Is firm performance achieved by fairness or tournaments? Evidence from Brazilian matched data*

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Abstract

Theory and evidence are ambiguous about the effect of within-firm wage inequality on firm performance. This paper tests empirically this relationship drawing on detailed Brazilian matched employer-employee panel data and considering alternative measures of inequality and performance. We find overwhelming evidence of a positive relationship between wage dispersion and firm performance when using cross-section analysis. However, this relationship weakens when considering controls for firm unobserved heterogeneity.

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1 Introduction

Relative wages are important determinants of workers' effort, since workers compare their wages with those of their peers. Within-firm wage dispersion is believed to exert some power over the workers' individual productivity and consequently on firm performance.

From the late 1990s onwards, few empirical studies have sought to answer the following questions: Can a larger (smaller) within-firm wage dispersion improve workers' performance in terms of effort and productivity? Can such compensation scheme represent better performance for these firms? These questions were raised in the theoretical studies originally developed by Lazear & Rosen (1981), Akerloff & Yellen (1988) and Akerloff & Yellen (1990).

These theoretical studies provide contradictory answers to the questions above. While the study by Lazear & Rosen (1981) states that a larger wage dispersion acts as incentive for workers' improved effort and productivity, the paper by Akerloff & Yellen (1990) considers that such inequality deteriorates the working environment and productivity due to the feeling of unfairness shared amongst workers.

Just as in the theoretical case, the available empirical studies have not yielded consistent results, as shown in the in-depth review of empirical studies on pay and performance available in Lallemand et al. (2007).

The following studies corroborate, either partially or totally, the hypothesis of a negative relationship between wage dispersion and firm performance: DeBrock et al. (2001) and Martins (n.d.). On the other hand, the following studies corroborate, either partially or totally, the hypothesis of a positive relationship between wage dispersion and firm performance: Main et al. (1993), Winter-Ebmer & Zweimuller (1999), Eriksson (1999), Hibbs & Locking (2000), and Heyman (2005)[1]. Moreover, the works by Lallemand et al. (2004), and Lallemand et al. (2007) support the tournament theory. The study by Leonard (1990) does not establish any significant relationship.

The present paper shows that there is a paucity of empirical studies on this issue and that in many cases they are restricted to the analysis of sectors (or professional segments) that are quite specific to developed economies. The lack of empirical tests for developing economies is a particular characteristic of this literature.

The present paper provides empirical evidence for the Brazilian economy using informa-

[1]A further description (database, methodology, econometric methods, etc) of these works is presented in Lallemand et al. (2007).

tion from three different databases: RAIS (Annual Social Information Report issued by the Ministry of Labor and Employment), PIA (Annual Industrial Survey published by the Brazilian Institute of Geography and Statistics) and PAS (Service Annual Survey by the Brazilian Institute of Geography and Statistics). The richness of information obtained from the combination of these databases allow for a comprehensive analysis of the sectors that make up the Brazilian economy.

The empirical test is based on the sampling of manufacturing firms and service firms in the 1998-2001 period. Alternative measures of within-firm inequality are used and firm performance is determined by the profits and added value per worker. Different econometric models are introduced so as to deal with possible biases related to OLS estimates. The paper provides results for the relationship between wage inequality and performance obtained from estimates based on cross-sectional and longitudinal analysis. In this regard, OLS estimates, quantile regressions, instrumental variables, fixed effects and fixed-effects regression with instrumental variables are introduced. This paper provides evidence of a positive relationship between wage dispersion and firm performance for most of the econometric tests used.

The remainder of this paper is organized as follows. Section 2 presents the theoretical arguments of tournament, equity and fairness models, as well as a survey of the empirical literature on the topic. Section 2 presents the data, some descriptive statistics and the measures of inequality used. Sections 3 and 4 present the results. Finally, Section 5 concludes.

2 Data

The present paper uses information from three databases: (1) RAIS[2]; (2) PIA; and (3) PAS. The study assesses the 1998-2001 period, and all nominal variables used herein are calculated using the prices for 1998, deflated by the Brazilian consumer price index (INPC).

The sample used herein includes information about a balanced panel of 7,689 firms, of which 4,990 belong to the manufacturing sector and 2,699 to the service sector.

The sample was constructed so as to allow the inclusion of over 50 employees per firm during the study period. This restriction allows obtaining sufficient degrees of freedom for the estimation of wage regressions for every firm and every year, as will be elucidated in the subsequent paragraphs.

[2]See Martins & Esteves (2006).

Owing to some distortions of the profit variable in the PAS and PIA databases, the sample is restricted to firms whose profits lie on central 95% distribution of profit sharing per worker throughout the study period.

The RAIS information is used here in two distinct ways: (1) in the first stage, individual information on the workers is used to calculate a conditional measure of inequality through the residuals of a wage regression (this issue will be further developed in the subsequent section); (2) in the second stage, the means for the human capital variables per firm are used in firm performance regressions.

In the first stage above, individual information about nearly 1,300,000 workers/year (740,000 from the manufacturing sector and 560,000 from the service sector) was used.

The list of variables used in the second stage of regressions, i.e., in the firm performance regressions, is shown in Table 8 at the end of this paper. Tables 1, 9 and 10 show the descriptive statistics of these variables for the whole set of firms, for the set of manufacturing firms and for the set of service firms, respectively.

The following key points should be highlighted regarding Tables 1, 9 and 10: (a) service firms employ on average more workers than do manufacturing firms; (b) except for 1998, the profits per average worker in manufacturing firms were higher than those in service firms; (c) profit dispersion in the manufacturing sector was larger than in the service sector; (d) manufacturing firms were more unequal than those in the service sector; (e) except for the sigma values, all other measures of inequality increased considerably in 2001.

