Assessing the relation between labor market imperfection and price-cost markup: an empirical analysis for Brazil

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Abstract

This study aims to assess how competition can affect labor market imperfections. Using four-digit manufacturing industry data in Brazil from 2007 to 2015, we estimated markups and classified the labor market into different regimes of competition. The results show an average price-cost markup of 1.7 in the Brazilian manufacturing sector. Subsequently, we verified how the type of competition in the labor market responds to markup variations. We found that perfect competition in the labor market is associated with increased competition in the final product market. The study sheds light on the effect of product market power on the labor market power by providing evidences of the relation between industry price-cost markup and competition in the labor market.

JEL classification: J42, J52, L11
Keywords: Efficient bargain, monopsony power, price-cost markup.

Resumo

O objetivo deste estudo é avaliar como a concorrência no mercado final pode ser afetada pelas imperfeições do mercado de trabalho. Usando dados da indústria de transformação no Brasil de 2007 a 2015 (4 dígitos da CNAE), os markups industriais são estimadas e o mercado de trabalho é classificado em diferentes regimes de competição. Os resultados mostram uma razão entre preço e custo marginal média de 1,7 na industria de transformação brasileira. Então, pode-se ver como o tipo de concorrência no mercado de trabalho responde às variações no markup. Concluímos que a concorrência perfeita no mercado de trabalho está associada ao aumento da concorrência no mercado do produto final. O artigo lança luz sobre o efeito do poder de mercado do bem final sobre a competição no mercado de trabalho, fornecendo evidências sobre a relação entre o markup industrial e a concorrência no mercado de trabalho.

JEL classification: J42, J52, L11
Palavras-chaves: Barganha eficiente, monopsônio, markup.

Classificação ANPEC: Área 8 - Microeconomia, Métodos Quantitativos e Finanças

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1 Introduction

The labor market has always drawn attention to its particularities; unsurprisingly, it is rarely analyzed without taking into account any market failure. Uncertainty, asymmetric information, and market power are typical examples of failures that prevent wages and employment from reaching the same levels that they would attain under perfect competition.

During the 1970s and 1980s, much of the labor market literature focused on the distortions caused by the relationship between firms and unions. This market structure started to be modeled with the bargain concept proposed by Nash Jr [1950]: a situation of conflict of interests in which agents can reach an agreement that benefits all parties involved.

Recently, studies on the labor market regarding bargaining between employers and employees have resurfaced. The literature on markup estimation started to also incorporate imperfect competition in the labor market. Some precursors of this process are Crépon et al. [2005] and Dobbelaere [2004]. Both studies have estimated simultaneously the markup of firms and the bargaining power of workers, founding that ignoring imperfection in the labor market leads to an underestimation of price to marginal cost ratio when perfect competition is assumed in the labor market.

Other authors employed a similar methodology when investigating the relation between workers' bargaining power and international trade (Brock and Dobbelaere [2006], Dumont et al. [2006], Abraham et al. [2009], Boulhol et al. [2011]), regulatory policies in the labor market (Pal and Rathore [2016]), and type of sector (Amador and Soares [2017], Soares [2019]). All of these studies have one aspect in common: they admit that an efficient bargaining process between employees and employers characterizes the regime of competition in the labor market.

However, there is an emerging literature concerned with analyzing labor market power. In these studies, the firm's hiring decision affects the wage setting process in the local market, that is, employers have some decision power over wage setting. Azar et al. [2020] and Azar et al. [2018] find that the more concentrated employer markets are in relation to employers, the lower are the wages charged, indicating that firms have labor market power. In turn, Manning [2003] showed evidence for the increase in monopsony power in the labor market.

According to Krueger [2018], monopoly power has always existed, but it used to be overcome by other forces operating in the labor market, such as workers' bargaining power. Therefore, setting the type of competition that best characterizes the labor market is a difficult task. Another challenging and underexplored question in the literature is to understand the extent to which the decrease in competition in the labor market is correlated to the increase in profit margins (Berry et al. [2019]).

This study addresses the issues of monopsony, barganing power and competition within the context of the Brazilian manufacturing sector. The objectives include identification of the markups and classification of the competition regime in the labor market. We adopted the methodology proposed by Dobbelaere and Kiyota [2018], according to which the type of competition can be obtained through input's output elasticity estimated by the Production-Approach. Once the labor market competition type is determined, we analyze how it correlates with markup.[1]

In turn, the literature on Production-Approach for recovering markups has evolved substantially in recent decades. The seminal article by Hall [1988] is taken as a starting point in measuring markups. The author used Solow residual as a strategy to identify markups. Three critical aspects of Hall's methodology must be emphasized. The first concerns the need to estimate an average markup, that is, it is impossible to estimate the specific markup for each firm. The second point refers to the fact that the conclusions depend on the hypotheses about returns to scale, since this approach is not robust

[1]See Bergès and Caprice [2008] and Symeonidis [2008] for a theoretical approach to this relationship.

to increasing or decreasing returns to scale. Finally, Hall's methodology does not take into account imperfect competition in the factor market.

De Loecker [2011] proposes a methodology to avoid the first two critical aspects above mentioned if Production-Approach is used. This was put into practice in De Loecker and Warzynski [2012] for empirically recovering the markup as the ratio of an input's output elasticity and its revenue share. Although other studies have used this methodology, Lucinda and Meyer [2013] estimated sectorial markups using Brazilian industrial production data. The authors used Annual Industrial Research data (PIA) carried out by the Brazilian Institute of Geography and Statistics (IBGE), much like this study, although for a different period of time.

The identification strategy proposed by De Loecker and Warzynski [2012] starts from a standard static cost minimization and it requires the absence of inputs markets distortions. In this sense, the contribution of Dobbelaere and Mairesse [2013] is relevant because it allows to identify any gap between the markups estimated by different inputs as caused by the type of competition that prevails in the labor market. The authors portrayed three types of competition in labor market: efficient bargaining, monopsony power, and perfect competition. The imperfection parameter ψ, which represents the gap, is the necessary instrument for identifying the regime that best characterizes the labor market.

The point of convergence for De Loecker and Warzynski [2012] and Dobbelaere and Mairesse [2013] is at Dobbelaere and Kiyota [2018]. The authors use the empirical strategy proposed by De Loecker and Warzynski [2012] to find the imperfection parameter ψ and then classify the labor market according to the regime of competition. This methodology has been largely applied to relate labor market power to international trade (Dobbelaere and Kiyota [2018], Nesta and Schiavo [2019], Damoah [2019], Dobbelaere and Wiersma [2020], Mertens [2020]).

