Strike Duration after Collective Bargaining Legislation Changes: A Reappraisal of the 1988 Brazilian New Federal Constitution with Better Micro Data[1]

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Abstract

We empirically analyze strike duration in Brazil, with emphasis on legislation changes induced by the new Federal Constitution of 1988. Our empirical background comes from a very rich micro dataset built by Noronha et al. (1998). By means of a sequence of estimation and testing procedures based on both proportional and non-proportional hazards model, and controlling for effects associated with economic indicators as well as geographic dummies, we are able to find significant differences on strike duration induced by the new Brazilian Constitution. Results suggest that the Constitution changed the pattern of strike duration, increasing its length and changing its etiology. Also, we evidenced qualitatively differences between periods of analysis as well, since the proportional hazards specification was thoroughly rejected for post-constitutional strikes. The reduction of hazard rate in the post-constitution period we found can be tentatively rationalized as a logical effect of increased organizational level, greater bargaining power of unions and clearer rules of legal procedures brought by the new Constitution. Finally, there is evidence that strikes initiated in São Paulo conforms better to orthodox models of strike dynamics *vis-a-vis* the rest of the country.

Keywords: Collective Bargaining, Strikes, Duration Analysis
JEL Codes: J52, K31, C41
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Resumo

Analisamos empiricamente a duração de greves no Brasil, com ênfase nas mudanças na legislação induzidas pela nova Constituição Federal de 1988. Nosso arcabouço empírico advém de uma base de dados muito rica construída por Noronha et al. (1998). Por meio de uma seqüência de procedimentos de estimação e testes baseados tanto no modelo de risco proporcional quanto no modelo não-proporcional, controlando os efeitos associados através de indicadores econômicos, bem como *dummies* geográficas, fomos capazes de encontrar diferenças significativas na duração das greves, induzidas pela nova Constituição brasileira. Os resultados sugerem que a Constituição mudou o padrão de duração das greves, aumentando a sua duração e mudando a sua etiologia. Além disso, evidenciamos diferenças qualitativas entre os períodos de análise, uma vez que a especificação de riscos proporcionais foi completamente rejeitada para greves ocorridas no período pós-constitucional. A redução da taxa de risco no período pós-Constituição que encontramos pode ser provisoriamente racionalizada como um efeito lógico de aumento do nível de organização, maior poder de barganha dos sindicatos e regras mais claras de procedimentos legais trazidas pela nova Constituição. Finalmente, há evidências de que as greves iniciadas em São Paulo conformam melhor com os modelos ortodoxos de dinâmica de greve *vis-à-vis* o resto do país.

Palavras-chave: Barganha Coletiva, Greves, Análise de Duração

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[1] This paper is an improvement on the second chapter of Devide's PhD Thesis "Ensaios Empíricos sobre Compensação Executiva e Dinâmica das Greves no Brasil" – CAEN/UFC, see Devide (2010).

1.   Introduction

Strikes are defined as work stoppages caused by the mass refusal of employees to work, usually used to pressure governments and/or employers to change policies or to achieve better working conditions. It is characterized as a final form of negotiation between employers and employees, after not reaching a common agreement in previous negotiations. However, there is not a consensus in the economics literature about the determinants of occurrence and duration of strikes. The main problem is the lack of a unified theory that accomplishes a fully explanation of when a strike will begin, how long it should last and its main determinants , as well as the negotiated requirements and their potential outcomes, trying to avoid or at least to minimize their costs [Kennan (1987)].

Two segments in the literature, explaining the reasons for the occurrence of strikes and subsequently of their durations, are identified by Perez et al. (2006). The first strand originated in Hicks (1932) Theory of Wages and suggests that strikes are mistakes or accidents that occur during negotiations. Strikes are then the consequence of faulty negotiations. Unions would be more willing to accept lower wages in higher periods of strikes, while the firms are more willing to accept the payment of higher wages proportion to the duration of the strike – both resulting in larger costs. The duration of the strike and the result of negotiations will depend on the equilibrium between the costs of inactivity for both parties and the relation between changes in unions' demands and strike duration is negative. The second strand of literature considers that the occurrence and duration of strikes are related to the existence of asymmetric and private information. Considering that each part involved forms its expectations about the result of negotiations based on their own information, the assumptions imply that the strikes are more frequent and have longer duration the larger the differences between the proposals.