As to the comparisons of human capital, both sectors had similar means for educational level and female participation in the labor force. Workers in the manufacturing sector are younger, but their job tenure is longer.

2.1 Inequality measures

We use two types of measurements for wage dispersion, namely, conditional and unconditional measures of inequality. Unconditional measures do not contemplate worker heterogeneity in terms of the observed characteristics of human capital (educational level, gender, job tenure, experience, and age).

Three different unconditional measures are used to assess wage inequality in the present paper: (i) standard deviation of the wages of firm j at time t; (ii) coefficient of wage differential of firm j at time t; and (iii) ratio between the minimum and maximum wages observed at firm j at time t.

A limitation of the use of unconditional measures of inequality is that large worker heterogeneity in a given firm may imply large wage dispersion that is not brought about by an incentive policy.

An appropriate test for the relationship between within-firm wage dispersion and performance should take into account the extent of wage dispersion among homogeneous workers. A way to circumvent this problem is to use standard errors of a wage regression (sigma), as suggested by Winter-Ebmer & Zweimuller (1999). In this case, the test is performed in two stages, the first of which consists in obtaining wage regressions for each firm/year, according to the following specification:

$$ln(w_i) = \mathbf{x}_i\beta' + \epsilon_i, \tag{1}$$

where $ln(w_i)$ is the log of hourly wage of individual i; and $\mathbf{x}_i$ is a vector of variables related to the attributes of worker i. After obtaining the regressions for each firm/year, the conditional measure of inequality will be the standard error of wage regression (sigma), as specified below:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{n}\left[ln(w_i) - \widehat{ln(w_i)}\right]^2}{(n-k)}}, \tag{2}$$

where σ_j represents the standard error of wage regression for firm j; $\widehat{ln(w_i)}$ is the value estimated for the log of the hourly wage of individual i; and n-k are the degrees of freedom.

This study uses individual information about approximately 1,300,000 workers/year employed at 7,689 firms, i.e., in the first stage, nearly 7,689 regressions/year were calculated. Information on educational level, gender, job tenure and age of workers was used as control in wage regressions.

The second stage includes wage dispersion variables (either conditional or unconditional) as firm performance determinants. Unlike wage regressions of the first stage (worker level), performance regressions include only information on the human capital of the workforce at the firm level, i.e., information on the means of human capital variables per firm.

3 Results - Cross-Sectional Analysis

This section describes the results of performance regressions (second stage of Winter-Ebmer & Zweimuller (1999)) for Brazilian firms. The analyses used herein are categorized into three different sets of results: (1) ordinary least squares (OLS) estimates, (2) quantile regressions and (3) instrumental variables (IV).

3.1 OLS

Here we present the results obtained from OLS estimates for each sampled year. The econometric model is specified in the equation that follows:

$$ln(P/n)_j = M_{zj}\beta + \mathbf{x}_j\delta' + \mathbf{f}_j\varphi' + \epsilon_j, \quad (3)$$

where the dependent variable is the ln of profit (or the ln of the added value) per worker at firm j; M is the measure of inequality or wage dispersion and subscript z is the set of different measures of inequality, where $z =$ [sigma; standard deviation; coefficient of variation; maxmin ratio]; $\mathbf{x}$ is the vector of variables related to the characteristics of the workers employed at firm j; and $\mathbf{f}$ is the vector of variables related to the characteristics of firm j. The Greek letters represent the parameters.

Just as in the study conducted by Lallemand et al. (2004), the functional specification of the performance regression with the log of profits per worker is used as dependent variable.

Cross-sectional regressions were obtained for each sampled year and for each of the four wage dispersion measures, thus totaling 16 different regressions. The results are demonstrated in Table 11. All the coefficients of wage dispersion measures have a positive sign, but the results are not significant for the sigma and maxmin ratio in 1998, or for the sigma, coefficient of variation and maxmin ratio in 1999.

A problem with the functional specification of Lallemand et al. (2004) is that by using the ln of profits per worker as dependent variable, a strong restriction is imposed on the sample, since only the information on firms with positive results (profits) will be taken into account. This implies the loss of a large number of annual observations, which are equivalent to those of firms with negative financial results for the period.

An alternative is the use of the ln of the added value of firms as dependent variable. This improves the quality of the functional specification without the loss of a large number of observations[3]

Cross-sectional analyses were obtained again for each year and for each of the four wage dispersion measures, using the econometric specification with the ln of the added value per worker in this case. The results can be seen in Table 2. Just as in the results displayed in Table 11, all of the 16 coefficients have a positive sign, being statistically significant at the 1% significance level.

By comparing the results in Tables 11 and 2, the specification with the ln of the added value (Table 2) improves the statistical significance of the tests and also prevents the large loss of observations comparatively to the results in Table 11 (approximately 2,400 observations of firms per year)[4].

Tables 3 and 4 show the results of the cross-sectional regressions separately obtained for the manufacturing and service sectors, respectively. All coefficients have a positive sign and are significant at the 1% significance level. Except for the coefficient of the maxmin variable for 1998, all other coefficients are higher for the manufacturing sector than for the service sector.

The evidence above suggests a positive relationship between within-firm wage dispersion and economic performance for Brazilian firms. It also suggests that incentives generated by wage inequality are even more effective in the case of manufacturing firms.

The second piece of evidence seems to corroborate the argument by Milgrom (1988) and Milgrom & Roberts (1990). The idea is that white-collar workers (more intensive work in the service sector) tend to withhold information from managers in order to increase their influence (e.g.: to get a promotion, to get prizes) and to engage in rent seeking activities instead of productive work. In this regard, the implementation of some wage compression is desirable for these workers.