Therefore, this study contributes to the literature by providing empirical evidence that price-cost markup is related to competition in the labor market. When wages exceed the marginal revenue product of labor (*i.e.* wage markup), it is assumed that the prevailing competition regime is efficient bargaining. In this case, market power is assigned to employees through costs of firing, hiring and training. On the other hand, when the wages are lower than the marginal revenue product of labor (*i.e.* wage markdown), it is assumed that firms have monopsony power in the labor market. In this case, market power is assigned to employees since there are heterogeneous preferences in relation to the working environments, which generates labor supply curves less than perfectly elastic and that increase with wages.

Our results show the probability of wages being exogenously set decreases if the product price detaches from the marginal cost. Therefore, higher markups are associated with efficient bargaining and monopsony processes when compared to perfect competition in the labor market. This result suggests that the greater mobility of the labor factor provided by perfect competition is negatively correlated to price-cost markup.

The rest of the paper is organized as follows. Section 2 presents the methodology, which is divided into two parts: theoretical and empirical approach. Section 3 describes the data and its structure. We present the results in section 4 and additional robustness checks in Section 5. Finally, we add some remarks and arrive to the main conclusion in Section 6.

2 Methodology

The theoretical approach presented in this study consisted of estimating markups and classifying the regimes that prevail in the labor market for each industry in a given time period. Then, we analyzed the relationship between imperfections in the labor market brought by changes related to the variation of the imperfection regime in the labor market and the estimated markup.

2.1 Theoretical Framework

Assume firm i at time t produces output Q_{it} using the following production technology:

$$Q_{it} = F(M_{it}, N_{it}, K_{it}, \beta)\exp(\omega_{it}) \tag{1}$$

Where Q symbolizes the value of production. Inputs M, N and K represent materials, labor and capital, respectively. ω portrays the firm's productivity, that is, the production function features Hicks-neutral technology.

Following De Loecker and Warzynski [2012], we admit that firms act as agents that minimize costs for a given level of output and, therefore, have the following Lagrangian problem:

$$L(N_{it}, M_{it}, K_{it}, \varphi_{it}) = j_{it}M_{it} + w_{it}N_{it} + r_{it}K_{it} - \varphi_{it}(Q_{it} - Q_{it}(.)) \tag{2}$$

Where j_{it}, w_{it} and r_{it} are the materials, labor and capital input prices, respectively. The first order conditions for materials and labor are represented by:

$$\frac{\partial L_{it}}{\partial M_{it}} = j_{it} - \varphi_{it}\frac{\partial Q(.)}{\partial M} = 0 \tag{3}$$

$$\frac{\partial L_{it}}{\partial N_{it}} = w_{it} - \varphi_{it}\frac{\partial Q(.)}{\partial N} = 0 \tag{4}$$

Since the Lagrangian multiplier of cost minimization, φ_{it}, represents the marginal cost, we can write:

$$\frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}} = \mu_{it} \tag{5}$$

$$\frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} = \mu_{it} \tag{6}$$

Such that $\alpha_{it}^{N} = \frac{w_{it}Nit}{P_{it}Q_{it}}$ and $\alpha_{it}^{M} = \frac{j_{it}Mit}{P_{it}Q_{it}}$ represent labor and material cost shares in total revenue, respectively. The parameter $\mu_{it} = \frac{P_{it}}{Cmg_{it}}$ is the price-cost markup. Thus, the characterization of the degree of imperfection in the product market can be made from the markup estimates. De Loecker and Warzynski [2012] presented details of the markup estimation procedure using the value added approach. However, the same procedure can be adopted by the gross output approach and that any differences in the values obtained from μ_{it} in the equations 5 and 6 must be the result of labor market distortions.

According to Dobbelaere and Mairesse [2013] it is possible to define the labor market imperfection parameter as follows: $\psi_{it} = \frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} - \frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}}$. The ψ sign can be associated with three different labor market regimes: 1) $\psi_{it} = 0$ if the labor market is perfectly competitive [2]; 2) $\psi_{it} > 0$ if the labor market is characterized by an efficient bargain process as in McDonald and Solow [1981]; and 3) $\psi_{it} < 0$ if monopsony power *à la* Manning [2003] exists. The optimal labor demand by each firm depends on the regime in which it is inserted. Details for each of the three regimes can be found in A. Thus, it is important to understand how the different wage setting processes in each regime affect the gap between the marginal revenue product of labor and the marginal cost of labor.

[2]In this case, it may be that wages are set exogenously or through a bargaining process between labor organizations and firms, which choose the level of employment unilaterally as proposed by Nickell and Andrews [1983].

Perfect Competition: Firms and workers are both price takers in the labor market. In this case, the profit maximization of firms implies that the marginal revenue product of labor will be equal to their marginal cost.

Efficient Bargain: Workers have market power. Part of the profits is captured by unions, or labor organizations. Under this regime, the marginal cost tends to exceed the marginal revenue product of labor and the firm pays a wage markup.

Monopsony: Firms have market power. The supply of labor increases with higher wages, due to the heterogeneous preferences of workers in relation to job characteristics. In this situation, the marginal revenue product of labor is greater than the marginal cost and the firm stipulates a wage markdown.

The procedure for classifying the labor market depends on the output elasticities. These will be obtained through the empirical procedure that will be detailed in the next section.

2.2 The Empirical Model

We assume the logarithmic version of the production function 1 such as $y_{it} = \ln Q_{it} + \epsilon_{it}$. That is, ϵ_{it} represents unpredictable shocks in production and measurement error.

$$y_{it} = f(m_{it}, n_{it}, k_{it}, \beta) + \omega_{it} + \epsilon_{it} \tag{7}$$

In order to obtain consistent estimates of the production function parameters, we must control the unobserved productivity shocks, which are potentially correlated with inputs choices. We apply the procedure proposed by Ackerberg et al. [2015] to control the correlation between input choices and unobserved productivity.

The k capital is a dynamic input. Both materials and labor are short-run inputs however, a small difference between them is admitted. Following Dobbelaere and Kiyota [2018], n is chosen by the firm i in time $t-b$ where $(0 < b < 1)$, after k is chosen in $t-1$, but before m be chosen in t.

