07	Encerrado o prazo de Convocação de Anexo pelo fornecedor DIVENA LITORAL VEICULOS LTDA., CNPJ/CPF: 02.990.234/0001-59.
Habilitado	18/02/2013 15:42:43	Habilitação individual da proposta. Fornecedor: DIVENA LITORAL VEICULOS LTDA., CNPJ/CPF: 02.990.234/0001-59, pelo melhor lance de R$ 148.000,0000. Motivo: A documentação está em conformidade com o Edital.
Registro Intenção de Recurso	18/02/2013 16:06:22	Registro de Intenção de Recurso. Fornecedor: DE NIGRIS DISTRIBUIDORA DE VEICULOS LTDA CNPJ/CPF: 61591459000100. Motivo: Declaramos o interresse em interpor recurso no pregão em questão, pois não tivemos acesso a proposta apresentada pela concorrente. Demais argumentos iremos nos expressar na peça re
Registro Intenção de Recurso	18/02/2013 16:08:11	Registro de Intenção de Recurso. Fornecedor: DE NIGRIS DISTRIBUIDORA DE VEICULOS LTDA CNPJ/CPF: 61591459000100. Motivo: Declaramos o interesse em interpor recurso no pregão em questão, pois não tivemos acesso a proposta apresentada pela concorrente. Demais argumentos iremos nos expressar na peça rec
Intenção de Recurso Recusada	18/02/2013 16:33:17	Intenção de recurso rejeitada. Fornecedor: DE NIGRIS DISTRIBUIDORA DE VEICULOS LTDA, CNPJ/CPF: 61591459000100. Motivo: A simples alegação de não acesso à proposta da vencedora não atende ao requisito da motivação, visto que a proposta foi analisada e, efetivamente, atende ao exigido. Ademais, conforme Acordão 600/2011 - Plenário/TCU, "a mera afirmação de que a licitante declarada vencedora possivelmente não cumpriu com as exigências do edital não evidenciará intenção motivada de recorrer"; fica configurado o não atendimento da motivação para recorrer. Isto posto, REJEITO a intenção de recurso da empresa.

Figure A7: ComprasNet Auction Report - Bids

Lances (Obs: lances com * na frente foram excluídos pelo pregoeiro)

Valor do Lance	CNPJ/CPF	Data/Hora Registro
R$ 188.000,0000	02.990.234/0001-59	18/02/2013 13:11:25:730
R$ 188.000,0000	00.913.443/0001-73	18/02/2013 13:11:25:753
R$ 250.000,0000	08.933.586/0001-59	18/02/2013 13:11:25:773
R$ 237.515,0000	39.786.983/0009-26	18/02/2013 13:11:25:773
R$ 350.000,0000	14.092.091/0001-47	18/02/2013 13:11:25:780
R$ 300.000,0000	06.177.772/0001-80	18/02/2013 13:11:25:780
R$ 805.000,0000	10.614.837/0001-84	18/02/2013 13:11:25:783
R$ 780.000,0000	61.591.459/0001-00	18/02/2013 13:11:25:783
R$ 500.000,0000	63.411.623/0021-10	18/02/2013 13:11:25:783
R$ 500.000,0000	11.463.567/0001-10	18/02/2013 13:11:25:783
R$ 237.514,9800	61.591.459/0001-00	18/02/2013 14:00:55:127
R$ 249.000,0000	63.411.623/0021-10	18/02/2013 14:03:07:040
R$ 180.000,0000	00.913.443/0001-73	18/02/2013 14:08:11:867
R$ 237.500,0000	61.591.459/0001-00	18/02/2013 14:09:28:890
R$ 237.400,0000	61.591.459/0001-00	18/02/2013 14:09:54:787
R$ 187.900,0000	02.990.234/0001-59	18/02/2013 14:10:21:457
R$ 187.888,0000	61.591.459/0001-00	18/02/2013 14:15:24:473
R$ 187.500,0000	11.463.567/0001-10	18/02/2013 14:18:57:667
R$ 236.000,0000	63.411.623/0021-10	18/02/2013 14:23:48:743
R$ 187.498,0000	61.591.459/0001-00	18/02/2013 14:25:02:343
R$ 179.900,0000	02.990.234/0001-59	18/02/2013 14:25:48:090
R$ 179.000,0000	00.913.443/0001-73	18/02/2013 14:27:30:843
R$ 178.500,0000	02.990.234/0001-59	18/02/2013 14:29:15:507
R$ 178.000,0000	00.913.443/0001-73	18/02/2013 14:31:00:560
R$ 178.498,0000	61.591.459/0001-00	18/02/2013 14:41:36:787
R$ 177.973,0000	61.591.459/0001-00	18/02/2013 14:44:35:603
R$ 177.000,0000	02.990.234/0001-59	18/02/2013 14:44:56:090
R$ 176.971,0000	61.591.459/0001-00	18/02/2013 14:44:56:887
R$ 177.000,0000	00.913.443/0001-73	18/02/2013 14:45:10:083
R$ 176.000,0000	02.990.234/0001-59	18/02/2013 14:45:20:380
R$ 175.991,0000	61.591.459/0001-00	18/02/2013 14:45:21:150
R$ 175.990,0000	11.463.567/0001-10	18/02/2013 14:45:30:637
R$ 175.970,0000	61.591.459/0001-00	18/02/2013 14:45:41:367
R$ 175.000,0000	02.990.234/0001-59	18/02/2013 14:45:46:140
R$ 174.999,0000	11.463.567/0001-10	18/02/2013 14:45:54:190
R$ 174.979,0000	61.591.459/0001-00	18/02/2013 14:46:01:460

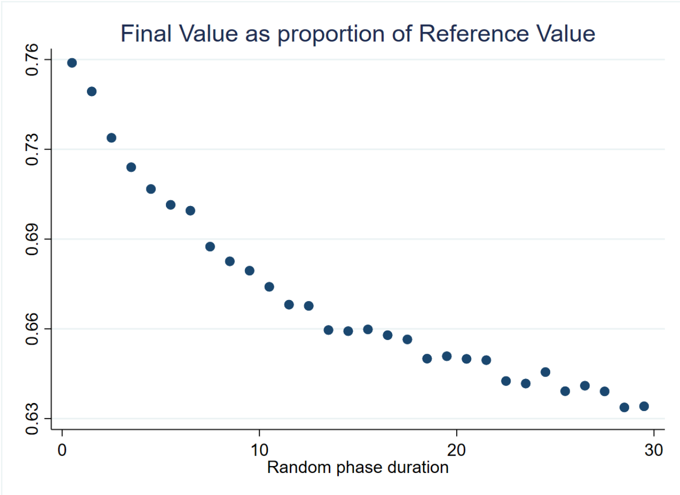
Random phase begins 14:45:16

[Omitted 57 bids placed between 14:46:02 and 14:52:22]

Valor do Lance	CNPJ/CPF	Data/Hora Registro
R$ 153.200,0000	00.913.443/0001-73	18/02/2013 14:52:22:380
R$ 161.000,0000	11.463.567/0001-10	18/02/2013 14:52:28:337
R$ 153.000,0000	02.990.234/0001-59	18/02/2013 14:52:37:173
R$ 152.900,0000	00.913.443/0001-73	18/02/2013 14:52:49:903
R$ 152.899,0000	02.990.234/0001-59	18/02/2013 14:53:23:013
R$ 159.600,0000	11.463.567/0001-10	18/02/2013 14:53:43:927
R$ 152.500,0000	00.913.443/0001-73	18/02/2013 14:54:02:580
R$ 152.499,0000	02.990.234/0001-59	18/02/2013 14:54:17:013
R$ 152.400,0000	00.913.443/0001-73	18/02/2013 14:54:47:337
R$ 152.300,0000	02.990.234/0001-59	18/02/2013 14:55:06:667
R$ 152.000,0000	00.913.443/0001-73	18/02/2013 14:55:08:663
R$ 151.999,0000	02.990.234/0001-59	18/02/2013 14:55:27:463
R$ 150.000,0000	00.913.443/0001-73	18/02/2013 14:55:34:707
R$ 149.900,0000	00.913.443/0001-73	18/02/2013 14:55:59:843
R$ 149.400,0000	02.990.234/0001-59	18/02/2013 14:56:07:170
R$ 149.000,0000	00.913.443/0001-73	18/02/2013 14:56:30:627
R$ 148.999,0000	02.990.234/0001-59	18/02/2013 14:56:48:650
R$ 148.900,0000	00.913.443/0001-73	18/02/2013 14:57:11:933
R$ 148.899,0000	02.990.234/0001-59	18/02/2013 14:57:43:307
R$ 148.500,0000	00.913.443/0001-73	18/02/2013 14:57:46:813
R$ 148.499,0000	02.990.234/0001-59	18/02/2013 14:58:51:680
R$ 148.400,0000	00.913.443/0001-73	18/02/2013 14:59:19:530
R$ 148.399,0000	02.990.234/0001-59	18/02/2013 14:59:42:900
R$ 148.300,0000	00.913.443/0001-73	18/02/2013 15:00:08:213
R$ 148.000,0000	02.990.234/0001-59	18/02/2013 15:00:28:847

Random phase ends 15:00:29

Figure A8: Contract Value and Auction Duration



Notes: Reference value is the estimated market value of each item being purchased in an auction. The final value is the contract value obtained at the end of auction. The Figure shows (binned) scatter plot of the relationship between final value as proportion of reference value and the auction duration which was determined randomly for each auction.