Brazil is a country with many legal restrictions in the labor market, considered excessively regulated. These restrictions reduce the flexibility of companies to turnover, and consequently the production efficiency [Zylberstajn (2006) and Tafner (2006)]. The CLT (*Consolidação das Leis do Trabalho* – Consolidation of Labor Laws) and the Federal Constitution are the most important labor laws in the country. The reformulation of the Constitution in 1988 altered the labor relationship significantly, bringing about many changes on Brazilian labor markets such as: (a) more meticulous and inflexible statement about work conditions, increasing the importance of collective bargaining; (b) more expressive role for unions, reducing restrictions on the bases of the category and (c) development of specific labor laws, establishing the role of unions on individual and collective bargaining. Also, the Constitution of 1988 expanded workers' rights, including a very detailed specification of the responsibilities of union actions and collective agreements.

Clearly, the new Constitution had a significant role in changing the dynamics of strikes. If previously there were legal restrictions on strikes and the claims of right were not legitimized by the state,

the proclamation of the Constitution reaffirmed the strikers' rights and the leaders of strikes were consolidated as negotiators validated by the government [NORONHA et al. (1998)]. In this context Brazilian strikes experienced important changes, not only due to greater power of representation of unions that increases their bargaining power, but also due to the definition of clearer and more specific rules of negotiation between the parts involved.

Although some authors like CAMARGO and AMADEO (1990) and DE BARROS and CORSEUIL (2004) assessed the impact of changes induced by the new Constitution on labor market performance they either touched tangentially the issue of strike dynamics or not discuss it at all. Others like Picchetti (2002), although devoted an entire analysis to a discussion of empirical estimation models of strike duration as well as strike occurrence, completely forget to make any appraisal about the specific role played by constitutional changes. Hence, it appears to have a scientific knowledge gap about the impact of the new Brazilian constitution on strike dynamics, especially those based on sound empirical methodology that employs microeconometrics.

In fact, econometric studies about duration of strikes are scarce, compared to empirical studies about occurrence of strikes. In general, one of the largest problems in recent empirical attempts is data set limitation: even in large samples of contract negotiations there are few cases that are not resolved by consensus, resulting in strikes. Also, even in registered strikes, there is a lack of information about its duration and general characteristics [Card (1990)].

Based on these remarks, and enjoying the fact that the enactment of a new Constitution is a rare event, this paper aims to verify the characteristics of strikes in Brazil over the period from 1983 to 1991, with emphasis on the impact of institutional changes brought by the Federal Constitution in 1988. We analyze the characteristics and determinants of Brazilian strikes using duration analysis. Given the not so frequent process of constitutional change observed in both developed and developing economies as well as the quality of our available micro data set[2], we believe to be in a unique position to assess economic changes due to a new, and rare, constitutional law enactment.

We advance to the reader that we refrain from calling the Brazilian 1988 new constitutional law a "natural experiment", at least in this paper. This by no way means that we made a strong claim that it is not a "natural experiment", but our position is grounded on pragmatic reasons: we are not interested in establishing causality. In fact, we believe that another paper could explore the informational shock brought by the new constitution and model it as a "natural experiment", but this belongs to another scientific endeavor.

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[2] In fact, our database consist of information about urban stoppages in Brazil ranging the period 1983-1991, obtained from the Consortium of Social Information (CIS – *Consórcio de Informações Sociais*), presented by Noronha et al. (1998). It is a unique micro data set containing all strikes that occurred on that period.

After a series of detailed parametric and non-parametric analysis, overall, we are able to find marked differences in the characteristics of strikes before and after the constitutional law. Besides the distinction between the non-parametric survival curves in two periods, our results indicate that the number of strikes is positively related with the duration of stoppages, consistent with that found by Harrison and Stewart (1993) for Canadian strikes for wage claims up to 500 strikers, but different to verified in Spanish strikes by Perez et al. (2006) and Canadian strikes by Cramton et al. (1999). More important, there is a statistically significant reduction on the hazard rate in the post-constitution period. Although we should refrain from issues of causality, our results indicate that it might be the effect of the increased organizational level and the bargaining power of unions *ex-post* the constitutional change, which implies a reduction of the impact of changes in unemployment on the wage differential proposed in the negotiations, increasing the duration of stoppages.