We assume that unobservable productivity (ω_{it}) relies on an endogenous first-order Markov process. Given these time assumptions, the demand for the material input of the firm i at time t depends directly on n chosen before m, that is, the input demand function for m is conditional on n_{it}:

$$m_{it} = m_t(k_{it}, n_{it}, imp_{it}, exp_{it}, sh_{it}, w_{it}^{BC}, w_{it}^{WC}, \omega_{it}) \tag{8}$$

Where imp_{it}, exp_{it}, sh_{it}, w_{it}^{BC} and w_{it}^{WC} represent an imports penetration coefficient, the export coefficient, the share of industrial production, the wage bill of blue collar and white collar workers, respectively. The variables imp_{it}, exp_{it} are more aggregated, as explained in the data section. We set the vector $z_{it} = \left\{imp_{it}, exp_{it}, sh_{it}, w_{it}^{BC}, w_{it}^{WC}\right\}$. The variables that explain the demand for materials, but do not belong to the production function, are necessary for the identification of the parameters (Gandhi et al. [2018]).

The materials demand by firm i is a function of the state variables, where ω_{it} is the only variable, among those contained in the demand for materials function, which is not directly observable. Since we impose that $m_t(.)$ is strictly increasing in ω_{it} conditional on n_{it}, k_{it} and z_{it}, it is possible to invert the equation 8 as follows (strict monotonicity hypothesis):

$$\omega_{it} = m_t^{-1}(k_{it}, m_{it}, n_{it}, z_{it}) \tag{9}$$

We estimate a translog production function. This allows the output elasticities to depend on the input use intensity.

$$\begin{aligned} y_{it} =& \beta_m m_{it} + \beta_n n_{it} + \beta_k k_{it} + \beta_{mm} m_{it}^2 + \beta_{nn} n_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{kn} n_{it} k_{it} + \\ & \beta_{mn} n_{it} m_{it} + \beta_{mk} m_{it} k_{it} + \omega_{it} + \epsilon_{it} \end{aligned} \tag{10}$$

Using the invertibility condition 9 in 10, we run in a first stage:

$$y_{it} = f_{it}(.) + m_t^{-1}(k_{it}, m_{it}, n_{it}, z_{it}) + \epsilon_{it} = \phi_{it}(k_{it}, m_{it}, n_{it}, z_{it}) + \epsilon_{it} \tag{11}$$

This way, it is possible to obtain the predicted values, $\widehat{\phi_{it}}$, which are given by the expression:

$$\begin{aligned} \phi_{it} =& \beta_m m_{it} + \beta_n n_{it} + \beta_k k_{it} + \beta_{mm} m_{it}^2 + \beta_n n_{it}^2 + \beta_k k_{it}^2 + \beta_{kn} n_{it} k_{it} + \\ & \beta_{mn} n_{it} m_{it} + \beta_{mk} m_{it} k_{it} + h_t(m_{it}, k_{it}, n_{it}) \end{aligned} \tag{12}$$

The first step of the procedure allows you to purge the term of productivity as a function of the vector β. More specifically, productivity is computed for a given β vector, such that

$$\begin{aligned} \omega_{it}(\beta) =& \widehat{\phi_{it}} - \beta_m m_{it} - \beta_n n_{it} - \beta_k k_{it} - \beta_{mm} m_{it}^2 - \beta_n n_{it}^2 - \beta_k k_{it}^2 - \\ & \beta_{kn} n_{it} k_{it} - \beta_{mn} n_{it} m_{it} - \beta_{mk} m_{it} k_{it} \end{aligned} \tag{13}$$

To estimate the coefficients of the production function, it is assumed the following law of motion for productivity in the second stage:

$$\omega_{it} = g_t(\omega_{it-1}) + \xi_{it} \tag{14}$$

Finally, from the residual obtained by nonparametrically regressing ξ_{it} on its lag, one can estimate the vector β by exploring the following moment conditions:

$$E\left(\xi_{it}(\beta) \begin{pmatrix} n_{it-1} \\ n_{it-1}^2 \\ m_{it-1} \\ m_{it-1}^2 \\ k_{it} \\ k_{it}^2 \\ k_{it} n_{it-1} \\ k_{it} n_{it-1} \\ n_{it-1} m_{it-1} \end{pmatrix}\right) = 0 \tag{15}$$

The output elasticities are calculated using the estimated coefficients of the production function. Under a translog gross output production function, the output elasticity for labor (n) and materials (m) is given, respectively, by:

$$\begin{cases} (\widehat{\varepsilon}_N^Q)_{it} = & \widehat{\beta}_n + 2\widehat{\beta}_{nn} n_{it} + \widehat{\beta}_{nm} m_{it} + \widehat{\beta}_{nk} k_{it} \\ (\widehat{\varepsilon}_M^Q)_{it} = & \widehat{\beta}_m + 2\widehat{\beta}_{mm} m_{it} + \widehat{\beta}_{mn} n_{it} + \widehat{\beta}_{mk} k_{it} \end{cases} \tag{16}$$

Since we admit a potential measurement error and unanticipated output shock, such that $Y_{it} = Q_{it}\exp(\epsilon_{it})$, we can recover the correct input share values by

$$\widehat{\alpha}_{it}^{M} = \frac{j_{it}Mit}{P_{it}\frac{Y_{it}}{\exp(\epsilon_{it})}} \tag{17}$$

$$\widehat{\alpha}_{it}^{N} = \frac{w_{it}Nit}{P_{it}\frac{Y_{it}}{\exp(\epsilon_{it})}} \tag{18}$$

From output elasticities and input shares, it is possible to compute both imperfection parameters as follows:

$$\widehat{\mu}_{it} = \frac{(\widehat{\varepsilon}_{M}^{Q})_{it}}{\widehat{\alpha}_{it}^{M}} \qquad \text{and} \qquad \widehat{\psi}_{it} = \frac{(\widehat{\varepsilon}_{M}^{Q})_{it}}{\widehat{\alpha}_{it}^{M}} - \frac{(\widehat{\varepsilon}_{N}^{Q})_{it}}{\widehat{\alpha}_{it}^{N}} \tag{19}$$

For the classification of type of competition in labor markup, the standard errors were obtained using the delta method. Then, confidence intervals were built. Two different criteria were adopted. The first criterion was designed as follows. If the lower bound of $\widehat{\psi}_{it}$ confidence interval is greater than zero, then the industry is classified as an efficient bargain at that time. If the upper bound of the $\widehat{\psi}_{it}$ confidence interval is less than zero, then the industry is classified as a monopsony at that time. If zero belongs to $\widehat{\psi}_{it}$ confidence interval then the industry is classified as perfect competition, in that instant of time.