Appendix C Tables

Table A1: % Auctions and % Value per Group of Products

Categories	% auctions	% value
Vehicles and parts	4.61%	14.78%
Industrial, commercial and agri equipment	5.42%	6.65%
Safety, cooling, hydraulic, etc. equipment	6.87%	7.27%
Building materials, tools, etc.	11.02%	9.79%
Electric and communication equipment	7.66%	6.09%
Medical and scientific equipment	12.81%	12.86%
Computers, parts, etc.	4.23%	2.13%
Furniture	3.64%	4.71%
Food preparation utensils and equipment	6.16%	4.28%
Office supplies and printed material	7.06%	3.72%
Recreation, sports and musical equipment	2.94%	1.19%
Cleaning supplies, packages	6.86%	4.49%
Personal hygiene and clothing	4.70%	4.70%
Live animals ans agricultural supplies	1.84%	1.56%
Food	4.92%	7.31%
Fuels and minerals	3.18%	4.03%
Misc.	6.06%	4.45%

Notes: The table groups close auctions into product categories and reports the fraction of auctions and the fraction of total value in *Reais* that corresponds to each category.

Table A2: Placebo identity of lowest bidder when auction ended x seconds earlier

Placebo Lowest Bidder if auction ended...		
	Lowest Bidder	Runner-up
2 seconds earlier	0.83	0.17
6 seconds earlier	0.57	0.40
10 seconds earlier	0.43	0.50
14 seconds earlier	0.40	0.50
18 seconds earlier	0.47	0.41
22 seconds earlier	0.60	0.29
26 seconds earlier	0.63	0.25

Notes: The Column "Lowest Bidder" shows the fraction of lowest bidder firms that would have won the contract if the action ended x seconds earlier. The Column "Runner-up" shows the fraction of runner-up firms that would have won the contract if the auction ended x seconds earlier.

Table A3: Close Auction Summary Statistics

	Mean	Standard Deviation
Reference Value (BRL)	52,992	694,242
Winning Bid (BRL)	28,287	433,888
Auction Duration (min)	51.8	51.3
Random Phase Duration (min)	14.7	8.4
Number of firms who submit initial proposal	9.0	6.3
Number of firms during auction	6.1	4.3
Number of firms during random phase	4.5	2.7
Number of firms during last 30 Seconds	2.3	0.7
% Difference between 2 lowest bids	0.12	0.13
Rank of Lowest Bidder's Initial Proposal	2.1	1.3
Rank of Runner-up's Initial Proposal	2.0	1.2
Number of bids in auction	72.6	52.1
Number of bids in random phase	55.0	45.1
Number of outbids in random phase	46.8	36.9
Lowest Bidder's Outbids During Random Phase	18.6	15.0
Runner-up's Outbids During Random Phase	17.0	14.6
Lowest Bidder's Outbids During Last 30 Seconds	1.3	0.4
Runner-up's Outbids During Last 30 Seconds	1.0	0.3
Lowest Bidder's Seconds as Leader During Last 30 Seconds	10.8	6.4
Runner-up's Seconds as Leader During Last 30 Seconds	9.0	5.8
Observations	225,093	

Notes: This table shows summary statistics for close auctions held by federal purchasing units between 2011 and 2016. We define close auctions as those auctions where (i) both the winner and runnerup placed bids in the last 30 seconds of the auction, and (ii) the runnerup bid does not exceed the winning bid by more than 0.5%.

Table A4: Contract Values resulting from Close Auctions

	(1) Observations	(2) Mean	(3) Std. dev.	(4) 10 pctile	(5) 50 pctile	(6) 90 pctile
Contract value (R$)	171,225	32,535.31	572,668.68	173.27	2,896.02	40,673.73
Contract value per worker (R$)	171,225	5,048.51	37,494.73	28.42	523.05	8,191.53
Contract value as % of annual wage bill	171,225	45.3	372.0	0.2	3.8	69.1

Notes: This table shows summary statistics of contract values for winner of close auctions that were present in RAIS in the year before the auction happened. Contract value is the total amount in Brazilian *Reais* received by the contract winner. Contract value per worker is calculated using the number of employees in year $t-1$. Contract value as % of annual wage bill is calculated using number of employees and wages in year $t-1$.

Table A5: Comparison between Auction Participants and Non-Participants in RAIS

	Participants	Non-Participants
Earnings	1414.33	1266.44
Contractual Wage	1348.45	1218.76
Employees	25.67	14.03
Firm Age	9.09	9.09
% College	16.86	11.02
% High Skill	5.18	4.45
% Intermediate Skill	8.24	6.38
% Low Skill	79.38	83.98
% Female	38.07	44.44
Observations	30,039	20,200,632

Notes: Comparison between participants (as lowest bidders or second lowest bidders) in close auctions and all other firms in RAIS between 2011 and 2016. Earnings and Contractual Wages are in 2018 Brazilian Reais. Firm age is measured in years since first appearing in RAIS.

Table A6: Results - Robustness using Contractual Wages

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.014***	0.018***	0.017***	0.017***
	(0.004)	(0.004)	(0.005)	(0.005)
	Panel B. IV estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.019***	0.024***	0.022***	0.022***
	(0.006)	(0.005)	(0.006)	(0.007)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.745***	0.752***	0.758***	0.768***
	(0.005)	(0.005)	(0.006)	(0.006)
Auction FEs	✓	✓	✓	✓
Observations	248874	191672	132082	80208

Notes: Reduced form and IV Regressions of log of contractual wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A7: Results - Robustness using Hourly Wages

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.013***	0.017***	0.016***	0.002
	(0.004)	(0.004)	(0.004)	(0.011)
	Panel B. IV estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.017***	0.022***	0.022***	0.003
	(0.005)	(0.005)	(0.006)	(0.014)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.745***	0.752***	0.758***	0.768***
	(0.005)	(0.005)	(0.006)	(0.006)
Auction FEs	✓	✓	✓	✓
Observations	248972	191732	132324	81254

Notes: Reduced form and IV Regressions of log of hourly wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A8: Results - Young *versus* Old Firms - Robustness using Contractual Wages

	Young Firms				Old Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.020***	0.024***	0.026***	0.032***	-0.005	0.001	-0.004	-0.009
	(0.005)	(0.005)	(0.006)	(0.007)	(0.013)	(0.010)	(0.011)	(0.010)
	Panel B. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.027***	0.033***	0.035***	0.042***	-0.007	0.001	-0.005	-0.011
	(0.007)	(0.007)	(0.008)	(0.009)	(0.017)	(0.013)	(0.014)	(0.013)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.735***	0.743***	0.754***	0.766***	0.770***	0.771***	0.773***	0.771***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.011)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107914	83188	57424	33914	34274	25752	17830	11298

Notes: IV Regressions of log of contractual wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm age. Columns (1) to (4) report results for young firms, defined as those with 8 years or less of existence. Columns (5) to (8) report results for firms with age of 9+ years. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A9: Results - Young *versus* Old Firms - Robustness using Hourly Wages

	Young Firms				Old Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Lowest Bidder	0.019***	0.025***	0.025***	0.013	-0.006	-0.003	-0.002	-0.009
	(0.005)	(0.005)	(0.006)	(0.013)	(0.012)	(0.010)	(0.010)	(0.010)
	Panel B. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
Contract Winner	0.026***	0.034***	0.033***	0.017	-0.008	-0.004	-0.003	-0.011
	(0.007)	(0.006)	(0.007)	(0.018)	(0.016)	(0.012)	(0.013)	(0.013)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.735***	0.743***	0.754***	0.766***	0.770***	0.771***	0.773***	0.771***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.011)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107988	83240	57516	34484	34278	25752	17846	11304

