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

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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 direct evidence of bargaining.

JEL classification: J01, J23, J30

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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, 2018; Kroft et al., 2020; Amodio and de Roux, 2021), 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; 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 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 (Burdett and Mortensen, 1998; Manning, 2011; Card et al., 2018; Berger et al., 2022). Under posting, an increase in firm-specific demand leads the firm to increase wages to attract more workers. As a consequence, under posting, 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, and under posting, where gaps arise from different sorting into firms. For instance, there is recent evidence that the gender wage gap increases when workers are allowed to bargain their wages, driven partly by women not engaging in negotiations (Biasi and Sarsons, 2022).

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 (Kline et al., 2019; Kroft et al., 2020; Amodio and de Roux, 2021). 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 the 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 runner-ups 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.[1] 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 stronger among young firms, with a wage increase of 2.7%. Moreover, 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 investigate whether winning a contract leads to compositional changes (according to their gender, age, education, past wages, etc). On the one hand, the shock itself could affect composition directly. For instance, winning an auction could make the firm hire more skilled workers, or change their separation rate disproportionately. On the other hand, under non-competitive markets, as firms raise wages, we expect them to potentially attract better workers. Our results indicate that, following the shock, the composition of new hires improves but the composition of stayers remains unchanged (i.e, the contract does not cause the winning firm to retain a different profile of workers). Importantly, the wage effects are robust when we restrict our sample to all employees who were working in the firm before the auction regardless of whether they stayed or not (therefore, keeping composition constant).

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.

We provide further evidence on potential mechanisms associated to wage posting

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

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).[2] 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, dynamic models of wage posting with recruitment frictions predict that higher wages decrease worker separation rates (Kline et al., 2019; Burdett and Mortensen, 1998; Postel-Vinay and Robin, 2002). Despite a response of wages to higher firm demand, we find no effect on separation rates. Finally, using data on collective bargaining agreements, we find larger wage responses in firms that had a collective bargaining agreement prior to the auction.

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, 2018; Kroft et al., 2020; Amodio and de Roux, 2021), 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 demand shocks (Garin and Silvério, 2018). 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)

[2]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.

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 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.

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. Finally, Section 6 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.

To build this 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 (Appendix Figure A2). The query returns a page (Appendix 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 (Appendix 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 (Appendix 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 (Appendix 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 (Appendix 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.[3] 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 Appendix Table A1 for a breakdown).

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).

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

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

comparing auction winners and losers raises several concerns. These firms are likely different in their production function, size, and worker composition, any 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).

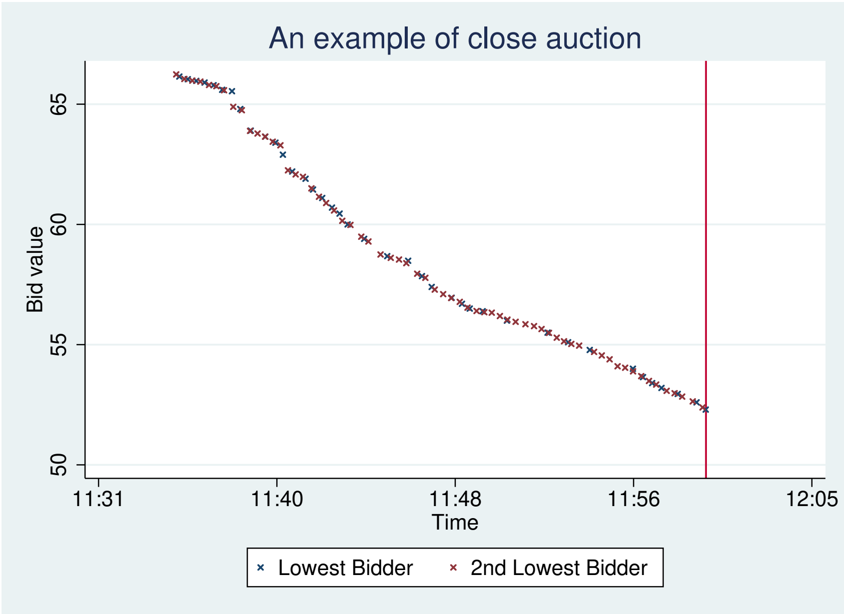
We use the time and value of each bid for all auctions and firms in our full data set to formulate our empirical definition of close auctions. We define these as auctions having at least two bids in the last 30 seconds and with a difference between bid values of at most 0.5%. After defining these auctions, 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 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 time-consuming insertion of the bid and the randomness of the auction end.[4] When the auction reaches the random phase, participants are not able to anticipate when it is

[4]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.