The second criteria adopted follows closely Dobbelaere and Kiyota [2018]. Labor market is characterized by efficient bargain if $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{it}^{M}}$ confidence interval lower bound is greater than $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ confidence interval upper bound hence $\widehat{\psi}_{it} > 0$. Monopsony prevails if $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ confidence interval lower bound is greater than $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{it}^{M}}$ confidence interval upper bound hence $\widehat{\psi}_{it} > 0$. Perfect competition prevails if $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{i/t}^{M}}$ confidence interval overlaps $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ confidence interval which implies that $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{it}^{M}}$ is not significantly different from $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ hence $\widehat{\psi}_{it} = 0$.

In the first criteria, confidence interval were computed directely from $\widehat{\psi}_{it}$. In the second criteria confidence interval were computed for $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{it}^{M}}$ and $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ separately.

Once the labor market is classified and the markups are recovered, the effect of the labor market imperfection regimes on the market power represented by the markups can be identified. The benchmark equation is:

$$\theta_{it} = \delta_1 \ln \widehat{\mu}_{it} + \delta_2 \widehat{\omega}_{it} + \mathbf{b}_{it}^{\prime}\sigma + \nu_{it} \tag{20}$$

Where θ is a binary variable representing imperfect competition in labor market. The variable assumes value 1 if labor market is settled as efficient bargain or monopsony and 0, otherwise. The productivity $\widehat{\omega}$ is recovered using the equation 13. The $\mathbf{b}$ vector contains other covariates.

We adopted a two-stage instrumental variable approach to account for endogeneity issue. The source of endogeneity comes from the simultaneity that arises from labor and product market imperfection settings. We relied on lagged versions of manufacturing production share, sh, and industrial parts, pt, as instruments for markups, $\ln \widehat{\mu}$. We admitted that changes in our set of instruments are associated with changes in $\ln \widehat{\mu}$ but cannot change in θ, directly. We will discuss further below the suitability of the proposed instruments.

3 Data

The production data variables used in this study were taken from the Annual Industrial Survey (PIA-Empresa), conducted by the Brazilian Institute of Geography and Statistics (IBGE). The aggregation data level is given by four-digit manufacturing industry data from the National Economic Activities Classification (CNAE). In the analysis, 244 manufacturing industries were considered in the period between 2007 and 2015. Since some industries presented missing data for certain years, we decided to remove them from the sample. Thus, the database is composed of a balanced panel with 237 industries and 9 periods.

In relation to production data variables, we must to obtain series for gross output, materials, labor, capital, blue collar and white collar wages, in addition to the input shares and industrial production share. First, it should be noted that all series were divided by the number of firms in each industry.

The "Industrial Gross Product Value" series was used to construct the gross output variable. Labor input was obtained by the "Number of employees active on December 31st". For the material input variable, the "Industrial Operations Costs" series was used. In relation to capital, the "Total Assets" series for 2007 was used, and the following years, the values were obtained by adding the investment and subtracting depreciation from the previous period.[3]

The variables gross output and materials were deflated by the "wholesale price index" (IPA), reported by the Getúlio Vargas Foundation (FGV). The capital was deflated by the "implicit capital formation deflator" published by IBGE. [4] Production share (sh_{it}) was calculated based on the share of gross output of all industries in manufacturing sector. We used the production share as an instrumental variable (IV) our analysis. Another IV applied was the nominal value of industrial parts pt that composes material input.

Input shares were created from the nominal series. The shares of material α^M and labor α^N are constructed by dividing respectively the undeflated "Salaries" and "Industrial Operations Costs" by undeflated "Industrial Gross Product Value". For the blue collar and white collar salary, the nominal values of the salary mass of the two types of workers were used. The export and import penetration coefficients are released by the National Confederation of Industry (CNI). In this case, the variables level is more aggregated, that is, grouped by two-digit manufacturing industry data from the CNAE. The descriptive statistics of the main variables used in this study were reported in Table 1.

Table 1: Summary Statistics

			Percentiles		
Variable	Mean	Std. Dev.	P25	P50	P75
Materials	115481.5	519614.1	7955.15	19884.5	59521.09
Capital	210798.2	798033.6	13212.09	31590.42	96364.98
Gross Product	183254.6	779653.4	15545.42	34734.79	96675.98
Labor	314.31	677.86	99.5	145.4	275.56
Labor share [$=\alpha^N$]	0.13	0.06	0.09	0.13	0.17
Material share [$=\alpha^M$]	0.57	0.11	0.49	0.56	0.64
Imports coef.	15.63	11.58	4.5	12.88	25.6
Exports coef.	14.16	9.2	7.23	12	20.04
Production share [$=sh$]	0.0029	0.0121	0.0002	0.0006	0.0016