Notes: IV Regressions of log of hourly wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm age. Columns (1) to (4) report results for young firms, defined as those with 8 years or less of existence. Columns (5) to (8) report results for firms with age of 9+ years. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A10: Effect on Number of Employees
All firms

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest Bidder	0.019***	0.012*	0.009	0.015*
	(0.005)	(0.006)	(0.007)	(0.009)
	Panel B. IV estimates			
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Contract Winner	0.025***	0.015*	0.012	0.020*
	(0.007)	(0.008)	(0.009)	(0.011)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.745***	0.752***	0.758***	0.768***
	(0.005)	(0.005)	(0.006)	(0.006)
Auction FEs	✓	✓	✓	✓
Observations	248972	191732	132324	81254

Notes: Reduced form and IV Regressions of log number of employees $j = \{1, 2, 3, 4\}$ years after the auction on contract winner. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A11: Effect on Number of Employees
Young vs Old Firms

	Young Firms				Old Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	$\log(\text{n})_{t+1}$	$\log(\text{n})_{t+2}$	$\log(\text{n})_{t+3}$	$\log(\text{n})_{t+4}$	$\log(\text{n})_{t+1}$	$\log(\text{n})_{t+2}$	$\log(\text{n})_{t+3}$	$\log(\text{n})_{t+4}$
Lowest Bidder	0.017**	0.006	0.005	0.029**	0.020**	0.018*	0.017	0.009
	(0.008)	(0.009)	(0.009)	(0.014)	(0.008)	(0.010)	(0.012)	(0.015)
	Panel B. IV estimates							
Dep Var	$\log(\text{n})_{t+1}$	$\log(\text{n})_{t+2}$	$\log(\text{n})_{t+3}$	$\log(\text{n})_{t+4}$	$\log(\text{n})_{t+1}$	$\log(\text{n})_{t+2}$	$\log(\text{n})_{t+3}$	$\log(\text{n})_{t+4}$
Contract Winner	0.023**	0.008	0.007	0.038**	0.026**	0.023*	0.022	0.012
	(0.011)	(0.013)	(0.013)	(0.018)	(0.010)	(0.013)	(0.016)	(0.020)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.735***	0.743***	0.754***	0.766***	0.770***	0.771***	0.773***	0.771***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.011)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107988	83240	57516	34484	34278	25752	17846	11304

Notes: IV Regressions of log number of employees $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm age. Columns (1) to (4) report results for young firms, defined as those with 8 years or less of existence. Columns (5) to (8) report results for firms with age of 9+ years. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A12: Effects on Firm Survival

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	Active Firm$_{t+1}$	Active Firm$_{t+2}$	Active Firm$_{t+3}$	Active Firm$_{t+4}$
Lowest Bidder	0.008***	0.009***	0.006*	0.006
	(0.003)	(0.003)	(0.004)	(0.004)
	Panel B. IV estimates			
Dep Var	Active Firm$_{t+1}$	Active Firm$_{t+2}$	Active Firm$_{t+3}$	Active Firm$_{t+4}$
Contract Winner	0.011***	0.012***	0.009*	0.008
	(0.004)	(0.004)	(0.005)	(0.006)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.724***	0.728***	0.729***	0.733***
	(0.004)	(0.004)	(0.004)	(0.005)
Auction FEs	✓	✓	✓	✓
Observations	500164	421296	340448	242376

Notes: Reduced form and IV Regressions of dummy variables indicating whether the firm was present in RAIS $j = \{1, 2, 3, 4\}$ years after the auction on contract winner. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A13: Heterogeneity by Race

Dep Var	(1) $\log(w)_{t+1}$	(2) $\log(w)_{t+1}$	(3) $\log(w)_{t+2}$	(4) $\log(w)_{t+2}$	(5) $\log(w)_{t+3}$	(6) $\log(w)_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**White workers**			
Lowest Bidder	0.026***		0.021***		0.025***	
	(0.006)		(0.005)		(0.006)	
Contract Winner		0.035***		0.028***		0.033***
		(0.008)		(0.007)		(0.009)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	63,768	63,768	48,424	48,424	32,802	32,802
R-squared	0.591	0.038	0.581	0.027	0.569	0.019
Panel B						
Type of worker:			**Non-white workers**			
Lowest Bidder	0.003		0.013*		0.026***	
	(0.006)		(0.007)		(0.008)	
Contract Winner		0.005		0.017*		0.035***
		(0.009)		(0.009)		(0.011)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	20,730	20,730	15,868	15,868	11,466	11,466
R-squared	0.589	0.007	0.617	0.006	0.596	0.006

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. Sample is split by worker's race: white (Panel A) and non-white (Panel B). Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A14: Heterogeneity by Gender

Dep Var	(1) $\log(w)_{t+1}$	(2) $\log(w)_{t+1}$	(3) $\log(w)_{t+2}$	(4) $\log(w)_{t+2}$	(5) $\log(w)_{t+3}$	(6) $\log(w)_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**Female workers**			
Lowest Bidder	0.010**		0.010*		0.015***	
	(0.005)		(0.005)		(0.006)	
Contract Winner		0.014**		0.012*		0.020***
		(0.006)		(0.007)		(0.007)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	62,132	62,132	48,208	48,208	31,754	31,754
R-squared	0.580	0.017	0.572	0.008	0.569	0.003
Panel B						
Type of worker:			**Male workers**			
Lowest Bidder	0.021***		0.027***		0.020***	
	(0.006)		(0.006)		(0.006)	
Contract Winner		0.028***		0.036***		0.026***
		(0.009)		(0.008)		(0.008)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	76,414	76,414	57,622	57,622	41,008	41,008
R-squared	0.584	0.031	0.579	0.026	0.573	0.015

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. Sample is split by worker's gender: female (Panel A) and male (Panel B). Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A15: Heterogeneity by Education

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**High School Dropout**			
Lowest Bidder	0.005		0.022**		0.026***	
	(0.008)		(0.009)		(0.010)	
Contract Winner		0.007		0.030**		0.035***
		(0.011)		(0.012)		(0.013)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	19,602	19,602	14,568	14,568	9,928	9,928
R-squared	0.582	0.034	0.596	0.037	0.589	0.024
Panel B						
Type of worker:			**High School**			
Lowest Bidder	0.013***		0.014**		0.022***	
	(0.005)		(0.006)		(0.007)	
Contract Winner		0.018***		0.018**		0.029***
		(0.007)		(0.008)		(0.009)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	82,484	82,484	63,418	63,418	43,992	43,992
R-squared	0.593	0.037	0.578	0.027	0.569	0.018
Panel C						
Type of worker:			**College**			
Lowest Bidder	0.027**		0.020*		0.013	
	(0.013)		(0.012)		(0.009)	
Contract Winner		0.036**		0.027*		0.017
		(0.018)		(0.016)		(0.012)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	23,588	23,588	18,208	18,208	12,488	12,488
R-squared	0.574	0.013	0.580	0.011	0.598	0.006

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. Panel A shows results for workers who have not completed high school. Panel B shows results for workers who completed high school, but not college. Panel C shows results for those who own a college degree. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A16: Heterogeneity by Occupation

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**Low Skill**			
Lowest Bidder	0.019***		0.023***		0.023***	
	(0.005)		(0.005)		(0.006)	
Contract Winner		0.025***		0.031***		0.030***
		(0.007)		(0.007)		(0.007)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	107,648	107,648	82,680	82,680	56,966	56,966
R-squared	0.577	0.029	0.573	0.022	0.572	0.012
Panel B						
Type of worker:			**High Skill**			
Lowest Bidder	0.030***		0.025**		0.017	
	(0.011)		(0.012)		(0.012)	
Contract Winner		0.042***		0.034**		0.023
		(0.015)		(0.017)		(0.016)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	26,596	26,596	21,210	21,210	15,324	15,324
R-squared	0.589	0.033	0.565	0.016	0.566	0.018
Panel C						
Type of worker:			**Management**			
Lowest Bidder	0.028		0.015		0.009	
	(0.017)		(0.017)		(0.018)	
Contract Winner		0.039		0.022		0.012
		(0.024)		(0.024)		(0.026)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	7,650	7,650	6,622	6,622	4,410	4,410
R-squared	0.713	0.064	0.689	0.065	0.684	0.059

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. Panel A shows results for low-skill workers. Panel B shows results for high-skill workers. Panel C shows results for managers. Low-skill workers are those employed in occupations that do not require high education. High-skill workers are those employed in occupations that require high education. Managers are workers in leadership positions. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A17: Heterogeneity by Tenure