Figure 1: Example of close auction



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.

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

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. We obtain similar results when looking at outcomes measured one quarter before the auction (see Appendix Table A6). These patterns reinforce the intuition that winner and runner-up are as good as randomly assigned in our 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	1186	1194	7
	(692)	(746)	(8)
Contractual Wage	1139	1148	9
	(618)	(618)	(7)
Employees	14.2	13.3	-0.9
	(163.1)	(132.3)	(0.9)
Firm age	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.

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:

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

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.[5]

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:

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

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

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

[5]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.

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 A7 and A8)

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[6]) 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 A9 and A10).

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.

We also verify that winning firms grow relative to the runner-up. 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 A11). The effect is present for both young and old firms (see Appendix Table A12). We investigate also if winners are more likely to be present in RAIS (ie, have at least one employee) after the

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

auction: we find a small, but statistically significant effect (see Appendix Table A13). 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).

Next, we use our variation to perform a back of the envelope calculation for 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. 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. Using this information, we perform a back of the envelope calculation that tells us that one additional real (R$) increases wages by 4 cents of a real.[7] Then, 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 (2018). 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.

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

[7] See Appendix for details on this back of the envelope calculation.

1), 2.5% and 2.1% two years later (Column 3), 1.6% and 2.7% three years later (Column 5).[8] 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 hires, and that the effects are not substantially different between these groups.

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.[9] 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 A14 and A15). We also find that wages respond to winning a contract regardless of education with effects one year after stronger for college graduates (see Appendix Table A16). 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 A17). 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 A18 and A19).

4.4 Worker Composition

An 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.

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

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

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.

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. In Table 5 we directly explore the possibility of such changes in composition.

Panel A of Table 5 shows that one year after the shock neither the share of employees who are women or the average education of employees change in response to the shock. We find that the average age of employees drops by roughly six months.[10] Column (4) reports the impact on an index of worker "quality". Following Kline et al. (2019), we construct this index as firm-level average predicted wages, obtained from a regression of log wages on demographic characteristics of workers.[11] Panel A of Table 5 also shows that two years after winning an auction contract, average education increases by roughly half a month and the index of worker quality increases by 1.24% (Column 8). Finally, Panel B of Table 5 shows that three years after the shock, these patterns persist (Columns 1-4) until finally disappearing four years after winning the contract (Columns 5-8).

We explore these patterns further, by investigating if they are driven by either new hires or stayers. In principle, the composition of workers present prior to the auction happening (stayers) could change if winning a contract affects the separation rate of some groups of workers more so than others. We find that the shock has no impact on the composition in observables of stayers and improves that of new hires (see Appendix Table A20). Following Kline et al. (2019), another way to measure quality of a worker is by looking at their wages prior to the shock. We explore the effect of winning a contract on the quality, measured by pre-auction wages, of stayers, new hires, and separators (see Appendix Table A21). We find no effect of being the lowest bidder or winning a contract on the quality of stayers and a positive effect on the quality of new hires. Finally, we show that the quality of separators also increased. These results confirms that the shock alters the composition of new hires but not of stayers.

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 workers regardless of whether they remained in the firm in the following years. Table 6 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

[10] Kline et al. (2019) document similar results.

[11] Quadratic in age, dummies for education categories, ethnicity, and gender.

Table 5: 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.

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).