As stated by Lazear (1989) e Lazear (1995), the low impact of inequality on the performance of service firms may be associated with the fact that this sector has a larger number of non-cooperative workers (hawks) compared to the manufacturing sector (with a larger number of cooperative workers or doves).

[3]The authors seem to recognize this strong restriction in the study undertaken by Lallemand et al. (2004), since in Lallemand et al. (2007), they use the ln of the added value as dependent variable.

[4]The next subsections use only the specifications with the ln of the added value per worker as dependent variable.

The results presented so far indicate strong evidence in favor of the hypothesis of a positive relationship between within-firm wage dispersion and economic performance for the Brazilian case. This evidence is corroborated by unconditional measures and also by the sigma conditional measure of inequality[5].

However, note that the results obtained from OLS estimators may be biased. The next sections will deal with these problems and will provide the results obtained from alternative econometric methods.

3.2 Quantile Regression

The first restrictive hypothesis of OLS estimates rests upon the fact that these estimates are based on the mean conditional distribution of the dependent variable of the econometric model. This approach implicitly assumes that the possible differences in the impact of exogenous variables on the conditional distribution of the dependent variable are negligible (Martins & Pereira (2004)).

If the exogenous variables exert some influence on the parameters of the conditional distribution of the dependent variable, differently from the mean, the analysis at issue will be severely weakened (Koenker & Bassett (1978)). The aim of this section is to assess the coefficients with regard to the relationship between wage inequality and firm performance using quantile regression. Differently from OLS estimates, the quantile regression models fully characterize the conditional distribution of the dependent variable.

In a specification of the firm performance equation, the quantile regression model can be written as:

$$ln(P/n)_j = \mathbf{z}_j \beta'_\theta + u_{\theta j} \tag{4}$$

with

$$Quant_\theta[ln(P/n)_j|\mathbf{z}_j] = \mathbf{z}_j \beta'_\theta, \tag{5}$$

where $\mathbf{z}_j$ is a vector of exogenous variables (which include M_j, $\mathbf{x}_j$ e $\mathbf{f}_j$) and β'_θ is a vector of parameters. $Quant_\theta[ln(P/n)_j|\mathbf{z}_j]$ denotes the θth conditional quantile of $ln(P/n)$ given $\mathbf{z}$.

The coefficients β for the 1st, 10th or 90th percentiles are obtained, for instance, by setting

[5] As previously mentioned, the sigma measure is preferable to any other measure as far as the purpose of this study is concerned. The next sections will use specifications with the sigma measure only.

θ=0.01, θ=0.10, and θ=0.90, respectively. In this paper, we present the coefficients obtained for the 10th, 25th, 50th, 75th and 90th percentiles (dubbed P10, P25, P50, P75 and P90, respectively).

Tables 5, 12 and 13 show the results of quantile regressions for all firms, for manufacturing firms and for firms in the service sector, respectively. All coefficients have a positive sign and in most cases, they are statistically significant. Cases of nonsignificant coefficients were commonly found in the regressions with the sample that included all firms and with those obtained from the 10th percentile of the conditional distribution, P10.

The quantile regression results suggest that by considering firms with better conditional performance in the sample, one has a higher value for the coefficient of the relationship between wage inequality and firm performance, i.e., considering more efficient firms in the sample increases the positive impact of wage inequality on firm performance in terms of added value per worker.

As with OLS estimates, quantile regression estimates reveal higher coefficients for manufacturing firms compared to the coefficients obtained for service firms. The results obtained in this section show, once again, strong evidence in favor of the hypothesis of a positive correlation between within-firm wage dispersion and economic performance for the Brazilian economy.

3.3 Instrumental Variables

The previous sections showed that the results obtained from OLS estimates strongly support the hypothesis of a positive correlation between within-firm wage dispersion and profit (or added value) performance among Brazilian firms.

The possibility that such results might be biased was raised. A second source of problems with OLS estimates is the simultaneity between profits and wage dispersion. The idea of simultaneity is associated with the possibility of rent sharing. The firms, by sharing revenues with their workers might be increasing their wage dispersion, and therefore, causality could be considered from wage dispersion for profits (tournaments or equity) as well as of profits for wage dispersion (rent sharing).

In order to solve this problem, this section presents the results obtained through 2SLS estimates, as specified in the following equations:

$$ln(P/n)_{jt} = M_{zjt}\beta + \mathbf{x}_{jt}\delta' + \mathbf{f}_{jt}\varphi' + \epsilon_{jt} \tag{6}$$

$$M_{zjt} = M_{zj(t-1)}\varpi_1 + M_{zj(t-2)}\varpi_2 + ln(P/n)_{jt}\beta^* + \mathbf{x}_{jt}\phi' + \mathbf{f}_{jt}\theta' + \upsilon_{jt} \tag{7}$$

Just as in Heyman (2005), lagged wage dispersion measures are used as instrumental variables (IV). In this case, t-1 and t-2 of variable M_{zj} were used as IV.

Table 6 shows the coefficients of relation between dispersion measures and profits for years 2000 and 2001 (second stage of the 2SLS regression). There are no 2SLS estimates for years 1998 and 1999, since these years do not have enough lags for instrumentalization and tests of overidentifying restrictions for IV.