Also, we found that the inflation rate is positively related to strikes duration only in the pre-constitutional period. The unemployment rate presents an inverse relationship with the strikes duration in both periods, however, with different magnitudes. The remainder of the paper is structured as follows. Section 2 examines the econometric literature on the determinants of strikes duration. Section 3 presents the database describing Brazilian strikes initiated between 1983 and 1991. The methodology used in this study is presented in section 4, including the selected variables and its treatment, according to the characteristics of the database and the econometric model used in this study, model's estimation as well as comments. Section 5 draw main conclusions, including possible extensions of this research and the contribution to the relative economic literature, and develops final considerations.

2.   A Brief Review of the Literature on the Econometrics of Strikes

The international literature usually attempts to relate the occurrence and duration of strikes to specific characteristics of firms and macroeconomic factors. Perez et al. (2006) analyze the determinants of strikes duration in Spain, verifying the conditions of the different final results (agreement or no agreement). Evidence shows that the number of strikers is inversely related to their duration, since the strikes are relatively more effective in reducing the firms' profits due to greater inefficiency in production or by higher operating costs over the period. Harrison and Stewart (1993) examine the number of strikers as a determinant for strike duration. According to the authors, most of the empirical studies have been accomplished starting from data for strikes involving a great number of workers. A more complete study should examine the systematic differences between large and small strikes, therefore observing whether large strikes are representative for the general case. These authors remark that the number of strikers directly affects the duration of strikes, with significant differences in their final results when classified

according to size, concluding that studies based on work stoppages involving large numbers of workers present results that are not representative for all strikes.

The inflation rate has an important role in strikes duration, mainly the ones originated by wage claims. An increase in expected inflation implies a higher nominal wage demand. Since negotiations include compensation of monetary values (replacement or readjustment in general) models usually use a proxy for expected inflation as an independent variable, represented by the index of inflation in the previous period. Since both the occurrence and the duration of strikes are directly related to the difference between the wages offered and demanded in the negotiations, we have an expected positive effect of inflation from the previous period on the duration of stoppages.

Recent studies have shown that the duration of strikes is counter-cyclical – especially in periods of economic expansion, associated with shorter stoppages – and the unemployment rate is one of the most used variables to capture the effects of cycles. However, CRAMTON et al. (1999) states that the impact of unemployment is ambiguous, because when the job market is in expansion (presenting a low rate of unemployment) there is an increase of both operational costs in replacement of the workforce for the companies and the productive inefficiency – what decrease the expected duration of the strikes. But the lower labor supply reduces the bargaining power of strikers, increasing the wage demands and the duration of strikes. Therefore, the impact of unemployment on the duration of strikes depends on which effect is predominant in the economy.

NORONHA et al. (1998) conducted a study about the evolution of strikes in Brazil, identifying some key characteristics observed from the end of decade of 70 and until the beginning of decade of 90. According to the authors, the phenomenon of Brazilian strikes began around 1978 in ABC[3], considered the main industrial area of the country, identifying three major cycles of strikes: first cycle had an upward trajectory, ranging from 1978 to 1984, where the organization of unions began in São Paulo and spread to other regions in the country; the second cycle occurred between 1985 and 1989 and presents a flat evolution path; finally, the third cycle was characterized by the decline of stoppages in 1990, reached the end two years later.

The cyclical behavior denotes that the variation of the number of strikes is not caused by substantial variations in the main economic indicators such as employment, income, inflation or periods of election. From an initial occurrence of strikes on ABC – especially in the automobile companies – there was an increase in the number of work stoppages across the country, demonstrating a potential number of conflicts, previously covered by military governments. Although no significant changes occurred in the structure of unions, the Federal Constitution of 1988 represented a substantial change on the relationship among government, unions and businesses.

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[3] The acronym refers to the three metropolitan cities in the denominated Greater São Paulo – Santo André, São Bernardo dos Campos and São Caetano – that concentrate the main industrial centers in the country.