To summarize, we have found in Table 3 that young contract winners pay wages that are 2.7-3.8% higher, an effect that persists 4 years after the shock. We then turned our attention to understanding whether winning the contract causes composition changes in firms' employees. We found some evidence that after the shock these firms' workforce is younger, are of higher quality, and are more educated. While none of these composition effects is strong, by focusing exclusively on the group of workers who were originally at the firm we are able to verify whether our results is explained exclusively by composition. We conclude that, holding composition constant our results last for up to 3 years, and are significant at the 1% level. The magnitude is very similar to the baseline effects, ranging from 3.2% to 2.2% in the first three years but decreasing over time and fading out by the fourth year.

Table 6: 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. As described in the introduction 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. 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

$$y_j = z_j f(n_j)$$

where z_j is a firm specific shifter. Let f be such that $f(n) = n^{\alpha}$. 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 least the wage that was posted. However, ex-ante, workers do not know the z_j of the firm. 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.

Let w_j^p be the wage posted by a firm j. Define $E_i[w|w_j^p]$ as the wage the worker i expects to earn in a firm 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

$$\frac{\partial E_i[w|w_j^p]}{\partial w_j^p} > 0,$$

workers expect to earn more from firms that post higher wages. Following Card et al. (2018), 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 and a_j are firm-specific amenities common to all workers and $\epsilon_{i,j}$ captures idiosyncratic preferences for working at firm j. As a result, the ex-ante utility a worker i derives from working in a firm j is

$$u_{i,j} = E_i[w|w_j^p] - b + a_j + \epsilon_{i,j}. \tag{4}$$

Let $\epsilon_{i,j}$ be independent draws from a type I extreme value distribution. Then, by standard arguments (McFadden, 1973), workers have logit choice probabilities of the form

$$p(\text{choose to work for firm } j) = \frac{exp(E[w|w_j^p] - b + a_j)}{\sum_{\forall k} exp(E[w|w_k^p] - b + a_k)} \tag{5}$$

Assume the number of firms is large, then, the logit probabilities are well approximated by exponential probabilities:

$$p(\text{choose to work for firm } j) \approx \Lambda exp(E[w|w_j^p] - b + a_j) \tag{6}$$

where Λ is a constant common to all firms in the market. As a result, the number of workers, n, firm j posting wage w_j^p attracts is given by

$$log(n(w_j^p)) = log(\Lambda) + E[w|w_j^p] - b + a_j. \tag{7}$$

From the above expression we see that

$$\frac{\partial E_i[w|w_j^p]}{\partial w_j^p} > 0 \Rightarrow \frac{\partial n(w_j^p)}{\partial w_j^p} > 0. \tag{8}$$

Once the worker is hired by the firm they can engage in bargaining. Workers can only threaten the firm into losing their marginal product of labor.

As mentioned, bargained wages, w^{bg}, are not observed by outsiders to the firm and, hence, do not affect hiring. Then, the bargaining of a firm j with a worker i is the solution to

$$\max_{w^{bg}} (w^{bg} - b + a_j + \epsilon_{i,j})^{\beta} (pz\frac{\partial f(n)}{\partial n} - w^{bg} - \frac{\partial w^{bg}}{\partial n} n)^{1-\beta} \tag{9}$$

$$\text{subject to} \quad w^{gb} \geq w^p(n). \tag{10}$$

where the term $\frac{\partial w^{bg}}{\partial n} n$ comes from the fact that if a negotiation with a worker breaks down, wages are renegotiated with all workers remaining in the firm. As a result, the wage $w_{i,j}$ paid by the firm j to individual i is

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

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

where $\tilde{\beta} \equiv \frac{\beta}{1-\beta(1-\alpha)}$. See Appendix for derivation of w^{bg}. Now recall that $f(n) = n^\alpha$. Then, using $y = zn^\alpha$ we can rewrite this as

$$w_{i,j} = w^{bg}_{i,j} = \beta\alpha \frac{py}{n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}) \quad \text{if} \quad w^{bg}_{i,j} > w^p_j \tag{11}$$

$$w_{i,j} = w^p_j \quad \text{if} \quad w^{bg}_{i,j} \leq w^p_j. \tag{12}$$

Finally, note that the expected wage of a worker i given they accepted an offer associated to a wage posted w^p and amenity a_j is

$$E_i[w|w^p_j] = \int \max(w^{gb}_{i,j}(z), w^p_j) m(z) dz.$$

From this expression we see that

$$\frac{\partial E_i[w|w^p_j]}{\partial w^p_j} > 0.$$

Proposition 1 below delivers a linear equation that helps us interpret our empirical findings and microfound our main estimating equation (see Proof in the Appendix).