Table 6 also shows the values for the coefficients of instruments in auxiliary regressions (first stage of the 2SLS regression), the Shea partial R^2 values (Shea (1997)) and the Sargan statistics (Arellano & Bond (1991)). The coefficients of instruments have positive and statistically significant values, without any exception. The orthogonality of instruments with the errors is confirmed for all regressions according to the values obtained for the Sargan statistics. The explanatory power of the instruments over the endogenous variables is satisfactory, as pointed out by Shea partial R^2 values.

Once confirmed that the instruments used have satisfactory exogeneity and explanatory power of the endogenous variable, the 2SLS estimation is more consistent. As with other studies, the results with IV estimates have positive coefficient values that are comparatively higher than those obtained from OLS estimators.

All coefficients of the sigma variable in Table 6 have positive and statistically significant values, regardless of the sectors or years sampled. Again, the results shown herein point to higher coefficients for manufacturing firms compared to the coefficients obtained for service firms. Strong evidence in favor of the hypothesis of a positive correlation between within-firm wage dispersion and performance is provided through 2SLS estimates.

4 Results - Longitudinal Analysis

The previous sections showed that all estimates in the cross-sectional analysis corroborate the tournament theory for Brazilian firms. This section is going to deal with the longitudinal analysis of the sample, i.e., it will provide the results obtained from panel data estimates. Two approaches will be considered in this section: pooled regressions and fixed-effect regressions.

4.1 Pooled Regressions

In this section, the annual observations of firms (1998-2001) are pooled as cross-sectional time series data. The procedure implies the use of these data to reproduce the econometric methods previously applied in the cross-sectional analysis, i.e., OLS, quantile and 2SLS regressions[6]. The major aims of this section are to provide results that serve as baseline for the results to be developed with fixed-effect estimates and to assess the robustness of the analysis.

The first specification to be presented concerns the pooled OLS regression, as shown in the following equation:

$$ln(P/n)_{jt} = M_{zjt}\beta + \mathbf{x}_{jt}\delta' + \mathbf{f}_{jt}\varphi' + \mathbf{t}\lambda' + \epsilon_{jt} \tag{8}$$

Where $\mathbf{t}$ is a set of dummies (or fixed effects) for each sampled year.

As with cross-sectional analyses, the econometric treatment above was separately applied to all firms, to the group of manufacturing firms and to the group of service firms. The results for the coefficients with pooled OLS regressions are shown on the first line of Table 7. All coefficients are positive and significant at 1% and the coefficient for the sample of manufacturing firms (1.23) is nearly twice that of the coefficient obtained for the sample of service firms (0.64).

The second specification is that of the quantile regression with pooled data, as shown in the following equation:

$$ln(P/n)_j = \mathbf{z}_j\beta'_\theta + \mathbf{t}\lambda' + u_{\theta j} \tag{9}$$

Just as in previous analyses, the quantile regression coefficients were obtained for the 10th, 25th, 50th, 75th and 90th percentiles. The results for the coefficients obtained with the specification above are shown in Table 7, lines 2 (P10) through 6 (P90). Again, all coefficients are positive and significant at 1% and the coefficient values increase as higher percentiles are analyzed, independently of the type of sector that is sampled.

The third specification is that of the pooled 2SLS regression, as shown in the following

[6] The standard errors of the coefficients obtained from the pooled regressions are corrected for clusters, i.e., repeated observations for the same firm.

equation:

$$ln(P/n)_{jt} = M_{zjt}\beta + \mathbf{x}_{jt}\delta' + \mathbf{f}_{jt}\varphi' + \mathbf{t}\lambda' + \epsilon_{jt} \tag{10}$$

$$M_{zjt} = M_{zj(t-1)}\varpi_1 + M_{zj(t-2)}\varpi_2 + ln(P/n)_{jt}\beta^* + \mathbf{x}_{jt}\phi' + \mathbf{f}_{jt}\theta' + \mathbf{t}\zeta' + \upsilon_{jt} \tag{11}$$

Lagged wage dispersion measures are used as instrumental variables (IV), i.e., $t-1$ and $t-2$ of the M_{zj} variable.

The results for the coefficients obtained from the pooled 2SLS specification are shown in Table 7, line 7. All the coefficients are positive and significant at 1%, regardless of the type of sector that is sampled. Again, the coefficients obtained from the 2SLS regression yielded higher values than those obtained from the OLS estimates. 2SLS values are twice as high as those of OLS (2.63 vs. 1.23 in case of manufacturing firms, 1.45 vs. 0.64 in case of service firms and 2.32 vs. 1.08 for the whole set of firms).

4.2 Fixed-Effect Regressions

A source of bias in econometric estimates that had not been addressed yet in this paper concerns omitted variables. This section deals with this problem by using fixed-effect estimates.[7] The aim is to control for the unobserved and time-invariant heterogeneity of firms.

The econometric specification of the fixed-effect model is as follows:

$$ln(P/n)_{jt} = M_{zjt}\beta + \mathbf{x}_{jt}\delta' + \mathbf{f}_{jt}\varphi' + \mathbf{t}\lambda' + \mathbf{j}\psi' + \epsilon_{jt}, \tag{12}$$

where **j** are the fixed effects of firms.

The results for the coefficient obtained from the specification of the fixed-effect model are displayed in Table 7, line 8. The samples of all firms and of the set of manufacturing firms yielded positive coefficient values (0.05 and 0.09, respectively). On the other hand, firms in the service sector had a negative coefficient value (-0.007). However, no coefficient was statistically significant.

The results above should be viewed with caution, since two points may seriously compromise the fixed-effect estimates: (i) The panel is too short, with a time span of only 4 years, which hinders the correct identification of fixed effects; (ii) even if the unobserved and

[7]Hausman's specification test was used for random effect models and fixed-effect models. The fixed-effect model turned out to be the most appropriate.

time-invariant heterogeneity of firms is controlled, the endogeneity problem between wage inequality and performance remains unsolved.