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**Low Tenure**			
Lowest Bidder	0.019***		0.016***		0.020***	
	(0.007)		(0.005)		(0.006)	
Contract Winner		0.026***		0.021***		0.026***
		(0.009)		(0.007)		(0.007)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	77,816	77,816	62,102	62,102	46,406	46,406
R-squared	0.551	0.014	0.551	0.014	0.558	0.012
Panel B						
Type of worker:			**High Tenure**			
Lowest Bidder	0.020***		0.021***		0.026***	
	(0.005)		(0.006)		(0.006)	
Contract Winner		0.027***		0.028***		0.034***
		(0.007)		(0.008)		(0.008)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	86,826	86,826	64,868	64,868	41,404	41,404
R-squared	0.583	0.040	0.570	0.027	0.571	0.018

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. In Panel A, we consider only workers with tenure below the median within the firm. In Panel B, we consider only workers with tenure above the median within the firm. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A18: Heterogeneity by Wage

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+3}$
	RF	IV	RF	IV	RF	IV
Panel A						
Type of worker:			**Low wage workers**			
Lowest Bidder	0.015***		0.010**		0.018***	
	(0.005)		(0.005)		(0.005)	
Contract Winner		0.020***		0.014**		0.023***
		(0.007)		(0.007)		(0.006)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	62,630	62,630	49,028	49,028	34,406	34,406
R-squared	0.559	0.016	0.564	0.012	0.562	0.010
Panel B						
Type of worker:			**High wage workers**			
Lowest Bidder	0.023***		0.027***		0.026***	
	(0.006)		(0.006)		(0.007)	
Contract Winner		0.031***		0.036***		0.034***
		(0.008)		(0.008)		(0.009)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	107,648	107,648	82,690	82,690	56,972	56,972
R-squared	0.597	0.067	0.587	0.052	0.581	0.035

Notes: This table shows reduced-form and IV regressions of log of wages $j = \{1, 2, 3\}$ years after the auction on lowest bidder and contract winner. In Panel A, we consider only workers with wage below the median within the firm. In Panel B, we consider only workers with wage above the median within the firm. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A19: Worker Composition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A								
Dep Var	Female Share (t+1)	Avg age (t+1)	Avg Education (t+1)	Log(quality) (t+1)	Female share (t+2)	Avg age (t+2)	Avg Education (t+2)	Log(quality) (t+2)
Lowest Bidder	0.001	-0.466***	0.021	0.002	0.005	-0.469***	0.045**	0.012*
	(0.006)	(0.089)	(0.020)	(0.006)	(0.006)	(0.102)	(0.021)	(0.006)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107,674	107,674	107,674	107,674	82,716	82,716	82,716	82,716
R-squared	0.005	0.012	0.010	0.001	0.007	0.011	0.008	0.000
Panel B								
Dep Var	Female Share (t+3)	Avg age (t+3)	Avg Education (t+3)	Log(quality) (t+3)	Female share (t+4)	Avg age (t+4)	Avg Education (t+4)	Log(quality) (t+4)
Lowest Bidder	0.001	-0.396***	0.049**	0.018***	-0.003	-0.524***	0.025	0.014
	(0.007)	(0.107)	(0.025)	(0.007)	(0.009)	(0.116)	(0.024)	(0.009)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	56,990	56,990	56,990	56,990	33,646	33,646	33,646	33,646
R-squared	0.005	0.006	0.013	0.002	0.004	0.015	0.014	0.010

Notes: Regressions of firm outcomes on a dummy indicating whether the firm was the lowest bidder. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Outcomes are measured at one (Panel A, Columns 1-4), two (Panel A, Columns 5-8), three (Panel B, Columns 1-4) and four years (Panel A, Columns 5-8) years after the auction. Female share is the share of female workers in the firm. Average is calculated from a simple average of workers' age. Average education is calculated based on the level of education achieved of each worker. Log(quality) is the firm average of predicted values of a regression of log of wages on workers demographics (age, age square, dummies for education categories, ethnicity, and gender). Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A20: Worker Composition by Type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Female Share (t+1)	Avg age (t+1)	Avg Education (t+1)	Log(quality) (t+1)	Female share (t+3)	Avg age (t+3)	Avg Education (t+3)	Log(quality) (t+3)
Panel A								
Type of worker:				**Stayers**				
Lowest Bidder	-0.002	-0.596***	-0.004	-0.001	-0.020	-0.497*	0.005	0.007
	(0.009)	(0.158)	(0.0376)	(0.004)	(0.013)	(0.282)	(0.063)	(0.005)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	40,540	40,540	40,540	40,540	13,928	13,928	13,928	13,928
R-squared	0.553	0.526	0.550	0.524	0.543	0.524	0.517	0.528
Panel B								
Type of worker:				**New hires**				
Lowest Bidder	0.005	-0.309***	0.033*	-0.001	0.005	-0.214*	0.051**	0.005**
	(0.006)	(0.115)	(0.019)	(0.003)	(0.007)	(0.123)	(0.021)	(0.002)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	83,056	83,056	83,056	83,056	48,994	48,994	48,994	48,994
R-squared	0.533	0.520	0.541	0.525	0.552	0.523	0.548	0.526

Notes: This table shows content similar to Table A19 but split by worker type. Panel A shows results for stayers and Panel B shows results for New hires. Stayers are workers who were employed in the firm before and keep employed at the period for which the regression is run. New hires are workers who were admitted after the auction date. Regressions of firm outcomes on a dummy indicating whether the firm was the lowest bidder. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Outcomes are measured at one (Columns 1-4) and there (Columns 5-8) years after the auction. Female share is the share of female workers in the firm. Average is calculated from a simple average of workers' age. Average education is calculated based on the level of education achieved of each worker. Log(quality) is the firm average of predicted values of a regression of log of wages on workers demographics (age, age square, dummies for education categories, ethnicity, and gender). Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A21: Composition: Effects on Previous Wages

	(1)	(2)	(3)	(4)	(5)	(6)
	Stayers	Stayers	New hires	New hires	Separators	Separators
Dep Var	$\log(\text{w})_{t-1}$	$\log(\text{w})_{t-1}$	$\log(\text{w})_{t-1}$	$\log(\text{w})_{t-1}$	$\log(\text{w})_{t-1}$	$\log(\text{w})_{t-1}$
Lowest Bidder	0.009		0.017**		0.009**	
	(0.006)		(0.008)		(0.004)	
Contract Winner		0.012		0.024**		0.013**
		(0.008)		(0.010)		(0.006)
Auction FE	✓	✓	✓	✓	✓	✓
Observations	60,698	60,698	68,270	68,270	75,808	75,808
R-squared	0.585	0.018	0.564	0.017	0.592	0.018

Notes: This table shows reduced-form and IV regressions of worker's log wages prior to the auction on lowest bidder and contract winner. Columns (1) and (2) show results for stayers. Columns (3) and (4) show results for new hires. Columns (5) and (6) show results for separators. Stayers are workers who were employed in the firm before and keep employed at the period for which the regression is run. New hires are workers who were admitted after the auction date. Separators are workers who were employed in the firm before the auction but left the firm. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. All regressions include auction fixed effects. Columns (1), (3) and (5) are the reduced-form estimates. Columns (2), (4) and (6) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A22: Fixed-cohort
Robustness using Contractual Wage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	$\log(\text{w})_{t+1}$	$\log(\text{w})_{t+1}$	$\log(\text{w})_{t+2}$	$\log(\text{w})_{t+2}$	$\log(\text{w})_{t+3}$	$\log(\text{w})_{t+3}$	$\log(\text{w})_{t+4}$	$\log(\text{w})_{t+4}$
Lowest Bidder	0.020***		0.022***		0.018**		0.016*	
	(0.007)		(0.008)		(0.008)		(0.009)	
Contract Winner		0.027***		0.031***		0.025**		0.022*
		(0.009)		(0.011)		(0.011)		(0.013)
Auction FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	59,390	59,390	49,654	49,654	39,206	39,206	28,674	28,674
R-squared	0.539	0.011	0.523	0.008	0.532	0.018	0.529	0.011

Notes: This table shows reduced-form and IV regressions of log of contractual wages $j = \{1, 2, 3, 4\}$ years after the auction on lowest bidder and contract winner. Regressions include only lowest bidder and runner-up. Unit of observation is an auction-firm. Firm outcomes are measured using a fixed-cohort comprised of incumbent workers at the firm before the auction. the same workers are kept regardless of remaining or not in firm. All regressions include auction fixed effects. Columns (1), (3), (5) and (7) are the reduced-form estimates. Columns (2), (4), (6) and (8) present the IV results. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Standard errors clustered at the firm level are in parenthesis. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A23: Effects of Total Auction Revenue and Firm Size on Wages