Proposition 1.

$$log(E[w])_j = \zeta_0 + \zeta_1\xi_0 + \zeta_2 log(py) + (\zeta_3 + \zeta_1\xi_1) log(n) + (\xi_2 + \zeta_4) log(a)_j \tag{13}$$

where $\zeta_1 > 0, \zeta_2 > 0$, $\zeta_3 = -\zeta_2 < 0, \zeta_4 < 0$, $\xi_1 > 0$. *If only wage posting, then,* $\zeta_0 = 0$, $\zeta_1 = 1$, $\zeta_2 = 0$, $\zeta_3 = 0$, $\zeta_4 = 0$, *so,*

$$log(E[w])_j = \xi_0 + \xi_1 log(n) + \xi_2 log(a)_j. \tag{14}$$

If only wage bargaining, then, $\xi_0 = 0$, $\xi_1 = 0$, *and* $\xi_2 = 0$, *so*

$$log(E[w])_j = \zeta_0 + \zeta_2 log(py) + \zeta_3 log(n) + \zeta_4 log(a)_j. \tag{15}$$

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

1. Effect of contract value, py, only present if there is bargaining.

2. If coefficient on $log(n)$ non-positive there must be some bargaining even in the presence of wage posting.

3. If find $\zeta_2 > 0$ and the coefficient on log(n) is non-negative then there must be wage posting.

Intuitively, any effect of contract value py on wages can't come from the upward labor supply channel as this is controlled for by $log(n)$. As a result, our framework allows us to test whether the empirical evidence is consistent with bargaining or with firm specific upward sloping labor supply curves (wage posting).

5.2 Discussion and Empirical Estimation

In the previous sections, we saw that wages respond to increases in firm demand. As we mentioned in the introduction, given that previous papers only had one firm-specific shock, they have been unable to test between bargaining and posting. The recent literature (Kline et al., 2019; Amodio and de Roux, 2021; Kroft et al., 2020) has had to assume one model to estimate structural parameters, often interpreting wages responses to firm shocks as evidence of wage posting. Under such a setting, firms only 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

$$log(n)_{it} = B_0 + B_1 log(w)_{it} + \epsilon_{it} \tag{16}$$

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.[12] Conversely, we can invert this equation to write it as

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \upsilon_{it} \tag{17}$$

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.,

[12] 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.

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 (17) would be

$$log(w)_{it} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(pq)_{it} + \upsilon_{it} \tag{18}$$

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

Comparing equations (17) and (18) 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 $log(pq)_{i,t}$. Previous literature has not been able to do this because they all relied on only one shock to firm demand.

Our unique institutional setting gives us two different sources of variation that allow us to estimate equation (18). 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. 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.

Let w_{iat} be the wage paid by a firm i at period t that participated in close auction a. Let $value_{it}$ 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

$$log(w)_{iat} = \gamma_0 + \gamma_1 log(n)_{it} + \gamma_2 log(value)_{ia} + \delta' X_{ia} + \mu_a + \epsilon_{it}, \tag{19}$$

where $log(n)_{i,t}$ and $log(value)_{ia}$ are two endogenous variables. 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* $\cdot$ *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 (19). 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 pay higher wages. On the other hand, what might matter for firms in their decision of whether to continue participating is the alternative contract they can get if they do not continue to participate. In that case, we expect more productive (high wage) firms to have better outside options and to drop out from auctions that last too long. In any case, whatever the direction, this is not an issue for us, since by always comparing winner to runner-up we allow for firms in auctions of different duration to be different.

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 (19) 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 (19) 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.

5.3 Results

Table 7 (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 $IV_2 = Lowest\ bidder \cdot random\ t$ is significant and negative. The table shows that winning an auction that ended (randomly) ten minutes later decreases contract value by $17\% - 20\%$.