The solution to the first problem mentioned above implies the inclusion of further time periods in the sample. The solution to the second problem implies fixed-effect estimates with instrumental variables. Given the insolubility of the first problem, this paper seeks to partially circumvent the limitations of fixed-effect estimates by using instrumental variables.

The econometric specification of the fixed-effect model with instrumental variables is as follows:

$$ln(P/n)_{jt} = M_{zjt}\beta + \mathbf{x}_{jt}\delta' + \mathbf{f}_{jt}\varphi' + \mathbf{t}\lambda' + \mathbf{j}\psi' + \epsilon_{jt} \tag{13}$$

$$M_{zjt} = M_{zj(t-1)}\varpi_1 + M_{zj(t-2)}\varpi_2 + ln(P/n)_{jt}\beta^* + \mathbf{x}_{jt}\phi' + \mathbf{f}_{jt}\theta' + \mathbf{t}\zeta' + \mathbf{j}\psi' + \upsilon_{jt} \tag{14}$$

The results for the coefficients obtained from the specification of the fixed-effect model with instrumental variables are shown in Table 7, on the last line. Unlike fixed-effect estimates, all coefficients yielded positive values, but only the coefficient for the service sector was significant.

These results should be interpreted with caution since, as previously stated, the solution to the endogeneity problem between wage inequality and firm performance does not imply a solution to the panel extension.

5 Conclusions

The aim of this paper was to check the relationship between within-firm wage dispersion and performance for a set of Brazilian firms in the manufacturing and service sectors. To the knowledge of the author of this paper, no similar empirical analyses have addressed this issue for developing countries.

The present paper showed that economic theory and empirical evidence do not agree on the effects of within-firm wage dispersion on firm performance. Moreover, there is a paucity of empirical studies on this issue and, in many cases, they are restricted to the analysis of sectors (or professional segments) that are quite specific to developed economies.

The estimates of the relationship between performance and inequality were obtained from different within-firm wage dispersion measures (conditional and unconditional inequality), different sectors of economic activity (industry and services), different performance measures (profit per worker and added value per worker), different sample characteristics (cross-sectional and longitudinal designs) and different econometric estimators (OLS, quantile regression, 2SLS, fixed effects and fixed effects with instrumental variables).

Even though most econometric tests yield positive and statistically significant coefficients, fixed-effect analyses and fixed effects with instrumental variables are an exception, since most coefficients are nonsignificant. In fixed-effect analyses, only the coefficient of the sample of service firms with FEIV estimators was positive and statistically significant. Therefore, the results obtained herein partially confirm the tournament theory of Lazear & Rosen (1981).

It was suggested that the fixed-effect estimation results should be interpreted with caution, since the use of a short panel with only a 4-year span may hinder the correct identification of fixed effects, affecting the analysis.

An additional aim of this study was to obtain results so as to check the validity of each of the conflicting theories (tournament and fairness) in the case of the Brazilian economy. No results that could confirm the fairness hypothesis were obtained in any of the specifications or subsamples used, i.e., there was no negative and statistically significant correlation between wage dispersion and firm performance.

Finally, two sets of results deserve special attention: (i) The quantile regression results suggest that the positive impact of wage inequality on firm performance is enhanced when efficient firms are included in the sample (conditional performance); (ii) the results suggest that incentives generated by wage inequality are more effective in the case of manufacturing firms, that is, the coefficient values for the industry are higher than those for the service sector.

According to Lazear (1989) and Lazear (1995), the poor effect of inequality on the performance of service firms could be associated with the fact that this sector contains a larger number of non-cooperative workers (hawks) compared to the number of workers in the manufacturing sector (where most workers are cooperative).

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6 Theory

The study by Akerloff & Yellen (1988) offers a preliminary economic interpretation for the relationship between wage dispersion and firm performance. This interpretation is given by an efficiency wage model where, due to imperfect monitoring and imperfect measurement of worker heterogeneity, the problem of the firm lies in managing incentives in order to elicit more effort from workers.

In this study, the authors suggest that the workers' effort function can be expressed as:

$$e = e(\sigma^2(w)) \tag{15}$$

Where e is the effort, w is the wage and σ^2 is the within-firm wage differential. The expression above suggests that workers' effort does not depend solely on wages, but also on within-firm wage dispersion. In this case, as pointed out by the authors, higher wages and lower within-firm wage dispersion allow employers to demand more effort from their workers.

The idea of a tradeoff between wage dispersion and firm performance originating from a feeling of fairness is better elaborated by the authors in Akerloff & Yellen (1990). They assume that workers compare their wages internally and externally and choose their effort based on the following expression:

$$e = min\left[\frac{w}{w_f}, 1\right] \tag{16}$$

Where w is the wage earned by the worker, w_f is the wage level considered to be fair and 1 is the normal effort level. The equation above shows that workers' effort falls short of the wage they regard as fair. The idea of a fair wage, as previously mentioned, is based on the comparison of wage differentials within and outside firms.

A second theoretical argument that supports the hypothesis of a lower within-firm relative wage dispersion and economic performance is developed in Milgrom (1988) and Milgrom & Roberts (1990). The authors argue that white-collar workers have incentives to withhold information from managers in order to increase their influence and to engage in rent-seeking activities instead of productive work.

The authors also state that the implementation of some degree of wage equity can reduce the tendency of white-collar workers to take personal interest decisions instead of decisions that may be profitable for the organization as a whole.