Analyzing the duration of strikes in the Brazilian industrial sector, PICCHETTI (2002) notes that regardless of the cause of stoppages, strikes that resulted in gains for workers tend to have shorter durations, and that longer strikes usually are associated with wage demands with no gains for workers. Also, non-wage strikes tend to be longer. Using the Cox proportional hazard model, PICCHETTI (2002) finds that higher rates of unemployment are associated with longer strikes, and the duration is an increasing function of unemployment. His paper is the closest to ours. However, while PICCHETTI (2002) focus on strike incidence and duration, he does not consider the impact of the 1988 Constitution as well as he employed only Cox proportional model to assess strike duration. Least, our empirical background appears to be better than his.

Less researched by economists, however, it is the impact of legislation changes on strike dynamics. Analyzing the influence of collective bargaining legislation on strikes, Cramton et al. (1999) verify that changes in negotiation rules determined by labor rights affect the power of relationship between unions and firms, not only influencing the incidence and the duration of strikes, but also wage agreements. As well, those authors note that agreement policies have been ineffective in reducing the costs of strikes. An important interpretation of the study is that the uncertainty of unions about the propensity of the wages paid by firms has been positively and significantly related to the incidence and duration of the stoppages. The following section describes the database and the treatment of variables in the estimations.

3.   Data Set Description

The strikes database consists of information about urban stoppages in Brazil, covering the period 1983-1991, and was obtained from the Consortium of Social Information (CIS – *Consórcio de Informações Sociais*[4]). Noronha et al. (1998) was in charge of its construction and based it on survey information from the Ministry of Labour and from DIEESE (*Departamento Intersindical de Estatística e Estudos Socioeconômicos* - Department of Statistics and Socioeconomic Studies). The unemployment rate by sector – due to more specific reference to the sector in which the strike occurs – was obtained from Getúlio Vargas Foundation (FGV – *Fundação Getúlio Vargas*), and the inflation rate from IPEA *(Instituto de Pesquisa Econômica Aplicada* – Institute of Applied Economic Research). The price index IGP-DI (*Índice Geral de Preços (Disponibilidade Interna)* – General Price Index – (Domestic Availability)) – is used as an index of inflation. The sample also includes information on geographical location of strikes (states and regions), sector of activity (commercial, industrial or service) and also if the

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[4] The CIS (*Consórcio de Informações Sociais* – Consortium of Social Information) collects social scientific information in Brazil, aiming to offer free qualitative and quantitative data resulting from researches. It is maintained by the Department of Sociology at University of São Paulo and the National Association of Graduate Studies and Research in Social Sciences (ANPOCS), with financial and material support from USP and FAPESP.

stoppage is classified as strike category[5]. Table 1 summarizes the selected variables and the main characteristics.

Table 1 – Description of variables

Variable	Description	Characteristic
duracao	Strike duration dummy	Continuous
grev300	Number of strikers - up to 300 dummy	1 if $\leq$ 300 and 0 otherwise
grev300_1000	Number of strikers - 301 to 1000 dummy	1 if > 300 and $\leq$ 1000 and 0 otherwise
grev_1000	Number of strikers - more than 1000 dummy	1 if > 1000 and 0 otherwise
desemps	Unemployment rate in the industry	Continuous
igpdi_1	Inflation rate in the previous period	Continuous
de_sp	State of São Paulo dummy	1 if SP and 0 otherwise
d88	Post-period 1988 Constitution dummy	1 if year > 88 and 0 otherwise
ds_ind	Industrial sector dummy	1 if industrial and 0 otherwise
ds_com	Commercial sector dummy	1 if commercial and 0 otherwise
ds_ser	Service sector dummy	1 if service and 0 otherwise
gcateg	Category of strike dummy	1 if category strike and 0 otherwise

Source: elaborated by the authors

Length (duration) of strikes ranges from 1 to 211 days, with a cumulative frequency of 99% at 64 days (Appendix – Table 8) – thus, this study will consider only the strikes up to 60 days[6]. In turn, the number of strikers ranges from 4 to 7.000.000, with a cumulative frequency of 90% up to 6400 and strikers (Appendix – Table 9). Thus, in this paper we will only include cases up to 6.500 strikers[7].