Table 7 (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, $IV_1 = Lowest\ bidder$ 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 7 (Panel A) shows our second-stage results. Columns 1 to 3 show 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. 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. These results are consistent with a presence of bargaining in wage determination. Importantly, 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%.[13] Finally, our results are unchanged if we consider contractual wages (see Appendix Table A23), 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 A24). 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

[13]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%.

Table 7: Effects of Contract Value and Firm Size on 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***	0.004***	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)
Dep Var	log(n)			
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 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.

of employees are not associated to higher wages (Appendix Table A25). 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 causal impact on wages. Through the lens of our model, our results confirm 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 A26 and A27). 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 posting can arise due to recruitment frictions and hiring costs. In that case, higher wages increase worker retention, leading to a decrease in the separation rate of workers from firms. In section 5.4.2, we show that, despite wages responding to firm demand, separation rates are unchanged. Finally, wage bargaining theories predict that larger bargaining power leads to higher wage responses to increased firm demand. In section 5.4.3, 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 8: 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	✓	✓	✓	✓	✓	✓	✓	✓
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 8 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 Sorkin (2018) 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 9, 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%). 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 9: 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	-0.022***	-0.021***	-0.021***	-0.026**	-0.017***	-0.020***	-0.019***	-0.022**
random *t*	(0.006)	(0.007)	(0.008)	(0.010)	(0.005)	(0.006)	(0.007)	(0.009)
Dep Var	log(n)							
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	-0.002*	-0.002	-0.003**	-0.003*	-0.001	0.000	0.000	-0.001
random *t*	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Auction FEs	✓	✓	✓	✓	✓	✓	✓	✓
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 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 Separation rates

Dynamic models of wage posting with recruitment frictions and hiring costs usually have predictions for separation rates. In particular, higher wages increase worker retention, leading to lower separation rates (Kline et al., 2019; Burdett and Mortensen, 1998; Postel-Vinay and Robin, 2002; Cahuc et al., 2006). Since winning procurement contracts lead to wage increases, these theories predict it should lower separation rates. Table 10 shows that being a lowest bidder has no effect on worker separation rates, even three years after the shock (Columns 1, 3, and 5). Results are unchanged once we consider our IV estimation as seen by Columns 2, 4, and 6.

Table 10: Effects on Cumulative Separation Rates, Original Cohort

	(1)	(2)	(3)	(4)	(5)	(6)
	RF	IV	RF	IV	RF	IV
Dep Var	Sep. rate$_{t+1}$	Sep. rate$_{t+1}$	Sep. rate$_{t+2}$	Sep. rate$_{t+2}$	Sep. rate$_{t+3}$	Sep. rate$_{t+3}$
Lowest Bidder	-0.002		-0.003		-0.002	
	(0.006)		(0.007)		(0.009)	
Contract Winner		-0.003		-0.003		-0.002
		(0.008)		(0.010)		(0.013)
Observations	59,412	59,412	49,668	49,668	39,230	39,230
R-squared	0.527	0.057	0.531	0.048	0.518	0.027

Notes: This table shows reduced-form and IV regressions of cumulative separation rate of the original cohort of workers $j = \{1, 2, 3, 4\}$ years after the auction on lowest bidder and contract winner. The dependent variable is the proportion of workers from the original cohort that had left the firm by the end of year j. 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.

5.4.3 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 contract value and number of employees on wages vary 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 11 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 runner-ups 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 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 7, separately for firms with and without a previous collective agreement (see Appendix Table A28). 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.

Table 11: 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.

6 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 this effect is still present four years later. We also focus only on workers present at the firm before the auction and verify that our effect is not driven by 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.

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 show that bargaining is a relevant aspect of non-competitive labor markets. This result is 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).

Our findings also raise concerns with a strand of the literature that has attempted to outline non-competitive labor markets exclusively through labor supply elasticities. 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. 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 also corroborate 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) both find evidence of mergers that decreased wages without having an effect on employment.