6.1 Tournaments

As previously stated in the Introduction, the tournament theory was originally developed by Lazear & Rosen (1981), and points to the benefits of a more dispersed wage structure derived from a performance-based pay system, i.e., the most productive workers are awarded the largest prize; therefore, a higher effort is demanded from workers so that they remain in contention for the prize (bonuses or promotions).

This idea can be expressed in formal terms as follows: consider two identical risk-neutral workers, j and k, and a risk-neutral firm with a compensation scheme in the value of W_h for the most productive workers and of W_l for the least productive ones, where $W_h > W_l$. The output level of each player is given according to the following equation:

$$q_i = e_i + \epsilon_i \tag{17}$$

Where q is the output level, e is the effort level, $i = [j, k]$ and ϵ is a random component of output (e.g.: luck). Let us now suppose that the utility expected from player j is given by the following equation:

$$U_j = P\left(W_h - C(e_j)\right) + (1 - P)\left(W_l - C(e_j)\right) \tag{18}$$

Where U is the expected utility, P is the probability to win the game, and $C(.)$ is a cost function with $C' > 0$ and $C'' > 0$. The probability of player j winning the game is the following:

$$prob\left(q_j > q_i\right) = prob((\epsilon_k - \epsilon_j) < (e_j - e_k)) = prob((e_j - e_k) > \zeta) = G\left(e_j - e_k\right) \tag{19}$$

Where $\zeta = (\epsilon_k - \epsilon_j)$, ζ distributed in $g\left(\zeta\right)$ with mean zero, and G is the cumulative density function of ζ. The worker maximizes his expected utility, U, by choosing an effort level in which the marginal cost of his effort equates to the marginal benefit, that is:

$$(W_h - W_l)\frac{\partial P}{\partial e_i} - \frac{\partial C}{\partial e_i} = 0 \tag{20}$$

If both players, j and k, maximize their utilities, the marginal probability to win relative to their effort will be given by:

$$\frac{\partial\ P}{\partial\ e_j} = \frac{\partial\ G\,(e_j - e_k)}{\partial\ e_j} = g\,(e_j - e_k) \tag{21}$$

Substituting the equation above into the first-order condition for the maximization of the expected utility yields:

$$(W_h - W_l)\,g\,(e_j - e_k) = \frac{\partial\ C}{\partial\ e_j} \tag{22}$$

Given the hypothesis of homogeneous work, both players will choose the same effort level. According to the symmetric Nash equilibrium $e_j = e_k$, and the outcome of the game is random with $P = 0.5$. Thus, the latter equation can be written as:

$$(W_h - W_l)\,g\,(0) = \frac{\partial\ C}{\partial\ e_j} \tag{23}$$

The equation above indicates that a higher wage dispersion deriving from output-based reward strategies, $(W_h - W_l)$, implies larger marginal costs of effort for players, or simply higher levels of effort, since $C' > 0$ e $C'' > 0$, as previously stated.

Lazear (1989) and Lazear (1995) also argue that the efficiency of an output-based compensation system can be offset (or even neutralized) by the effect of a lower level of work cohesion due to the sabotage and non-cooperative behaviors. They show that high wage compression is crucial for an organization in which most workers are non-cooperative (hawks). According to these authors, following the arguments of Milgrom (1988) and Milgrom & Roberts (1990), hawks are commonly found among management and supervision staff members and among white-collar workers.

Table 1: Descriptive Statistics, All Firms

	Mean (Standard Deviation)			
	1998	1999	2000	2001
Variables				
Ln Employment	5,07	5.10	5.16	5.18
	(0.91)	(0.91)	(0.91)	(0.93)
Profits pw	934	1,022	1,051	926
	(3,000)	(3,079)	(3,017)	(2,984)
Value Added pw	16,007	15,909	16,198	16,019
	(14,305)	(14,722)	(14,813)	(14,923)
Sigma	0.16	0.15	0.15	0.15
	(0.09)	(0.09)	(0.09)	(0.10)
Standard Deviation	2.17	2.08	2.09	2.22
	(2.20)	(3.36)	(2.89)	(2.65)
Coef. of Variation	75.91	75.30	76.05	79.69
	(39.74)	(41.09)	(40.39)	(47.07)
Maxmin	37.01	38.04	38.76	45.48
	(92.33)	(82.50)	(57.45)	(70.64)
Tenure	36.41	39.44	40.76	42.84
	(21.84)	(22.61)	(22.61)	(23.52)
Schooling	6.67	6.87	7.07	7.25
	(1.77)	(1.74)	(1.76)	(1.77)
Age	32.43	32.76	32.88	33.17
	(3.75)	(3.75)	(3.79)	(3.81)
Fem	0.27	0.27	0.27	0.27
	(0.24)	(0.23)	(0.23)	(0.24)
Obs.	7689	7689	7689	7689

Notes: (1) Monetary values in R$ at 1998 prices (INPC deflator).