	(1)	(2)	(3)	(4)
	Panel A. IV estimates			
Dep Var	$\log(\text{w})_{t+1}$	$\log(\text{w})_{t+2}$	$\log(\text{w})_{t+3}$	$\log(\text{w})_{t+4}$
log(Total Auction Revenue)	0.049***	0.058***	0.056***	0.094**
	(0.013)	(0.012)	(0.014)	(0.038)
log(n)	-0.002	-0.047	-0.116	-0.306
	(0.259)	(0.254)	(0.466)	(0.374)
	Panel B. First-stage estimates			
Dep Var	log(value)			
Lowest Bidder	0.373***	0.392***	0.409***	0.436***
	(0.032)	(0.038)	(0.050)	(0.075)
Lowest bidder x random t	0.002	0.002	0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.003)
Dep Var	$\log(\text{n})_{t+1}$	$\log(\text{n})_{t+2}$	$\log(\text{n})_{t+3}$	$\log(\text{n})_{t+4}$
Lowest Bidder	0.030**	0.025*	0.017	0.059***
	(0.013)	(0.015)	(0.015)	(0.017)
Lowest bidder x random t	-0.001*	-0.001*	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓
Observations	107674	82716	56990	33646

Notes: IV Regressions of log of contractual wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n). Log(Total Auction Revenue) is the logarithm of the total revenue obtained from winning procurement auctions in the auction year. Log(Total Auction Revenue) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A24: Effects of Contract Value and Firm Size on Wages
(Robustness using Contractual Wages)

	(1)	(2)	(3)	(4)
	Panel A. IV estimates			
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
log(value)	0.004***	0.005***	0.005***	0.009*
	(0.001)	(0.001)	(0.001)	(0.005)
log(n)	-0.224	-0.466	-0.186	-0.587
	(0.355)	(0.402)	(0.525)	(0.706)
	Panel B. First-stage estimates			
Dep Var	log(value)			
Lowest Bidder	5.988***	6.047***	6.047***	6.001***
	(0.067)	(0.072)	(0.082)	(0.101)
Lowest Bidder x random t	-0.019***	-0.019***	-0.018***	-0.016***
	(0.003)	(0.003)	(0.004)	(0.005)
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest Bidder	0.030**	0.023	0.018	0.055***
	(0.013)	(0.015)	(0.015)	(0.017)
Lowest Bidder x random t	-0.001*	-0.001*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓
Observations	107914	83188	57424	33914

Notes: IV Regressions of log of contractual wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n). Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A25: Effects of Contract Value and Firm Size on Wages by Occupation

	Low Skill				High Skill			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. IV estimates							
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
log(value)	0.004**	0.004***	0.002	0.007**	0.006**	0.041	0.008	0.053
	(0.002)	(0.001)	(0.028)	(0.003)	(0.002)	(0.164)	(0.013)	(0.295)
log(n)	-0.703	-0.551	-6.357	-0.531	-0.348	-7.447	-1.495	-7.689
	(1.062)	(0.658)	(85.128)	(0.563)	(0.855)	(33.430)	(3.493)	(46.685)
	Panel B. First-stage estimates							
Dep Var	log(value)							
Lowest Bidder	5.986***	6.036***	6.041***	6.003***	5.899***	5.915***	5.770***	5.799***
	(0.067)	(0.072)	(0.082)	(0.101)	(0.118)	(0.125)	(0.148)	(0.177)
Lowest bidder x	-0.020***	-0.019***	-0.018***	-0.017***	-0.021***	-0.020***	-0.014*	-0.024***
random t	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)	(0.008)	(0.009)
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest Bidder	0.012	0.006	-0.001	0.039***	0.026	0.031*	0.027	0.038**
	(0.009)	(0.010)	(0.011)	(0.012)	(0.017)	(0.018)	(0.017)	(0.018)
Lowest bidder x	-0.000	-0.001	-0.000	-0.001*	-0.001	-0.000	-0.000	-0.000
random t	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	107648	82680	56966	33584	26596	21210	15324	9864

Notes: IV regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n) by workers' occupations. Low-skill workers are those employed in occupations that do not require high education. High-skill workers are those employed in occupations that require high education. Firm size is measured by the number of workers in that category. Columns (1) to (4) report results for low-skill workers. Columns (5) to (8) report results for high-skill workers. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A26: Effects of Contract Value and Firm Size on Wages by Education

	High School Dropout				High School				College			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A. IV estimates											
Dep Var	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$
log(value)	-0.000	0.004**	0.004	0.028	0.083	0.002	0.003	0.004**	0.004	0.012	-0.011	-0.002
	(0.004)	(0.002)	(0.002)	(0.142)	(8.111)	(0.002)	(0.002)	(0.002)	(0.007)	(0.028)	(0.040)	(0.011)
log(n)	-1.311	-0.067	-0.252	5.087	-78.898	-0.558	-0.440	-0.222	0.267	-1.602	2.899	0.758
	(2.962)	(0.261)	(0.826)	(32.020)	(7961.218)	(1.005)	(0.913)	(0.282)	(2.252)	(5.118)	(8.948)	(1.594)
	Panel B. First-stage estimates											
Dep Var	log(value)											
Lowest bidder	6.312***	6.456***	6.149***	6.401***	6.018***	6.052***	6.031***	6.006***	5.899***	5.956***	5.949***	5.908***
	(0.145)	(0.159)	(0.171)	(0.196)	(0.072)	(0.080)	(0.093)	(0.110)	(0.118)	(0.126)	(0.159)	(0.192)
Lowest bidder x	-0.023***	-0.029***	-0.017**	-0.027***	-0.024***	-0.022***	-0.017***	-0.019***	-0.018***	-0.022***	-0.025***	-0.018*
random t	(0.007)	(0.008)	(0.009)	(0.010)	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)	(0.007)	(0.008)	(0.009)
Dep Var	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest bidder	-0.000	0.033*	-0.000	-0.025	0.006	0.001	-0.002	0.032**	0.023	0.035**	0.022	0.048**
	(0.017)	(0.018)	(0.020)	(0.027)	(0.010)	(0.011)	(0.014)	(0.014)	(0.017)	(0.016)	(0.017)	(0.020)
Lowest bidder x	-0.000	-0.002**	-0.001	-0.000	-0.000	-0.000	-0.001	-0.002**	-0.000	-0.000	0.000	-0.001
random t	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	19602	14568	9928	6442	82484	63418	43992	26492	23588	18208	12488	8386

Notes: IV regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n) by workers' education. Columns (1) to (4) show results for workers who have not completed high school. Columns (5) to (8) show results for workers who completed high school, but not college. Columns (9) to (12) show results for those who own a college degree. Firm size is measured by the number of workers in that category. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A27: Heterogeneity by Enforcement of Labor Legislation

	High Enforcement				Low Enforcement			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Reduced form estimates							
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
Lowest Bidder	0.026***	0.031***	0.022***	0.029***	0.013*	0.023***	0.020**	0.016
	(0.008)	(0.008)	(0.008)	(0.010)	(0.008)	(0.007)	(0.009)	(0.012)
	Panel B. IV estimates							
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
Contract Winner	0.037***	0.042***	0.030***	0.038***	0.017*	0.029***	0.026**	0.021
	(0.011)	(0.011)	(0.011)	(0.012)	(0.009)	(0.009)	(0.011)	(0.015)
	Panel C. First-stage estimates							
Dep Var	Contract Winner							
Lowest Bidder	0.716***	0.731***	0.741***	0.755***	0.795***	0.780***	0.793***	0.789***
	(0.009)	(0.009)	(0.010)	(0.012)	(0.016)	(0.019)	(0.016)	(0.019)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	46910	36570	24972	14862	18936	14016	9590	5572

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by levels of labor regulation enforcement. Columns (1) to (4) report results for firms with higher enforcement, located in municipalities for which distance to the closest labor office is below the median. Columns (5) to (8) report results for firms with lower enforcement, located in municipalities for which distance to the closest labor office is above the median. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A28: Effects of Contract Value and Firm Size on Wages
by Enforcement of Labor Legislation