Throughout the analysis, we have classified wage-setting theories in two major groups: bargaining and wage-posting. There are, however, models that capture different elements from one or the other, and do not fit perfectly into one category. 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. This is consistent with our findings that larger surplus increases wages beyond movements in the labor supply curve. On the other hand, Postel-Vinay and Robin (2002) and Cahuc et al. (2006) also predict lower separation rates for firms paying higher wages, since it takes higher counter offers to convince their workers to leave. We do not find evidence for this prediction in our setting.

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 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. 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)).

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Appendix A Figures

Figure A1: Random Phase Duration (Histogram)

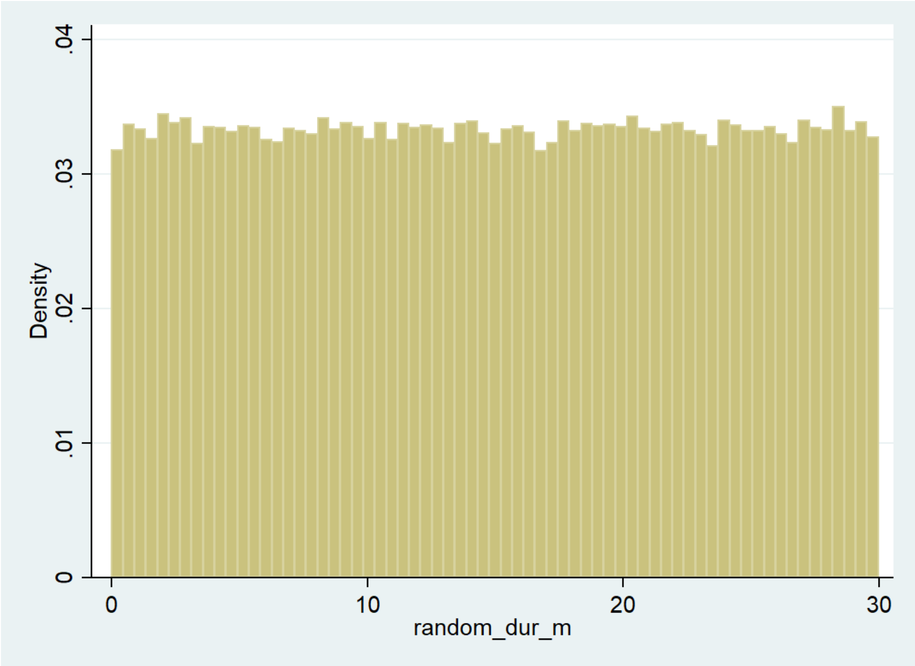

Figure A2: ComprasNet Platform - Home Screen

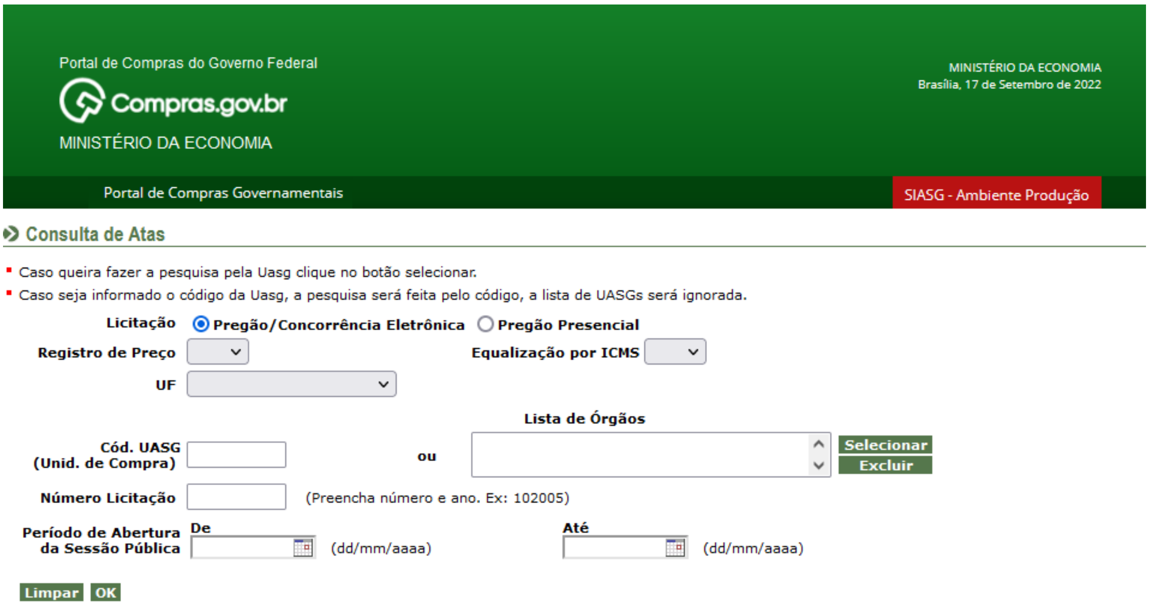

Figure A3: ComprasNet Platform - Query Result


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

Appendix B 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: Balancing: Winner *versus* Runner-up

	Means		Difference
Variables at Quarter$_{t-1}$	Runner-up	Winner	Runner-up vs Winner
Wage	1521	1526	5
	(805)	(829)	(15)
Employees	13.6	11.7	-1.9
	(169.4)	(95.8)	(1.3)
Firm age	9.6	9.3	-0.27
	(8.3)	(8.4)	(0.19)
% College	18.1	18.8	0.7
	(27.4)	(27.9)	(0.6)
% High Skill	5.4	5.2	-0.2
	(15.9)	(15.0)	(0.2)
% Intermediate Skill	6.02	5.9	-0.09
	(16.0)	(15.6)	(0.29)
% Low Skill	81.1	80.9	-0.2
	(27.0)	(27.4)	(0.6)
% Female	42.7	43.1	0.5
	(33.7)	(33.8)	(0.8)
Log(quality)	7.11	7.12	0.01
	(0.51)	(.52)	(0.01)
Observations	34,382	34,382	68,764

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 quarter before the auction. "Log quality" represents predicted log wage based on worker demographics. * represents 10% significance, ** represents 5% significance and *** represents 1% significance.

Table A7: Results - Robustness using Contractual Wages

	(1)	(2)	(3)	(4)
	Panel A. Reduced form estimates			
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+4}$
Lowest Bidder	0.014***	0.018***	0.017***	0.017***
	(0.004)	(0.004)	(0.005)	(0.005)
	Panel B. IV estimates			
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+4}$
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 A8: Results - Robustness using Hourly Wages

	(1)	(2)	(3)	(4)
		Panel A. Reduced form estimates		
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+4}$
Lowest Bidder	0.013***	0.017***	0.016***	0.002