Brazilian strikes present two main characteristics: short duration (stoppages up to 3 days correspond to about 40% of the cases) and moderate size (strikes up to 100 strikers correspond to less than 20% of cases and up to 450 strikers more than half of the cases). Although there is no consensus in the economic literature, low duration can be explained by situations where a threat to strike is not considered credible by companies – when strikes really occur, negotiations are more effective, thus agreements are reached in a shorter period of time. In the second case, schoolars attempt to explain the strikes size as a measure of bargaining power: if stoppages are composed by a large number of strikers, then the movement is characterized by a higher level of organization of workers, usually associated with unions; on the other hand, the strikes composed by a small number of strikers are associated with the most important sectors of the economy, characterized by fewer employees and greater bargaining power. Thus, the information about strikes suggests that Brazil is an intermediate case.

Due to strong concentration on the left distribution of the number of strikers, the use of absolute values in the Cox proportional hazards model generates an estimated coefficient very close to

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[5] Strikes category are characterized by stoppages that are not represented by a specific group of workers from a company, but by all employees of companies related to the same labor category, usually associated with a representative union that organizes and coordinates joint actions.
[6] Representing 98.88% of the sample.
[7] Representing 90.19% of the sample.

unity, not allowing an appropriate interpretation of results. The alternative adopted in this study to avoid this problem was the creation of dummy variables representing cohorts of number of strikers, allowing to determine the variation of hazard rate according to their ranges. To define the cohorts adopted in this study we consider the cases that demonstrate significance of coefficients in the Cox model and no violation of proportional hazards assumption in Wilcoxon and logrank tests. Thus, we selected three cohorts that attend these two requirements: the cohort ranging up to 300 strikers (about 46% cumulative frequency), from 300 to 1.000 (73.5%) and above 1.000.

Following the methodology adopted by Perez et al. (2006), we included variables representing unemployment rate in current year (as control variable to verify the effects of economic cycles on strikes duration) and the inflation rate in previous year (as a proxy for expected inflation by unions in contractual negotiations, mainly influencing the wage claims). Table 2 summarizes the characteristics of variables included in this paper:

Table 2 – Characteristics of strikes, by period

	Starting year		
	All	1983-1988	1989-1991
Number of strikes	11600	6041	5559
Mean duration of strikes (in days)	8.04	7.05	9.10
Median duration of strikes	5	4	6
Mean number of strikers	951.88	917.75	988.98
Median number of strikes	380	350	400
Proportion of strikers - up to 300	0.46	0.47	0.45
Proportion of strikers - 301 to 1000	0.27	0.28	0.27
Proportion of strikers - more than 1000	0.27	0.25	0.28
Industrial unemployment rate	3.93	3.81	4.06
Inflation rate in the previous period	17.68	13.04	22.73
Proportion of State of São Paulo	0.43	0.42	0.45
Proportion of post Constitutional period	0.48	-	-
Proportion of industrial sector	0.49	0.47	0.52
Proportion of commercial sector	0.05	0.05	0.05
Proportion of service sector	0.46	0.48	0.44
Proportion of category strike	0.15	0.16	0.15

Source: elaborated by the authors

Note that the dummy for the state of São Paulo has a considerable representation, not only for his percentage (about 43% of the sample) but mainly because the state is the place of the most important strikes and union activities in the country in the period of analysis. Since our paper aims to verify the impact of institutional changes due to the Federal Constitution reformulation, it is important to note that the constitutional dummy indicates that the period after 1988 period accounts for nearly half of the sample. The other binary variables are also representative, as the industrial sector dummy presents the highest proportion, with about half of the sample, the service sector corresponding about 46% and the commercial sector accounts for only less than 5%. The category strikes represent only 15% of the sample.

The sample includes information about strikes started in different companies and institutions in the national territory. Thus, considering the regional differences (geographical and institutional, for example), the assumption of no specific distribution of the information is reasonable, justifying the use of semi-parametric estimator of Cox.