	High Enforcement				Low Enforcement			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. IV estimates							
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
log(value)	0.004***	0.005***	0.004***	0.009	-0.000	0.004	0.004	0.005
	(0.002)	(0.001)	(0.002)	(0.006)	(0.008)	(0.003)	(0.005)	(0.009)
log(n)	0.038	0.025	-0.136	-0.662	1.511	-1.227	-0.583	-0.683
	(0.200)	(0.161)	(0.403)	(0.924)	(4.502)	(2.143)	(2.603)	(2.575)
	Panel B. First-stage estimates							
Dep Var	log(value)							
Lowest Bidder	5.840***	5.931***	5.933***	5.943***	6.316***	6.373***	6.378***	6.314***
	(0.100)	(0.105)	(0.120)	(0.144)	(0.131)	(0.142)	(0.160)	(0.205)
Lowest bidder x	-0.013***	-0.011**	-0.010*	-0.010	-0.025***	-0.032***	-0.029***	-0.033***
random t	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)	(0.011)
Dep Var	log(n)$_{t+1}$	log(n)$_{t+2}$	log(n)$_{t+3}$	log(n)$_{t+4}$	log(n)$_{t+1}$	log(n)$_{t+2}$	log(n)$_{t+3}$	log(n)$_{t+4}$
Lowest Bidder	0.056**	0.065**	0.033	0.054**	0.005	0.012	0.018	0.030
	(0.024)	(0.027)	(0.026)	(0.026)	(0.018)	(0.021)	(0.026)	(0.035)
Lowest bidder x	-0.002**	-0.003**	-0.002	-0.001	0.000	-0.001	-0.001	-0.001
random t	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	46910	36570	24972	14862	18936	14016	9590	5572

Notes: IV regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n) by levels of labor regulation enforcement. Columns (1) to (4) report results for firms with high enforcement (low informality), located in municipalities for which distance to the closest labor office is below the median. Columns (5) to (8) report results for firms with low enforcement (high informality), located in municipalities for which distance to the closest labor office is above the median. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A29: Results - Heterogeneity by Payroll Share

	Top 10% Payroll Share			
	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
Lowest Bidder	0.007	0.048**	0.047*	0.024
	(0.017)	(0.021)	(0.026)	(0.029)
	Panel B. IV estimates			
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
Contract Winner	0.009	0.065**	0.064*	0.032
	(0.022)	(0.029)	(0.035)	(0.039)
	Panel C. First-stage estimates			
Dep Var	Contract Winner			
Lowest Bidder	0.755***	0.732***	0.737***	0.743***
	(0.024)	(0.032)	(0.037)	(0.041)
Auction FEs	✓	✓	✓	✓
Average Payroll share	55%	55%	55%	55%
Observations	1700	1266	824	682

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by firm level payroll share. Payroll share is measured with respective to the local labor market. Local labor market is the combination of municipality and five-digit industry. Results in this table refer to firms with payroll share at the top 10% of the payroll share distribution. Unit of observation is an auction-firm. Regressions are run separately for each j. *Contract winner* is a dummy taking value 1 if the firm won the auction contract or 0 if the firm did not. Winning the contract is instrumented by a dummy taking value 1 if the firm was the lowest bidder and 0 if the firm was the runner-up. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A30: Effects of Contract Value and Firm Size on Wages
by Payroll Share

	Top 10% Payroll Share			
	(1)	(2)	(3)	(4)
	Panel A. IV estimates			
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
log(value)	-0.007	-0.116	0.014**	0.009
	(0.043)	(17.541)	(0.006)	(0.006)
log(n)	3.464	-33.400	-0.391	-0.227
	(15.463)	(4617.885)	(0.556)	(0.325)
	Panel B. First-stage estimates			
Dep Var	log(value)			
Lowest Bidder	6.076***	6.302***	6.302***	6.426***
	(0.399)	(0.511)	(0.667)	(0.756)
Lowest bidder x	-0.055***	-0.073***	-0.082**	-0.100***
random t	(0.021)	(0.025)	(0.032)	(0.034)
Dep Var	log(n)$_{t+1}$	log(n)$_{t+2}$	log(n)$_{t+3}$	log(n)$_{t+4}$
Lowest Bidder	0.023	-0.024	-0.053	-0.104
	(0.040)	(0.065)	(0.114)	(0.154)
Lowest bidder x	-0.001	0.000	0.006	0.010
random t	(0.002)	(0.004)	(0.006)	(0.007)
Auction FEs	✓	✓	✓	✓
Average Payroll share	55%	55%	55%	55%
Observations	1700	1266	824	682

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on log(contract value) and log(n) by firm level payroll share. Payroll share is measured with respective to the local labor market. Local labor market is the combination of municipality and five-digit industry. Results in this table refer to firms with payroll share at the top 10% of the payroll share distribution. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A31: Effects of Contract Value and Firm Size on Wages by Participation in Previous Firm- or Industry-Level Collective Bargaining Agreement

	CBA: Yes				CBA: No			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. IV estimates							
Dep Var	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$	log(w)$_{t+1}$	log(w)$_{t+2}$	log(w)$_{t+3}$	log(w)$_{t+4}$
log(value)	0.014	0.007*	0.010	0.012**	0.004*	0.003***	0.003***	0.006**
	(0.042)	(0.004)	(0.007)	(0.005)	(0.002)	(0.001)	(0.001)	(0.003)
log(n)	-1.502	-0.296	0.478	-0.276	-0.658	-0.210	0.116	-0.393
	(8.094)	(0.877)	(1.260)	(1.050)	(0.762)	(0.473)	(1.054)	(0.470)
	Panel B. First-stage estimates							
Dep Var	log(value)							
Lowest Bidder	5.656***	6.000***	5.817***	5.756***	6.007***	6.056***	6.101***	6.146***
	(0.201)	(0.202)	(0.232)	(0.328)	(0.080)	(0.089)	(0.103)	(0.127)
Lowest bidder x	-0.010	-0.026**	-0.020	-0.019	-0.019***	-0.018***	-0.018***	-0.017***
random t	(0.011)	(0.012)	(0.014)	(0.018)	(0.004)	(0.004)	(0.005)	(0.007)
Dep Var	log(n)$_{t+1}$	log(n)$_{t+2}$	log(n)$_{t+3}$	log(n)$_{t+4}$	log(n)$_{t+1}$	log(n)$_{t+2}$	log(n)$_{t+3}$	log(n)$_{t+4}$
Lowest Bidder	0.024	-0.008	-0.050	0.035	0.023*	0.007	0.006	0.052**
	(0.035)	(0.045)	(0.056)	(0.063)	(0.012)	(0.015)	(0.018)	(0.023)
Lowest bidder x	0.000	0.001	0.001	-0.002	-0.001	-0.001	-0.000	-0.002
random t	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
Observations	6334	4964	3590	2254	65450	49856	33794	19762

Notes: IV Regressions of log of wages $j = \{1, 2, 3, 4\}$ years after the auction on contract winner by participation in any (firm- or industry-level) collective bargaining agreement (CBA) in the year before the auction. Columns (1) to (4) report results for firms that were part of a CBA in the previous year. Columns (5) to (8) report results for firms that were not part of any CBA. Unit of observation is an auction-firm. Log(value) is the logarithm of the auction contract value obtained by the winner. We set the variable to be equal to 0 for non-winners. Log(value) and log(n) are instrumented by a dummy indicating the lowest bidder and an interaction between this dummy and the (random) duration of the auction. Regressions only include lowest bidder and runner-up firms of close auctions. All regressions include auction fixed effects. Standard errors are clustered at the firm level. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Appendix D Bias associated to using contract value

Our model delivers equation

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(pq)_{it} + \upsilon_{it}. \tag{23}$$

In our data we only observe contract value, $log(value)_{it}$. To see how our results change by using $value_{it}$ instead of revenue pq_{it}, note that the equation above can be rewritten as

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(pq\frac{value}{value})_{it} + \upsilon_{it}, \tag{24}$$

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(value)_{it} - \gamma_2 log(\frac{value}{pq})_{it} + \upsilon_{it}. \tag{25}$$

Our estimating equation

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(value)_{it} + \epsilon_{it} \tag{26}$$

corresponds to having

$$\epsilon_{it} = -\gamma_2 log(\frac{value}{pq})_{it} + \upsilon_{it} \tag{27}$$

as our error term. As a result, the estimate of γ_2 suffers from an omitted variable, and therefore could be biased. Nevertheless, our estimating equation still allows us to test for pure wage posting against the presence of bargaining for two reasons. First, under no bargaining $\gamma_2 = 0$. In this case, the omitted variable is also zero, and $\epsilon_{it} = \upsilon_{it}$. Therefore:

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \epsilon_{it}. \tag{28}$$

In other words, classical wage posting implies that $\gamma_2 = 0$ and γ_1 is estimated consistently. Therefore, an estimate of γ_2 statistically different than zero implies the rejection of pure classical wage posting alone, and is indicative of wage bargaining.