	(0.004)	(0.004)	(0.004)	(0.011)
		Panel B. IV estimates		
Dep Var	$\log(\mathrm{w})_{t+1}$	$\log(\mathrm{w})_{t+2}$	$\log(\mathrm{w})_{t+3}$	$\log(\mathrm{w})_{t+4}$
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 A9: 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 A10: 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 A11: 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 A12: 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	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
Lowest Bidder	0.017**	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	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$	$\log(n)_{t+1}$	$\log(n)_{t+2}$	$\log(n)_{t+3}$	$\log(n)_{t+4}$
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 A13: 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 A14: 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 A15: Heterogeneity by Gender

	(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:			**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 A16: Heterogeneity by Education

	(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:			**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 A17: 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 A18: 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 A19: 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 A20: Worker Composition by Type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Female Share	Avg age	Avg Education	Log(quality)	Female share	Avg age	Avg Education	Log(quality)
	(t+1)	(t+1)	(t+1)	(t+1)	(t+3)	(t+3)	(t+3)	(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 5 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	$\log(w)_{t-1}$	$\log(w)_{t-1}$	$\log(w)_{t-1}$	$\log(w)_{t-1}$	$\log(w)_{t-1}$	$\log(w)_{t-1}$
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	$\log(w)_{t+1}$	$\log(w)_{t+1}$	$\log(w)_{t+2}$	$\log(w)_{t+2}$	$\log(w)_{t+3}$	$\log(w)_{t+3}$	$\log(w)_{t+4}$	$\log(w)_{t+4}$
Lowest Bidder	0.020***		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 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)			
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 A24: 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)							
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 A25: 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)											
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 A26: 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 A27: 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)				
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 A28: 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)							
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 C Derivation of bargained wage