4. Methodology

We present first the characteristics of *duration* and survival function (not considering the effects of covariates) by means of the Cox proportional hazards model, emphasizing the impact of the promulgation of the Brazilian Constitution in 1988. Following, covariates are included, initially checking for their individual representativeness by testing the hypothesis of equality of survival curves. Table 3 presents information about strikes duration. The data is uncensored – also called complete data. Considering only strikes up to 60 days, the average duration is around 8 days and the median duration is 5 days. The survival time (expressed in terms of cumulative frequency shows that the expectation of a strike ends up to 2 days is 25%, up to 5 days (the median duration) is 50% and the probability of ending up to 10 days is 75%.

Table 3 – Main characteristics of strikes duration

Strikes duration			
	All	1983-1988	1989-1991
Number of observations	11600	6041	5559
Fails	11600	6041	5559
Mean	8.0368	7.0543	9.1045
Min	1	1	1
Median	5	4	6
Max	60	58	60
Survival time			
25%	2	2	3
50%	5	4	6
75%	10	9	12

Source: elaborated by the authors

The histogram complements graphically this information (Figure 1), demonstrating that the frequency is highly concentrated on the left.

Figure 1 – Strikes duration histogram
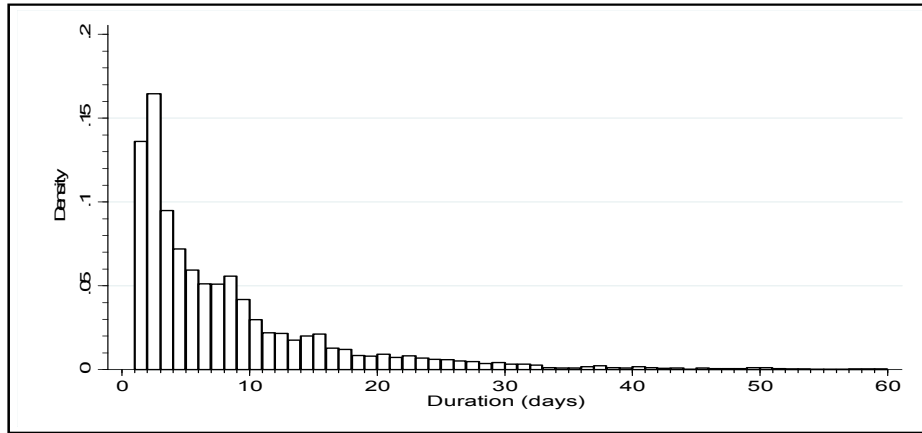
Source: elaborated by the authors

For purpose of analysis of the slopes and the distance between the survival functions in pre and post-constitutional periods, figure 2 presents the Kaplan-Meier curves for both periods. The initial slope suggests that there is a significant reduction in the probability of continuity of strikes in the early days – corroborating the histogram. The distance between the curves also evidences the distinction between the characteristics of the stoppages over the periods, confirming a tendency of higher strikes duration after 1988.

Figure 2 – Kaplan-Meier survival curves
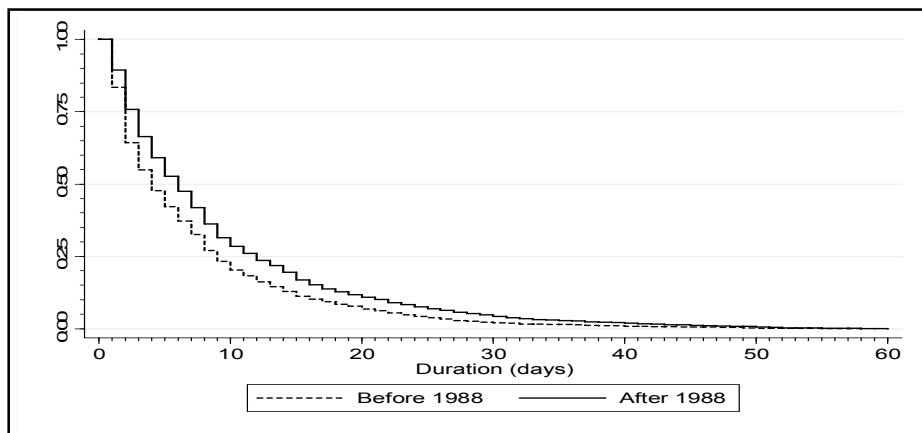
Source: elaborated by the authors

The assumption of equality of survival curves between periods should be verified. Logrank and Wilcoxon statistical tests are performed to check if there are significant differences between times to failure. The tests present the null hypothesis of both groups having identical survival and hazard functions, where the alternative hypothesis of significant differences between the curves suggests that the inclusion of the variable in the estimation is adequate. The difference between the statistical tests is that the *logrank* test equally weights all points of the estimated survival curve, while the Wilcoxon test weights more the

initial points of time. Following the methodology adopted by Giolo and Colosimo (2006), we include in the model the variables that present a *p-value* less than 0.25 in at least one test of comparison of survival curves.