Number of observations: 2133

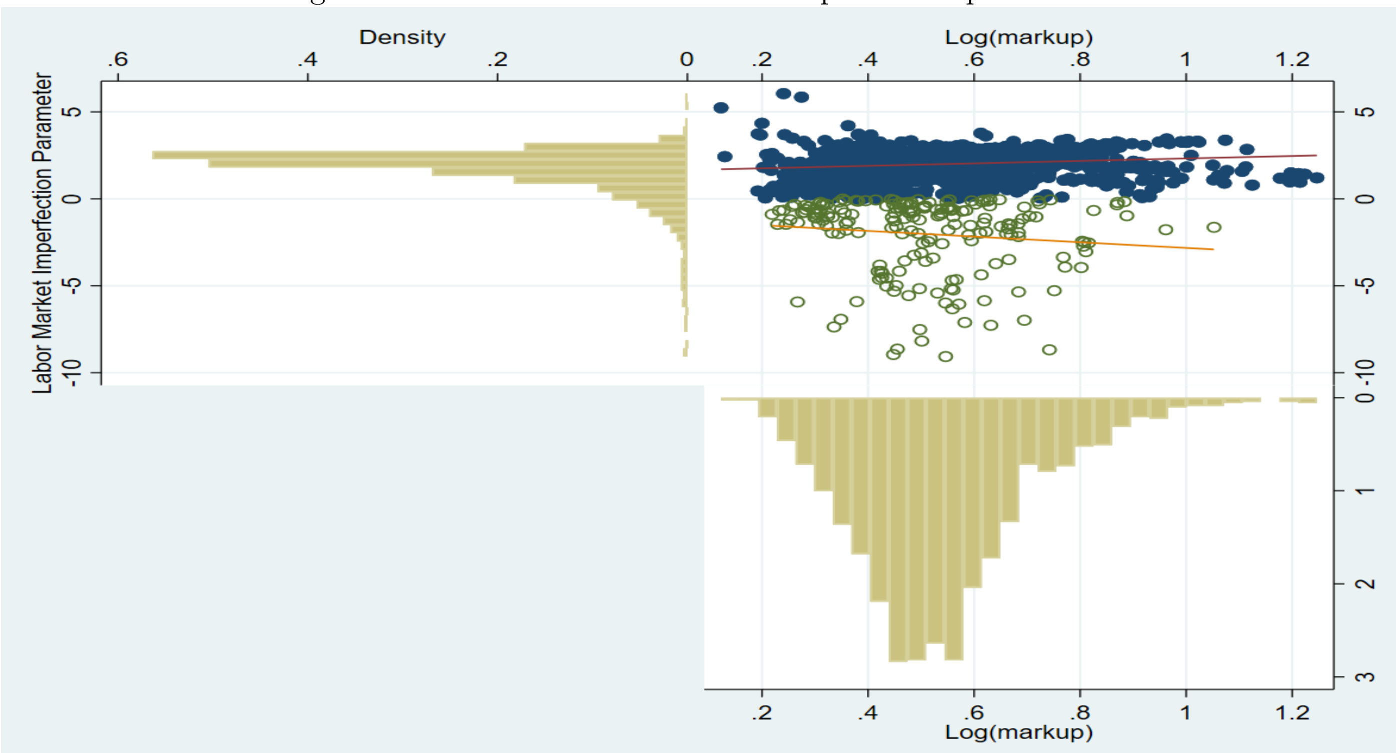
[3] The data investment and depreciation are available at PIA-Enterprise.

[4] All monetary variables were expressed in terms of constant 2010 BRL.

4 Results

The results of this study can be divided into two parts. The first part concerns the estimation of markups, μ and the classification of the type of competition that prevails in the industries' labor market through the parameter ψ. Since the methodology makes it possible to compute μ and ψ for each of the database industries at each time, the results take the form of histograms.[5] To recover μ and ψ, the elasticities computed from the translog production function estimation were used.[6]

Figure 1: Product and labor market imperfection parameters



Source: The authors.

Figure 1 shows the distributions and a scatterplot for logged markup, $\ln\widehat{\mu}$, and labor market imperfection parameter, $\widehat{\psi}$. The blue circles represent positives estimates for $\widehat{\psi}$ and the red line are the respective fitted values. Similarly, the hollow green circles represent negatives estimates for $\widehat{\psi}$ and the orange line are the respective fitted values. Both the markup and the labor market imperfection parameter are highly heterogeneous, that is, the computed values represent a relatively long interval.[7] About the first, an average value of 1.7 stands out. As compared to Lucinda and Meyer [2013], which found an average price of 2.4 times the marginal cost, this result may indicate an increase in the competition of the Brazilian manufacturing industry, since their analysis ranged from 1996 to 2007.

However, Lucinda and Meyer [2013] estimate a value added production function, while in this article the gross output was used. According to Basu and Fernald [2002], under the gross output perspective, it is expected to find lower values for markups than under the added value approach. This is because it is not possible to know, from the perspective of gross output, when the final product was used as

[5]Due to the current conditions of the GMM, it was not possible to recover the estimates for 2007.

[6]The standard errors of the estimated parameters of the production function were obtained through bootstrap (500 replications).

[7]Especially in relation to the labor market imperfection parameter.

an intermediate good. On the other hand, the value added approach admits no distortions in labor market for recovering markup. Regarding international literature, De Loecker and Scott [2016] stands out, in which the authors, when estimating a translog gross output production function, find an average markup of 1.4 for the United States brewing industry.

The imperfection parameter ψ presents a high concentration in positive values, which indicates the predominance of the efficient bargaining regime in the Brazilian labor market. In addition, many computed values are close to zero, suggesting perfect competition. The classification procedure is applied by means of two criteria as described in the Methodology section at 90% and 95% of significance. Table 2 shows that the perfect competition regime prevails and that there are no observations classified as monopsony in all cases. At 95% significance level, the perfect competition regime contemplates 89.35% (93.41%) of the data and the efficient bargain, 10.65% (6.59%) for the first criteria (second criteria). Dobbelaere and Kiyota [2018], using a procedure similar to the second criteria, found, based on data at the firm level, that the dominant scenario in the Japanese labor market is efficient bargaining (42%), followed by perfect competition (30%) and monopsony (28%).

Table 2: Proportion of the sample for each competition regime in the labor market

	Criteria I		Criteria II	
	IC 90	IC 95	IC 90	IC 95
Perfect competition	78.80%	89.35%	84.18%	93.41%
Efficient bargaining	21.20%	10.65%	15.82%	6.59%
Monopsony	-	-	-	-

Source: The authors.

Once the dummy variables that represent the competition regimes in the labor market were created, we can correlate price-cost markup to labor market imperfections. To do so, we applied the linear probability model (LPM) and probit regression techniques. An obvious question is whether the model suffers from simultaneity bias. It is reasonable to admit that product and labor market imperfections affect each other simultaneously. One could argue that the theoretical approach corroborates this kind of endogeneity issue since we are recovering markups and classifying the type of competition in labor market from related expressions. Table 3 presents the results in which an IV technique takes into account the endogeneity of this specification.