From the bargaining problem we obtain,

$$w_{i,j}^{bg} + \beta \frac{\partial w_{i,j}^{bg}}{\partial n} n = \beta p z \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}). \tag{20}$$

Now rewrite the expression characterizing w^{bg} as

$$\frac{w^{bg}}{\beta n} + \frac{\partial w}{\partial n} = \frac{\alpha p z n^{\alpha-1}}{n} + \frac{(1-\beta)b}{\beta n} - \frac{(1-\beta)(a+\epsilon)}{\beta n} \tag{21}$$

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

$$w n^{\frac{1}{\beta}} = \frac{\alpha p z \beta n^{\frac{1-\beta(1-\alpha)}{\beta}}}{1-\beta(1-\alpha)} + n^{\frac{1}{\beta}}(1-\beta)b - n^{\frac{1}{\beta}}(1-\beta)(a+\epsilon). \tag{22}$$

Rearranging we get

$$w = \frac{\beta \alpha p z n^{\alpha-1}}{1-\beta(1-\alpha)} + (1-\beta)b - (1-\beta)(a+\epsilon) = \tilde{\beta} p \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a+\epsilon) \tag{23}$$

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

$$w_{i,j} = w_{i,j}^{bg} = \tilde{\beta} p \frac{\partial f(n)}{\partial n} + (1-\beta)b - (1-\beta)(a_j + \epsilon_{i,j}) \quad \text{if} \quad w_{i,j}^{bg} > w_j^p \tag{24}$$

$$w_{i,j} = w_j^p \quad \text{if} \quad w_{i,j}^{bg} \leq w_j^p. \tag{25}$$

Appendix D Proof of Proposition 1

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

$$y = zf(n) \Rightarrow y = zn^{\alpha} \Rightarrow \hat{n} = (\frac{y}{z})^{\frac{1}{\alpha}}$$

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 $w^p = \overline{w}(\hat{n})$.

Define $\underline{\epsilon}_j(w^p)$ as the cutoff ϵ such that for a given wage w^p all workers with $\epsilon_{i,j} \geq \underline{\epsilon}_j(w^p)$ work for j. In other words,

$$\underline{\epsilon}_{i,j}(w^p) = -a_j - (E_i[w|w^p] - b).$$

Note that

$$\frac{\partial \underline{\epsilon}_j(w^p)}{\partial w^p} < 0.$$

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

$$H(w^p) \equiv Prob(w_j^p \geq w_{i,j}^{bg}) = (1 - G(\frac{\tilde{\beta}\alpha py}{(1-\beta)n} + b - a_j - \frac{w_j^p}{1-\beta}|\epsilon > \underline{\epsilon}(w_j^p))). \quad (26)$$

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

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

Next, replace w^{bg} by its expression inside $E_j[w]$. Next, log-linearize the expression for $E_j[w]$ for a_j, py, n and w^p. This gives us

$$log(E[w])_j = \zeta_0 + \zeta_1 log(w^p) + \zeta_2 log(py) + \zeta_3 log(n) + \zeta_4 log(a)_j \quad (27)$$

where $\zeta_1 > 0$, $\zeta_2 > 0$, $\zeta_3 < 0$ and $\zeta_4 < 0$. Next, log-linearize the expression for w^p for a_j and n to get

$$log(w^p) = \xi_0 + \xi_1 log(n) + \xi_2 log(a)_j \quad (28)$$

where $\xi_1 > 0$. Next, replace this expression for $log(w^p)$ in the equation for $log(E[w])_j$ to get the desired result

$$log(E[w])_j = \zeta_0 + \zeta_1\xi_0 + \zeta_2 log(py) + (\zeta_3 + \zeta_1\xi_1)log(n) + (\xi_2 + \zeta_4)log(a)_j. \tag{29}$$

Appendix E 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. We start by estimating the following equation

$$w_{iat} = \alpha_0 + \alpha_1 \frac{\text{value}_{ia}}{n} + \delta' X_{ia} + \mu_a + \epsilon_{it} \tag{30}$$

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.