7 Additional tables

Table 2: Cross Section Analysis, OLS - All Firms

Dependent Variable: Ln Value Added pw				
	1998	1999	2000	2001
Regressors				
Sigma	1,17	1,11	1,30	1,00
	(0,07)***	(0,07)***	(0,07)***	(0,06)***
Standard Deviation	0,13	0,13	0,14	0,08
	(0,003)***	(0,001)***	(0,002)***	(0,002)***
Coef. Variation	0,002	0,001	0,001	0,001
	(0,0001)***	(0,0001)***	(0,0001)***	(0,0001)***
Maxmin	0,001	0,0007	0,0009	0,0006
	(0,00007)***	(0,00007)***	(0,0001)***	(0,0001)***
Obs.	7635	7630	7621	7626

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 3: Cross Section Analysis, OLS - Manufacturing Firms

Dependent Variable: Ln Value Added pw				
	1998	1999	2000	2001
Regressors				
Sigma	1,33	1,23	1,45	1,19
	(0,10)***	(0,10)***	(0,09)***	(0,09)***
Standard Deviation	0,13	0,14	0,15	0,09
	(0,004)***	(0,002)***	(0,002)***	(0,003)***
Coef. Variation	0,002	0,001	0,002	0,001
	(0,0002)***	(0,0002)***	(0,0002)***	(0,0002)***
Maxmin	0,0002	0,0008	0,001	0,0007
	(0,0000)***	(0,0001)***	(0,0002)***	(0,0001)***
Obs.	4940	4944	4935	4944

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 4: Cross Section Analysis, OLS - Services Firms

	Dependent Variable: Ln Value Added pw			
	1998	1999	2000	2001
Regressors				
Sigma	0,74	0,66	0,93	0,54
	(0,08)***	(0,07)***	(0,08)***	(0,06)***
Standard Deviation	0,10	0,09	0,11	0,05
	(0,004)***	(0,003)***	(0,004)***	(0,003)***
Coef. Variation	0,001	0,0006	0,0008	0,0003
	(0,0002)***	(0,0001)***	(0,0001)***	(0,0001)***
Maxmin	0,0007	0,0003	0,0004	0,0003
	(0,0001)***	(0,0001)***	(0,0001)***	(0,0001)***
Obs.	2695	2686	2683	2681

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 5: Cross Section Analysis, Quantile Regressions - All Firms

	Dependent Variable: Ln Value Added pw					
	P10	P25	P50	P75	P90	N
Sigma						
1998	0,85	1,03	1,16	1,15	1,19	7633
	(2,53)	(1,37)	(0,96)	(0,33)***	(1,53)	
1999	0,67	0,87	1,03	1,20	1,28	7628
	(1,19)	(0,41)**	(0,48)**	(0,26)**	(0,48)***	
2000	0,75	0,90	1,29	1,45	1,49	7614
	(9,01)	(2,62)	(1,50)	(0,97)	(3,16)	
2001	0,54	0,78	0,96	1,02	1,09	7621
	(0,69)	(0,23)***	(0,28)***	(0,21)***	(0,21)***	

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 6: Cross Section Analysis, 2SLS

	Dependent Variable: Ln Value Added pw_t					
	Manufacturing 2000	Manufacturing 2001	Services 2000	Services 2001	All Firms 2000	All Firms 2001
Second Stage						
Sigma_t	2,69	2,43	1,58	1,34	2,46	2,12
	(0,39)***	(0,35)***	(0,16)***	(0,17)***	(0,25)***	(0,23)***
First Stage						
Sigma_{t-1}	0,44	0,32	0,39	0,38	0,42	0,35
	(0,01)***	(0,01)***	(0,02)***	(0,02)**	(0,01)***	(0,01)***
Sigma_{t-2}	0,21	0,29	0,24	0,25	0,23	0,28
	(0,01)***	(0,01)***	(0,01)***	(0,02)***	(0,01)***	(0,01)***
$\text{Sargan}^{(a)}$	2,00	0,45	0,19	5,13	1,64	2,01
	(0,15)	(0,50)	(0,66)	(0,02)	(0,20)	(0,15)
Shea R^2 *Partial*	0,32	0,26	0,32	0,23	0,33	0,26

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator); (a) P-Valor in parenthesis.

Table 7: Longitudinal Analysis

	Dependent Variable: Ln VA pw_t		
	Manufacturing	Services	All Firms
Pooled OLS	1,23	0,64	1,08
	(0,12)***	(0,07)***	(0,08)***
P10	0,86	0,31	0,69
	(0,16)***	(0,11)***	(0,08)***
P25	1,07	0,48	0,91
	(0,07)***	(0,05)***	(0,05)***
P50	1,22	0,63	1,08
	(0,05)***	(0,04)***	(0,03)***
P75	1,30	0,80	1,14
	(0,04)***	(0,04)***	(0,03)***
P90	1,41	0,89	1,25
	(0,05)***	(0,05)***	(0,04)***
Pooled 2SLS	2,63	1,45	2,32
	(0,26)***	(0,12)***	(0,17)***
Fixed Effects	0,09	-0,007	0,05
	(0,12)	(0,04)	(0,08)
IV - Fixed Effects	0,35	0,24	0,31
	(0,43)	(0,16)***	(0,30)

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Cluster standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location, sector, and year; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 8: List of Variables

Variables	Description:
Ln Employment	Log of employees - proxy for firm size
Profits pw	Profits per worker by firm in R$, 1998 prices
Value Added pw	Value Added per worker by firm in R$, 1998 prices
Ln Profit	Log of Profits pw
Ln Value Added	Log of Value Added pw
Sigma	Standard Error of Wage Regression by Firm-Year
Standard Deviation	Standard Deviation of Wages by Firm-Year
Coef. Variation	Wages Coefficient of Variation by Firm-Year
Maxmin	Maximum-Minimun Wages Ratio by Firm-Year
Tenure	Tenure in months - Firm-Year Average
Schooling	Years of Schooling - Firm-Year Average
Age	Age of Workers - Firm-Year Average
Fem	Female participation in % by Firm-Year
Location	Dummies for 27 Brazilian States
Sector	Dummies for sectors 3-digit CNAE