Second, we can derive this bias. In particular, our estimate $\hat{\gamma_2}$ is such that:

$$\begin{aligned} plim\ \hat{\gamma_2} = \gamma_2 + Bias = \gamma_2 + \frac{COV(log(value)_{it}, -\gamma_2 log(\frac{value}{pq})_{it})}{Var(log(value)_{it})} \\ = \gamma_2 + \frac{COV(log(value)_{it}, -\gamma_2 log(value)_{it} + \gamma_2 log(pq)_{it})}{Var(log(value)_{it})} \\ = \gamma_2 - \frac{\gamma_2 Var(log(value)_{it})}{Var(log(value)_{it})} + \frac{\gamma_2 COV(log(value)_{it}, log(pq)_{it})}{Var(log(pq)_{it})} \\ = \frac{\gamma_2 COV(log(value)_{it}, log(pq)_{it})}{Var(log(pq)_{it})} = \gamma_2 CORR[log(value)_{it}, log(pq)_{it})] \leq \gamma_2 \end{aligned} \tag{29}$$

where COV stands for covariance and CORR for correlation.

Finally, note that under the assumption that winning a larger government contract leads to larger total revenue, $0 \leq CORR[log(value)_{it}, log(pq)_{it})] \leq 1$, our estimate is biased towards zero (attenuation bias), but still has the same sign as γ_2.

Appendix E Derivation of bargained wage

From the bargaining problem we obtain,

$$w_{i,j}^{bg} + \beta \frac{\partial w_{i,j}^{bg}}{\partial n} n = \beta p z \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}). \tag{30}$$

Now rewrite the expression characterizing w^{bg} as

$$\frac{w^{bg}}{\beta n} + \frac{\partial w}{\partial n} = \frac{\alpha p z n^{\alpha-1}}{n} + \frac{(1-\beta)b}{\beta n} - \frac{(1-\beta)(a+\epsilon)}{\beta n} \tag{31}$$

Multiplying both sides by $n^{\frac{1}{\beta}}$ and integrating over n gives

$$w n^{\frac{1}{\beta}} = \frac{\alpha p z \beta n^{\frac{1-\beta(1-\alpha)}{\beta}}}{1-\beta(1-\alpha)} + n^{\frac{1}{\beta}}(1-\beta)b - n^{\frac{1}{\beta}}(1-\beta)(a+\epsilon). \tag{32}$$

Rearranging we get

$$w = \frac{\beta \alpha p z n^{\alpha-1}}{1-\beta(1-\alpha)} + (1-\beta)b - (1-\beta)(a+\epsilon) = \tilde{\beta} p \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a+\epsilon) \tag{33}$$

where $\tilde{\beta} \equiv \frac{\beta}{1-\beta(1-\alpha)}$. To summarize,

$$w_{i,j} = w_{i,j}^{bg} = \tilde{\beta} p \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}) \quad \text{if} \quad w_{i,j}^{bg} > w_j^p \tag{34}$$

$$w_{i,j} = w_j^p \quad \text{if} \quad w_{i,j}^{bg} \leq w_j^p. \tag{35}$$

Appendix F Explicit Expression for $E[w|w_j^p, a_j, \epsilon_{i,j}]$

Using the expression for w^{bg}, we note that w^{bg} is increasing in p, while w^p is not. As a result, there exists a $\underline{p}$ such that $w^{bg}(\underline{p}) = w^p$. Then,

$$E[w|w_j^p, a_j, \epsilon_{i,j}] = \int_{\underline{p}} w^{bg} m(p) dp + \int^{\underline{p}} w^p m(p) dp \tag{36}$$

Now replacing w^{bg} by its expression we get

$$E[w|w_j^p, a_j, \epsilon_{i,j}] = \frac{\beta\alpha y}{n}\int_{\underline{p}} pm(p)dp + (1-\beta)(b-(a+\epsilon))(1-M(\underline{p})) + w_j^p M(\underline{p}) \quad (37)$$

where M is the CDF associated to m,

$$\underline{p} = (\frac{w^p + (1-\beta)(a+\epsilon-b)}{\beta\alpha y})n, \quad (38)$$

and

$$n = y^{\frac{1}{\alpha}}. \quad (39)$$

For the expression of n, we have used the fact that

$$y = f(n) = n^{\alpha}. \quad (40)$$

Appendix G Deriving the linear expression for wages

Define $\hat{\epsilon}_{i,j}$ as the ϵ such that $w^{gb} = w^p$. Then we can show that

$$\hat{\epsilon} = \frac{\tilde{\beta}\alpha p y}{(1-\beta)n} + b - \frac{w^p}{1-\beta} - a_j$$

In particular,

- $w^{bg} > w^p \iff \epsilon < \hat{\epsilon}$
- $w^{bg} < w^p \iff \epsilon > \hat{\epsilon}$.

Finally to find the wage posted by the firm note that

$$y = f(n) \Rightarrow y = n^{\alpha} \Rightarrow \hat{n} = y^{\frac{1}{\alpha}}$$

Let $\overline{w}(n)$ represent the function giving the required wage to hire at least n employees. In order to minimize cost, the firm will post the lowest wage sufficient to have n employees which is given by $w^p = \overline{w}(\hat{n})$.

Next, let $H(w^p)$ be the share of workers in firm j that receive wage w_j^p. Then,

$$H(w^p) \equiv Prob(w_j^p \geq w_{i,j}^{bg}) = (1 - G(\frac{\tilde{\beta}\alpha p y}{(1-\beta)n} + b - a_j - \frac{w_j^p}{1-\beta})) \quad (41)$$

From this expression we conclude that

$$\frac{\partial H(w^p)}{\partial w^p} > 0 \quad \text{and} \quad \frac{\partial H(w^p)}{\partial p} < 0.$$

The average wage in a firm is then given by

$$E_j[w] = Hw_j^p + \int^{\hat{\epsilon}(w^p)} w_{i,j}^{bg}(a_j, \epsilon) g(\epsilon) d\epsilon.$$

Next, replace w^{bg} by its expression inside $E_j[w]$ which gives

$$\begin{aligned} E_j[w] = Hw^p + \tilde{\beta}\frac{py}{n} \int^{\hat{\epsilon}(w^p)} g(\epsilon)d\epsilon + (1-\beta)b \int^{\hat{\epsilon}(w^p)} g(\epsilon)d\epsilon \\ - (1-\beta)a_j \int^{\hat{\epsilon}(w^p)} g(\epsilon)d\epsilon - (1-\beta) \int^{\hat{\epsilon}(w^p)} \epsilon g(\epsilon)d\epsilon \end{aligned} \tag{42}$$

Next, use a first order Taylor approximation to approximate $log(E_j[w])$ as a function of a_j, py, n and w^p around the respective points $[a^* = 1, p^*y^* = p^* = 1, n^*, w^{*,p} = w^* = w^{bg}(a^*, p^*, n^*, \epsilon = 0) = \tilde{\beta}\alpha\frac{p^*}{n^*} + (1-\beta)b - (1-\beta)]$. This gives us

$$\begin{aligned} log(E[w]_j) = \zeta_0 + H(w^*)w^*log(w^p)_j + \frac{\tilde{\beta}\alpha}{n^*}G(\hat{\epsilon}(w^*))p^*log(py) \\ - \frac{\tilde{\beta}\alpha p^*}{(n^*)^2}G(\hat{\epsilon}(w^*))n^*log(n) - (1-\beta)G(\hat{\epsilon}(w^*))log(a_j) \end{aligned} \tag{43}$$

In other words,

$$log(E[w]_j) = \zeta_0 + \zeta_1 log(w^p) + \zeta_2 log(py) + \zeta_3 log(n) + \zeta_4 log(a)_j \tag{44}$$

where

$$\zeta_1 = w^*H(w^*) = w^*(1 - G(\frac{\tilde{\beta}\alpha p^*}{(1-\beta)n^*} + b - a^* - \frac{w^*}{1-\beta})). \tag{45}$$

$$\zeta_2 = \frac{\tilde{\beta}\alpha p^*}{n^*}G(\hat{\epsilon}(w^*)) > 0. \tag{46}$$

and

$$\zeta_3 = -\frac{\tilde{\beta}\alpha p^* n^*}{(n^*)^2}G(\hat{\epsilon}(w^*)) < 0. \tag{47}$$

Next, take a first order Taylor approximation to write the $log(n(w^p))$ as a function of a_j and w^p around the respective points $[n^*, a^* = 1, w^*]$. Note that because the model is static, the posted wage w^p will be chosen to achieve exactly a firm size of $\hat{n}$ where $\hat{n}$ is determined by $y = f(\hat{n})$. As a result, since y is taken as given by the firm, n is directly pinned down, which in turn pins down w^p. Using the expression for $n(w^p)$ and taking log on both sides gives us

$$\begin{aligned} log(n(w^p))_j &= log(Prob(w^E(w_j^p, a_j, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a_j)) \\ &\equiv log(P(\text{choose firm } j | w_j^p, a_j)). \end{aligned} \tag{48}$$

Applying the first order Taylor approximation gives us

$$\begin{aligned} log(n(w^p)) = C &+ \frac{\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*}}{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)} w^* log(w^p) \\ &+ \frac{\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial a}|_{a = a^*}}{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)} a^* log(a)_j \end{aligned} \tag{49}$$

where C is a constant.