The basic assumption of the Cox model is that failure rates are proportional, that is, the risk for an individual is proportional to the risk for another individual, with constant rate over time (not depending on the duration). Assuming that we have p independent variables that satisfy the proportional hazards can be rewritten as:

$$h(t,X) = h_0(t)\exp(\beta_1 X_1 + \ldots + \beta_p X_p) \qquad (1)$$

The next step is to verify the proportional hazards assumption, using a chi-square statistical test performed for each variable (adjusted for the other variables included in the model). According to the test of proportional hazards based on scaled Schoenfeld residuals (Table 5), only for post-constitutional dummy the hypothesis is not satisfied, indicating that the coefficient (as well as the proportional hazards) is not constant over time, reducing his efficiency. Note that the lack of a constant hazard rate for the post-constitutional period flags a possible "effect" of the new Constitution. In fact, although a bit speculative, we interpreted that as an outcome of (incomplete) information and learning dynamics that might have a bite to explain strike dynamics after the enacting of the 1988 new Constitution!

Table 5 – Test of proportional hazards (*p-values*)

Variable	P(PH)
Number of strikers - 301 to 1000	0.1110
Number of strikers - more than 1000	0.4130
Unemployment rate in the industry	0.1231
Inflation rate in the previous period	0.7410
State of São Paulo	0.1706
Post-period 1988 Constitution	0.0077

Source: elaborated by the authors

The rejection of the null hypothesis suggests only that the residual is not constant over time, but does not demonstrate the sign of correlation, where the graphical representation show if the correlation with time is positive or negative. Thus, the graphical representation of the test is visually more informative. The relation between the scaled Schoenfeld residuals and time is presented in figure 3, demonstrating that the residuals are positively related for strikes until 8 days, with some variations in subsequent periods.

Figure 3 – Test of proportional hazards (graphic)
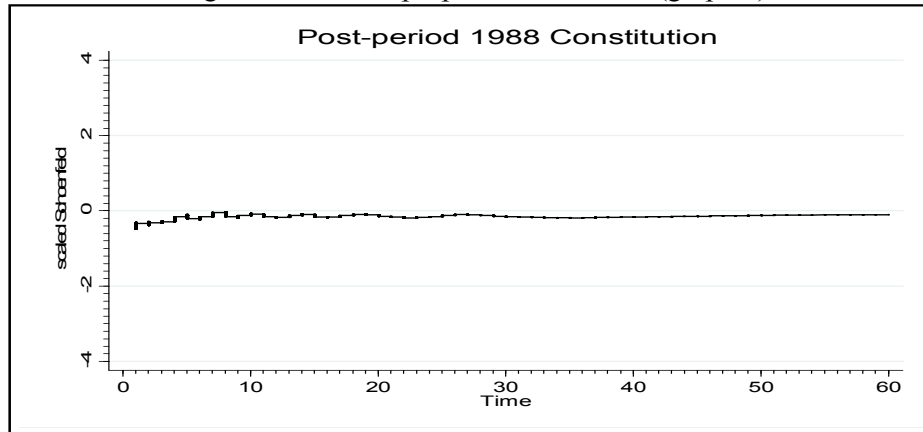
Source: elaborated by the authors

When the proportional hazards assumption is not satisfied, the procedure is the stratification or the inclusion of time-varying covariates. The post-Constitutional dummy is time-invariant, thus the specification of the model should consider the first case – also including in the model other variables that satisfy the hypothesis of proportional hazards. The general form of the stratified Cox model allows the stratification of several regressors. The hazard function of the stratified Cox model is expressed by:

$$h_g(t, X) = h_{0g}(t)\exp(\beta_1 X_1 + \ldots + \beta_\rho X_\rho), \ g = 1,\ldots,k^* \tag{2}$$

Where the subscript g indicates each cohort of the model and ρ is the number of regressors. The difference from the initial model is that in the stratified model the hazard functions for different periods are not the same, with distinct baseline hazard functions, that is, $h_{0g}(t)$ is defined for each cohort of the model, but coefficients $\beta_1, \beta_2, \ldots, \beta_p$ are identical. Due to these differences in baseline functions, the adjusted Cox model will generate different survival curves for each cohort. Also, the same coefficients will generate similar hazard functions. This characteristic is denominated *no interaction effects assumption*.