Table 3: Regression of the regime of competitiveness in labor market on price-cost markup

	Criteria I[a]				Criteria II[b]			
	(IC-90)		(IC-95)		(IC-90)		(IC-95)	
	LPM†	Probit dF/dx‡	LPM†	Probit dF/dx‡	LPM†	Probit dF/dx‡	LPM†	Probit dF/dx‡
$\ln \widehat{\mu}$	1.122***	1.151***	0.752***	0.515	0.898***	1.384**	0.510***	-0.266
	(0.178)	(0.272)	(0.164)	(0.884)	(0.180)	(0.627)	(0.132)	(1.471)
Productivity	-0.972***	-0.720***	-0.633***	-0.241	-0.849***	-1.005*	-0.443***	0.395
	(0.131)	(0.0552)	(0.116)	(0.732)	(0.128)	(0.581)	(0.0990)	(1.206)
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes
Instruments[c]	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1659	1659	1659	1659	1659	1659	1659	1659
I- Underidentification (p-value)[d]	0.0013		0.0013		0.0013		0.0013	
II- Overidentification (p-value)[e]	0.583		0.620		0.657		0.588	
III- Endogeneity (p-value)[f]	0.0007		0.0014		0.0000		0.0031	
IV- Weak identification (F statistic)[g]	32.71		32.71		32.71		32.71	

Source: Authors' elaboration.

† Linear probability model.

‡ Average marginal effects of probit model.

Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Note: All regressions include n, m, k, imp, exp and constant as controls. Standart Errors are robust to heteroskedasticity and autocorrelated within-group disturbances.

[a] confidence interval were computed directely from $\widehat{\psi}_{it}$ through delta method.

[b] confidence interval were computed for $\frac{(\widehat{\varepsilon}_{it}^{M})}{\widehat{\alpha}_{it}^{M}}$ and $\frac{(\widehat{\varepsilon}_{it}^{N})}{\widehat{\alpha}_{it}^{N}}$ separately through delta method.

[c] Instruments used are: sh and pt, both dated (t-1).

[d] LM test in which the null hypothesis that the equation is underidentified.

[e] Hansen's J test: the null hypothesis that the instruments are valid.

[f] The null hypothesis is that the endogenous regressor can be treated as exogenous.

[g] Wald test versions of the Kleibergen-Paap for weak identification.

Materials, capital, labor, and export and import coefficients are included as controls. Despite not being the main focus of this study, productivity represents an important control for the model since it has a strong relationship with the price-cost markup. There is a selection mechanism in which the most productive firms will have more market share and, consequently, higher markpus. To properly investigate the relationship between imperfections in the labor and product markets, we control for productivity.

The results show a positive correlation of productivity and perfect competition in labor market. Our findings suggest that more productive industries are associated with a higher flexibility of labor input market, as highlighted by Syverson [2011]. In the context of efficient bargaining, market power can be attributed to employees through costs of firing, hiring and training. This type of market distortion increases the gap between marginal products of labor and wage, resulting in decreased productivity and loss of allocative efficiency (Petrin and Sivadasan [2013]).

From Table 3 we also note that the probability for the industry to be characterized by an efficient barganing process rises as markup increases. The positive correlation between worker's bargain power and price-cost markups has already been pinpointed by Dobbelaere [2004] and Soares [2019]. The assumption is that unions and labor institutions are more likely to establish themselves if workers perceive that firms have market power. Once firms are able to extract rent from consumers, workers will try to get some of that rent for themselves. This interpretation runs from product market to labor market imperfection.

Due to the simultaneity problem already mentioned, we can argue in the opposite direction, that is, from labor market to product market imperfection. In this case, a decrease in the bargaining power of workers should enlarge rents left to firms and lead to an increase in the entry process. Therefore the competition increases and markups decrease as the long-run equilibrium proposed by Blanchard and Giavazzi [2003].

The additional variables used as instruments were lagged values of production share sh and industrial parts pt. An appropriate set of instruments must be exogenous, which means that it should affect the regime of competition in the labor market only through price-cost markup. There is no reason to believe that the set of instruments can affect the workers' ability to mobilize or influence the costs of hiring, firing and training.[8] The lagged values help to guarantee the exogeneity hypothesis. Simultaneously, instruments set are strongly correlated to price-cost markup. Production share is good proxy for market-share in a firm level analysis, which is positively correlated to markup. The material input includes industrial parts which are correlated to markup since we recover markups through material input.

This result suggests that price-cost markup translates into higher wage markup. The following section presents a sensitivity analysis approach to find empirical evidence for correlation between product and labor market competition.

5 Sensitivity analysis

We propose the classification of labor market regimes by another criterion, more specifically following Dobbelaere and Mairesse [2018]. Three tolerance possibilities for (im)perfect competition are defined. (i) As cutoff of $|1|$: 1) if $-1 < \psi_{it} < 1$, perfect competition prevails in labor market; 2) if $\psi_{it} < -1$, monopsony power prevails in labor market; if $\psi_{it} > 1$, efficient bargain prevails in labor market. (ii) As cutoff of $|0.5|$: 1) if $-0.5 < \psi_{it} < 0.5$, perfect competition prevails in labor market; 2) if $\psi_{it} < -0.5$, monopsony power prevails in labor market, 3) if $\psi_{it} > 0.5$, efficient bargain prevails in labor market.

[8] The set of instruments are also expected to be unrelated to job vacancies preferences that characterize the monoposony power in the labor market.

(iii) As cutoff of $|0.25|$: 1) if $-0.25 < \psi_{it} < 0.25$, perfect competition prevails in labor market; 2) if $\psi_{it} < -0.25$, monopsony power prevails in labor market; 3) if $\psi_{it} > 0.25$, efficient bargain prevails in labor market.

Cutoffs values were chosen so that the distribution of observations between competition regimes in the labor market was done in a balanced way. Table 4 presents, for each cutoff level, the proportion of the sample in each competition regime.

Table 4: Proportion of the sample for each competition regime in the labor market

	Cutoff value		
	(i)	**(ii)**	**(iii)**
Perfect competition	15.72%	7.54%	3.53%
Efficient bargaining	78.54%	84.76%	87.45%
Monopsony	5.64%	7.70%	9.02%

Source: The authors.

Finally, we grouped efficient bargain and monopsony regimes to create a new variable that assumes value 1 if the regime of competition in the labor market is imperfect, and zero otherwise.