Rearranging gives

$$\begin{aligned} log(w^p) = &- \frac{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{(\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*} w^*)} C \\ &+ \frac{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{(\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*} w^*)} log(n) \\ &- \frac{\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial a}|_{a = a^*}}{(\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*} w^*)} a^* log(a)_j \end{aligned} \tag{50}$$

In other words,

$$log(w^p) = \xi_0 + \xi_1 log(n) + \xi_2 log(a) \tag{51}$$

where

$$\xi_1 = \frac{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{(\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*} w^*)} > 0. \tag{52}$$

Note that $\frac{\partial w^E(w_j^p, a_j, \epsilon_{i,j})}{\partial w_j^p} > 0$ which implies $\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p} > 0$, and, as a consequence, $\xi_1 > 0$.

Now replacing the expression for $log(w^p)$ inside the expression for $log(E[w]_j)$ we get

$$log(E[w]_j) = \zeta_0 + \zeta_1 \xi_0 + \zeta_2 log(py) + (\zeta_3 + \zeta_1 \xi_1) log(n) + (\zeta_4 + \zeta_1 \xi_2) log(a)_j \tag{53}$$

where

$$\zeta_2 = \frac{\tilde{\beta}\alpha p^*}{n^*} G(\hat{\epsilon}(w^*)) > 0 \tag{54}$$

and

$$\zeta_3 + \zeta_1 \xi_1 = -\frac{\tilde{\beta}\alpha p^* n^*}{(n^*)^2} G(\hat{\epsilon}(w^*)) + w^*[1 - G(\frac{\tilde{\beta}\alpha p^*}{(1-\beta)n^*} + b - a^* - \frac{w^*}{1-\beta})]\xi_1 \tag{55}$$

where

$$\xi_1 = \frac{Prob(w^E(w^*, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{(\frac{\partial Prob(w^E(w_j^p, a^*, \epsilon_{i,j}) - \Lambda_{i,j} + \epsilon_{i,j} \geq -a^*)}{\partial w^p}|_{w^p = w^*} w^*)}. \tag{56}$$

Note that the sign of $\zeta_3 + \zeta_1 \xi_1$ is ambiguous given that $\xi_1 > 0$, $\zeta_1 > 0$ and $\zeta_3 < 0$.

Appendix H Proof of Proposition 1

Next, let us derive the equations for the wage posting and wage bargaining only cases. We consider the wage posting only case as being equivalent to workers having zero bargaining power $\beta = 0$. Note that $\beta = 0 \Rightarrow \tilde{\beta} = 0 \Rightarrow \zeta_2 = 0, \zeta_3 = 0$. Note that in this case, the bargained wage corresponds to

$$w^{bg} = b - (a_j + \epsilon_{i,j}) \tag{57}$$

which corresponds to the lowest possible wage the worker needs to get to be willing to work for the firm (reservation wage). The wage posted will always be equal or higher than that for a given worker. As a result, in this case, all workers are paid the posted wage, $H(w^p) = 1$, such that

$$E_j[w] = w_j^p \tag{58}$$

and so

$$log(E_j[w]) = log(w^p) = \xi_0 + \xi_1 log(n) + \xi_2 log(a). \tag{59}$$

If, on the other hand, all individuals valued a same firm equally, $\epsilon_{i,j} = \epsilon_j, \forall i$, then, either all workers accept to work for that firm or all workers do not. In that case, for each firm j there exists a wage value that makes all workers indifferent between working or not for that firm. Call this w_j. Since at w_j workers must be indifferent between working or not, then,

$$w_j = b - (a_j - \epsilon_j). \tag{60}$$

As a result, at the posting stage, each firm j can hire exactly their required labor $\hat{n}_j$

given by $f(\hat{n}_j) = y_j$ at rate w_j. As a result, the wage posted becomes of the form

$$log(w^p)_j = w_j = b - (a + \epsilon_j). \tag{61}$$

Upon being hired individuals bargain with the firm and receive wage

$$w^{bg} = \frac{\tilde{\beta} py}{n} + (1-\beta)(b - (a_j + \epsilon_j)) = \frac{\tilde{\beta} py}{n} + (1-\beta) w_j > w_j \tag{62}$$

for all $\beta > 0$. The inequality follows from the fact that $\tilde{\beta} > \beta$ and it will only be profitable for the firm to hire a worker if what they produce $pn^{\alpha-1} = \frac{py}{n}$ is larger than the reservation wage of the worker w_j. It follows that for all non-trivial cases, $\frac{py}{n} > w_j$. As a result, in this limit case, all workers are paid the wage equal to

$$w^{bg} = \frac{\tilde{\beta} py}{n} + (1-\beta)(b - (a_j + \epsilon_j)). \tag{63}$$

Note that having all workers receive the bargained wage and not the posted wage corresponds to the limit where $\hat{\epsilon} \to \infty$ which implies $G(\hat{\epsilon}) \to 1, \forall w$ (which corresponds to $H(w^p) = 0$). The average wage in a firm is then given by

$$E_j[w] = \int w^{bg}_{i,j}(a_j, \epsilon) g(\epsilon) d\epsilon = \frac{\tilde{\beta} py}{n} + (1-\beta)(b - a_j) - (1-\beta) \int \epsilon g(\epsilon) d\epsilon.$$

Next, we take logs of both sides and consider a first order Taylor approximation of $E_j[w]$ as a function of a_j, py, n around the point $[a^* = 1, p^* y^* = p^* = 1, n^*]$ which gives us

$$log(w) = \tilde{\zeta}_0 + \frac{\tilde{\beta} \alpha p^*}{n^*} log(py) - \frac{\tilde{\beta} \alpha p^*}{(n^*)^2} n^* log(n) - (1-\beta) log(a) \tag{64}$$

which corresponds to our wage equation for the "only bargaining" case since that corresponds also to having $G(\hat{\epsilon}) = 1$.

Appendix I Back of the Envelope Calculation

In this Section, we go over the details of our back of the envelope calculation for how to obtain by how much one additional Brazilian real (R$) in value added per worker changes wages. Unfortunately, we do not have firm-level information on profits, revenues or valued added. Therefore, we rely on aggregate value added and total revenue numbers provided by the Brazilian statistical agency (IBGE). In particular, we use statistics compiled precisely for the sectors covered in our sample.

We start by estimating the following equation

$$w_{iat} = \alpha_0 + \alpha_1 \frac{\text{value}_{ia}}{n} + \delta' X_{ia} + \mu_a + \epsilon_{it} \tag{65}$$

where w_{iat} is the wage level for firm i at period t that participated in auction a, $\frac{\text{value}_{ia}}{n}$ is the contract value for firms that won the contract and 0 for runners-up divided by number of workers at period t, and μ_a are auction fixed effects. We use *Lowest bidder*, a dummy with value equal to 1 if the firm bid the lowest value at the (random) end of the auction and equal to 0 for runners-up, as the instrument for value$_{ia}$.

Then, α_1 gives us by how much does the wage change if we increase firm revenue by one additional Brazilian real (R$). Next, we divide α_1 by the ratio of total value added to total revenue, to get by how much one additional real (R$) of value added increases wages, which gives us the 4 cents of real reported in the body of the paper.

Finally, using total value added and wage bill, we transform this number into an elasticity. This exercise delivers an elasticity of 0.1. This elasticity is within the values documented by studies using firm-level profit measures and individual-specific wages reviewed by Card et al. (2018). In particular, our estimate is above the 0.073 found by Card et al. (2014), just above the 0.09 found by Bagger et al. (2014), and below the 0.156 found by Card et al. (2016). Our back of the envelope estimate is smaller than the ones found by Kline et al. (2019) and Van Reenen (1996). A plausible explanation for why they find stronger elasticities is their focus on innovative firms (Kline et al., 2019). Finally, our back of the envelope estimate is close to the lower point in the range of 0.12-0.25 found by Garin and Silvério (2023). While, they look at the elasticity of wages to total sales or total value added, our back of the envelope calculation is for wages to value added per worker.