Table 9: Descriptive Statistics, Manufacturing Firms

	Mean (Standard Deviation)			
	1998	1999	2000	2001
Varibles				
Ln Employment	4.94	4.97	5.02	5.03
	(0.82)	(0.81)	(0.82)	(0.83)
Profits pw	836	1,049	1,103	952
	(3,392)	(3,511)	(3,437)	(3,420)
Value Added pw	19,060	19,102	19,583	19,453
	(16,386)	(16,908)	(16,911)	(17,103)
Sigma	0.16	0.16	0.16	0.16
	(0.09)	(0.09)	(0.09)	(0.10)
Standard Deviation	2.34	2.27	2.28	2.40
	(2.34)	(3.93)	(3.36)	(2.95)
Coef. of Variation	80.05	79.45	80.17	83.24
	(40.44)	(40.33)	(38.97)	(45.87)
Maxmin	37.19	36.85	37.46	43.69
	(108.03)	(90.64)	(52.96)	(70.24)
Tenure	40.23	43.03	44.00	46.69
	(21.60)	(22.26)	(22.30)	(22.82)
Schooling	6.63	6.85	7.07	7.24
	(1.67)	(1.64)	(1.67)	(1.70)
Age	31.80	32.10	32.18	32.50
	(3.46)	(3.44)	(3.43)	(3.46)
Fem	0.28	0.28	0.28	0.28
	(0.24)	(0.24)	(0.23)	(0.24)
Obs.	4990	4990	4990	4990

Notes: (1) Monetary values in R$ at 1998 prices (INPC deflator).

Table 10: Descriptive Statistics, Services Firms

	Mean (Standard Deviation)			
	1998	1999	2000	2001
Variables				
Ln Employment	5.31	5.35	5.42	5.46
	(1.03)	(1.02)	(1.02)	(1.04)
Profits pw	1.114.52	971.80	954.80	879.64
	(2,080.11)	(2,053.32)	(2,021.02)	(1,931.38)
Value Added pw	10,563	10,005	9,941	9,669
	(6,302)	(5,935)	(6,009)	(5,614)
Sigma	0.15	0.14	0.14	0.15
	(0.09)	(0.09)	(0.09)	(0.09)
Standard Deviation	1.84	1.73	1.75	1.90
	(1.87)	(1.87)	(1.67)	(1.95)
Coef. Variation	68.30	67.61	68.45	73.12
	(37.23)	(41.38)	(41.85)	(48.56)
Maxmin	36.68	40.24	41.18	48.79
	(52.40)	(64.78	(64.88)	(71.28)
Tenure	29.40	32.81	34.78	36.62
	(20.50)	(21.75)	(22.61)	(23.53)
Schooling	6.73	6.92	7.09	7.27
	(1.94)	(1.92)	(1.92)	(1.90)
Age	33.60	34.00	34.17	34.40
	(3.97)	(4.00)	(4.07)	(4.11)
Fem	0.25	0.25	0.25	0.26
	(0.23)	(0.23)	(0.23)	(0.25)
Obs.	2699	2699	2699	2699

Notes: (1) Monetary values in R$ at 1998 prices (INPC deflator).

Table 11: Cross Section Analysis, OLS - All Firms

	Dependent Variable: Ln Profits pw			
	1998	1999	2000	2001
Regressors				
Sigma	0,36	0,25	0,52	0,77
	(0,26)	(0,31)	(0,25)**	(0,22)***
Standard Deviation	0,04	0,04	0,05	0,07
	(0,01)***	(0,01)***	(0,01)***	(0,01)***
Coef. Variation	0,001	0,0005	0,001	0,002
	(0,0006)**	(0,0006)	(0,0005)*	(0,0005)***
Maxmin	0,0001	0,0004	0,001	0,001
	(0,0002)	(0,0005)	(0,0004)**	(0,0004)**
Observaes	5218	5287	5297	5200

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 12: Cross Section Analysis, Quantile Regressions - Manufacturing Firms

	Dependent Variable: Ln Value Added pw					
	P10	P25	P50	P75	P90	N
Sigma						
1998	0,80	1,24	1,43	1,36	1,45	4938
	(0,71)	(0,40)***	(0,15)***	(0,06)***	(0,21)***	
1999	0,64	0,86	1,07	1,34	1,57	4942
	(0,87)	(0,19)***	(0,22)***	(0,14)***	(0,23)***	
2000	1,15	1,16	1,39	1,46	1,65	4934
	(0,65)*	(0,38)***	(0,15)***	(0,15)***	(0,38)***	
2001	1,04	1,13	1,14	1,26	1,34	4940
	(0,60)*	(0,17)***	(0,18)***	(0,21)***	(0,11)***	

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).

Table 13: Cross Section Analysis, Quantile Regressions - Services Firms

	Dependent Variable: Ln Value Added pw					
	P10	P25	P50	P75	P90	N
Sigma						
1998	0,63	0,63	0,68	0,79	0,76	2695
	(0,30)**	(0,12)***	(0,08)***	(0,10)***	(0,14)***	
1999	0,32	0,58	0,60	0,75	0,83	2686
	(0,17)*	(0,08)***	(0,06)***	(0,09)***	(0,11)***	
2000	0,25	0,59	0,91	1,01	1,20	2680
	(0,23)	(0,11)***	(0,09)***	(0,07)***	(0,14)***	
2001	0,16	0,23	0,55	0,67	0,84	2681
	(0,12)	(0,09)**	(0,08)***	(0,06)***	(0,07)***	

Notes: (1) Significant at 1% (***), 5 % (**), and 10% (*); (2) Robust standard errors in parenthesis; (3) Each cell corresponds a different regression; (4) Regression also include the following control variables: ln employment, schooling, tenure, % female, dummies for location and sector; (5) Monetary values in R$ at 1998 prices (INPC deflator).