The interesting results obtained from this new regime classification criterion are reported in Table 5. The probability of setting labor market as imperfect competition increases when markups are higher. The literature that properly addresses how a decrease competition in the labor market could increase price-cost markup is scarce. In the proposed monopsony power model, the elasticity of labor supply is less than infinity which reflets heteregeneous preferences over workplace environments of different potential employers. In order to improve the tests statistics, the set of instruments includes the lagged levels of sh and pt dated $(t-1)$ and $(t-2)$.[9]

Therefore, from Tables 3 and 5, we observe strong empirical evidence indicating that perfect competition in the labor market is associated with lower price-cost markups. Thus, the results suggest that when wages are set exogenously, the market power of the manufacturing industry decreases.

To corroborate this analysis, we applied a different approach; instead of adopting strategies to classify the labor market, the absolute value of the $\left|\widehat{\psi}\right|$ imperfection parameter was used as the dependent variable. Results are presented in Table 6 and suggest that $\ln \mu$ has a positive effect on $\left|\widehat{\psi}\right|$. Although a straightforward interpretation of the new specification is nonsensical, it should be noted that as the value of $\left|\widehat{\psi}\right|$ increases, the more distant it becomes from a perfect competition regime in the labor market. Therefore, we found evidences of a positive correlation between competition in the labor market and competition in the final product market. Since observable industry characteristics might correlate with unobservable industry characteristics, such as workplace environment, we opt to account for possible industry fixed effects in this approach. Since our dependent variable was a binary one in the baseline scenario, treating for fixed effect becomes troublesome.

6 Final remarks

This paper has investigated how market power (price-cost markup) relates to the competition in labor market. Our results show that the gap between the marginal revenue and the marginal cost of

[9]Hansen's J statistics show better when an additional lag was implemented as instrument.

Table 5: Regression of the regime of competitiveness in labor market on price-cost markup

	(i)		(ii)		(iii)	
	LPM†	Probit $dF/dx^{\ddagger}$	LPM†	Probit $dF/dx^{\ddagger}$	LPM†	Probit $dF/dx^{\ddagger}$
$\ln \widehat{\mu}$	1.734***	1.474***	1.083***	0.814**	0.514***	0.308
	(0.247)	(0.536)	(0.221)	(0.364)	(0.169)	(0.210)
Productivity	-0.979***	-1.213***	-0.512***	-0.618**	-0.265***	-0.270
	(0.123)	(0.423)	(0.0937)	(0.305)	(0.0677)	(0.184)
Time dummies	yes	yes	yes	yes	yes	yes
Instruments[c]	yes	yes	yes	yes	yes	yes
Observations	1422	1422	1422	1422	1422	1422
I (p-value)	0.0000		0.0000		0.0000	
II (p-value)	0.1750		0.2260		0.6170	
III (p-value)	0.0000		0.0017		0.0223	
IV (F statistic)	38.10		38.10		38.10	

Source: Authors' elaboration.

† Linear probability model.

‡ Average Marginal effects of probit model.

Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Note: All regressions include n, m, k, imp, exp and constant as controls. Standart Errors are robust to heteroskedasticity and autocorrelated within-group disturbances.

[c] Instruments used are: sh and pt, both dated (t-1) and (t-2).

I-IV: We applied the same tests as in Table 3.

labor (wage markup or wage markdown) is interconected to the gap between price and marginal cost (price-cost markup).

First, we identified market power in the product and labor market. We set confidence intervals to classify the regime that prevails in the labor market of each industry at a given time. The results showed a predominance of perfect competition, although part of the observations were classified as an efficient bargain. The markup presented great variability and an average value of 1.7.

After finding an appropriate set of instruments to purge the endogeneity bias, we regressed the type of competition in labor market on price-cost markup. The results indicate that higher markup industries are more likely to be classified as efficient bargaining in relation to perfect competition in labor market. The results also show that perfect competition in the labor market is associated with perfect competition in the product market. These evidences would support that a higher competition of product market stimulates perfect competition in labor market. In order to better investigate this aspect, another criterion for the classification of regimes in the labor market was adopted. The findings corroborates the initial results.

The conclusions of this study are in accordance with the ideas of Syverson [2011]. According to the author, market power can be thought of as a measure of flexibility; that is, in competitive markets, it is easier for consumers to change their purchases from one producer to another. Thus, it is logical to assume that flexibility in input and product market are correlated. As productive factors move freely, companies and potential entrants may hire inputs more easily to accommodate eventual changes in demand. Thus, this study has empirically evidenced how competition in labor markets are negatively correlated with increased market power. Therefore, public policies that encourage competition in the product market would contributes for enhancing competition in the labor market.

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A Labor market imperfections

A.1 Perfect competition

Under perfect competition in the labor market, we can write:

$$\varepsilon_{it}^{Q,N} = \mu_{it}\alpha_{it}^{N} \tag{21}$$

$$\varepsilon_{it}^{Q,M} = \mu_{it}\alpha_{it}^{M} \tag{22}$$

where $\frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} = \frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}} = \mu_{it}$. Thus, the labor market imperfection parameter assumes zero value, $\psi = \frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} - \frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}} = 0$

A.2 Efficient Bargain

If we admit imperfect competition in the labor market, so that wages are formed by an efficient negotiation process between firms and unions, we have that wage determination is implemented as a maximization of a bargain function *à la* Nash, that is:

$$\max_{w_{it},N_{it},M_{it}} \left\{N_{it}w_{it} + \left(\bar{N}_{it} - N_{it}\right)\bar{w}_{it} - \bar{N}_{it}\bar{w}_{it}\right\}^{\phi_{it}} \left\{R_{it} - w_{it}N_{it} - j_{it}M_{it}\right\}^{1-\phi_{it}} \tag{23}$$

The efficient bargaining process involves setting (w_{it}), employment (N_{it}) and input materials (M_{it}). The union is risk neutral and its objective function is to maximize $U(w_{it}, N_{it}) = N_{it}w_{it} + (\bar{N}_{it} - N_{it})\bar{w}_{it} - \bar{N}_{it}\bar{w}_{it}$, where $\bar{N}$ is the number of union members ($0 < N \leq \bar{N}$) and $\bar{w}_{it} \leq w_{it}$ is the alternative wage (that is, a weighted average of wages in alternative markets and unemployment insurance).

The firm's objective is to maximize the short-term profit given by $\pi_{it} = R_{it} - w_{it} - j_{it}M_{it}$, where $R_{it} = P_{it}Q_{it}$ represents total revenue. The parameter $\phi_{it} \in [0,1]$ represents the bargaining power of workers. The first-order conditions obtained from 23 are:

$$[M_{it}] : R_{it}^{M} = j_{it} \tag{24}$$

$$[w_{it}] : w_{it} = \bar{w}_{it} + \gamma_{it}\left[\frac{R_{it} - w_{it}N_{it} - j_{it}M_{it}}{N_{it}}\right] \tag{25}$$

$$[N_{it}] : w_{it} = R_{it}^{N} + \phi_{it}\left[\frac{R_{it} - R_{it}^{N}N_{it} - j_{it}M_{it}}{N_{it}}\right] \tag{26}$$

Where $\gamma_{it} = \frac{\phi_{it}}{1-\phi_{it}}$ represents the relative bargain, R_{it}^{N} and R_{it}^{M} are the labor and material marginal revenue, respectively. The equation 24 results in the relationship obtained in 22, while simultaneously solving for 25 and 26 we find the expression of the contract curve:

$$R_{it}^{N} = \bar{w}_{it} \tag{27}$$

The equation 27 shows that, under the risk neutrality hypothesis, the firm adopts the same level of employment as in the competitive case (without bargaining), that is, the one that equates salary to alternative wage. Marginal revenue, marginal revenue of labor and marginal product of labor are defined by R_{it}^{Q}, R_{it}^{N} and Q_{it}^{N}, respectively. Using the fact that $\mu_{it} = \frac{P_{it}}{R_{it}^{Q}}$, we can establish that $R_{it}^{Q}Q_{it}^{N} = R_{it}^{Q}\varepsilon_{it}^{Q,N}\frac{Q_{it}}{N_{it}} = \frac{P_{it}Q_{it}^{N}}{\mu_{it}}$. By manipulating this expression together with 27, the following expression is obtained for the elasticity of the product:

$$\varepsilon_{it}^{Q,N} = \mu_{it}\left(\frac{\bar{w}_{it}N_{it}}{P_{it}Q_{it}}\right) = \mu_{it}\bar{\alpha}_{it}^{N} \tag{28}$$

Rewriting the equation 25 as $\alpha_{it}^{N} = \bar{\alpha}_{it}^{N} + \gamma_{it}\left[1 - \alpha_{it}^{N} - \alpha_{it}^{M}\right]$ and replacing in 28, we find:

$$\varepsilon_{it}^{Q,N} = \mu_{it}\alpha_{it}^{N} - \mu_{it}\gamma_{it}\left[1 - \alpha_{it}^{N} - \alpha_{it}^{M}\right] \tag{29}$$

Since $\frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} = \mu_{it}$, the labor market imperfection parameter can be set as:

$$\psi_{it} = \frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} - \frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}} = \mu_{it}\gamma_{it}\left[\frac{1 - \alpha_{it}^{N} - \alpha_{it}^{M}}{\alpha_{it}^{N}}\right] \tag{30}$$

A.3 Monopsony power

In perfect competition and efficient bargain regimes, it has been admitted that the labor supply is perfectly elastic, that is, a reduction in wages by the employer would cause a waiver of the entire job offer. Suppose a monopsonistic firm operating in an imperfect competition product market, which faces a labor supply curve as a increasing with wages and invertible function. The firm's objective, in the short run, is to maximize the profit function given the labor supply curve, that is:

$$\max_{N_{it},M_{it}} \pi\left(w_{it}, N_{it}, M_{it}\right) = R_{it}\left(N_{it}, M_{it}\right) - w_{it}\left(N_{it}\right) N_{it} - j_{it} M_{it} \tag{31}$$

The first order condition in relation to the materials used as inputs results in $R_{it}^{M} = j_{it}$, as well as 24. Maximization with respect to labor produces the following condition:

$$w_{it} = \beta_{it}\left(R_{it}^{N}\right) \tag{32}$$

Where $\beta_{it} = \frac{\varepsilon_{it}^{N,w}}{1+\varepsilon_{it}^{N,w}}$ and $\varepsilon_{it}^{N,w}$ represents the elasticity of labor supply in relation to wages. From 32, it can be seen that the market power resulting from monopsony, measured by the relationship $\frac{R_{it}^{N}}{w_{it}}$, depends negatively on $\varepsilon_{it}^{N,w}$. The more inelastic the labor supply curve in relation to wages, the greater the difference between marginal revenue of labor and wages. This difference is known as the exploitation rate $\left(\frac{R_{it}^{N}-w_{it}}{W_{it}} = \frac{1}{\varepsilon_{it}^{N,w}}\right)$ and from it we are able to rewrite the equation of output elasticity of labor:

$$\varepsilon_{it}^{Q,N} = \mu_{it}\alpha_{it}^{N}\left(1 + \frac{1}{\varepsilon_{it}^{N,w}}\right) \tag{33}$$

Finally, the imperfection parameter of labor market, in the case of monopsony, is expressed by:

$$\psi_{it} = \frac{\varepsilon_{it}^{Q,M}}{\alpha_{it}^{M}} - \frac{\varepsilon_{it}^{Q,N}}{\alpha_{it}^{N}} = -\mu_{it}\frac{1}{\varepsilon_{it}^{N,w}} \tag{34}$$

B Additional output

Table 6: Sensitivity analysis: $\left|\widehat{\psi}\right|$ as dependent variable

	(a)	(b)
$\ln \widehat{\mu}$	7.053***	4.851**
	(1.444)	(2.074)
Produtividade	-3.700***	-2.760***
	(0.545)	(0.270)
import coefficient	-0.0137	-0.0156
	(0.0106)	(0.0119)
export coefficient	0.00516	0.00579
	(0.00559)	(0.00449)
Log(Capital)	0.656***	0.379**
	(0.187)	(0.156)
Log(Materiais)	0.613*	0.276
	(0.321)	(0.407)
Log(Pessoal ocupado)	-1.610***	-1.025
	(0.502)	(0.660)
Observations	1896	1185
I (p-value)		0.000
II (p-value)		0.327
III (p-value)		0.823
IV (F statistic)		97.19

Source: Authors' elaboration.

Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Note: Standart Errors are robust to heteroskedasticity and autocorrelated within-group disturbances.

I-IV: We applied the same tests as in Table 3.

(a) This table reports results using a industry fixed effect model but there are no additional instruments.

(b) Instruments used are: *sh* and *pt*, both dated (t-1), (t-2) and (t-3). We control for industry fixed effects.