The model without interaction considers only one set of coefficients valid for the cohort, that is, assumes that the Constitutional dummy variable has no interaction with other independent variables in the model. If we allow the interaction, then different coefficients are expected for each cohort[8], representing the expected result to estimate proportional hazard models separately for the distinct period. The definition of the correct stratified model involves comparisons between the specifications with and without interaction, checking for the multiplicative impact of the variable that violates the assumption of proportional hazards with other independent variables. The null hypothesis suggests the use of the model without interaction. The stratified Cox model with interaction is defined by equation 3, where each

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[8] The variable d88 is a binary dummy, thus $k^* = 1$. So, the stratification of a variable composed of two categories will generate two strata.

variable has different coefficients for distinct period, as indicated by the subscript g. Thus, it is expressed with the inclusion of all variables initially defined, multiplied by the stratified term.

$$h_g(t,X) = h_{0g}(t)\exp(\beta_{1g}X_1 + \ldots + \beta_{\rho g}X_\rho), \ g = 1,\ldots,k^*$$
(3)

To statistically determine the appropriate model, we apply a log-likelihood test[9] comparing the statistics of the stratified Cox specifications. The result rejects the null hypothesis[10], suggesting the use of the model with interactive variables. Thus, the model has two baseline hazard functions (due to stratification of a single binary variable), where the coefficients are related to pre-and post-constitutional periods. Results are showed in Table 6.

The proportional hazard represents the risk of occurrence of an event – in this analysis expresses the end of the strike. If the value is larger than unity, the variable positively affects the end of the strike – in other words, contributes to reduce the duration of stoppages. On the other hand, values less than unity increase the probability of greater duration. In the estimation, the results indicate a positive relationship between number of strikers and strikes duration, same result presented by inflation in the previous period. Equivalently, the unemployment rate and the strikes initiated in the state of São Paulo tend to reduce the duration of the stoppages.

Table 6 – Stratified Cox proportional hazard model estimation

Variable	Coefficient	Hazard ratio	P>|z|	P(PH)
Number of strikers - 301 to 1000	-0.0458	0.9552	0.098	0.0535
Number of strikers - more than 1000	-0.0851	0.9184	0.005	0.4548
Unemployment rate in the industry	0.1094	1.1156	0.000	0.7065
Inflation rate in the previous period	-0.0152	0.9849	0.000	0.4324
State of São Paulo	0.1396	1.1498	0.000	0.2963
Number of strikers - 301 to 1000 (iterated)	-0.0106	0.9894	0.797	0.2673
Number of strikers - more than 1000 (iterated)	-0.0065	0.9935	0.880	0.5882
Unemployment rate in the industry (iterated)	-0.0734	0.9292	0.000	0.1215
Inflation rate in the previous period (iterated)	0.0160	1.0162	0.000	0.2090
State of São Paulo (iterated)	0.0727	1.0755	0.052	0.7106

Stratified by d88
Observations: 11600
Log likelihood: -89558.62

Source: elaborated by the authors

Considering variables included in this study, the equation that expresses the stratified Cox model with interaction is:

$$h_g(t,X) = h_{0g}(t)\exp(\beta_{1g}grev300\_1000 + \beta_{2g}grev\_1000 + \beta_{3g}desemps + \beta_{4g}igpdi\_1 + \beta_{5g}de\_sp)$$
(4)

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[9] The test is expressed by $LR = -2\log L_R - (-2\log L_C)$, where R represents the reduced model (without interaction) and C the full model (with interaction), with chi-square and g degrees of freedom and the null hypothesis of no interaction.

[10] The model includes the interaction of five independent variables in the stratification, thus the test has five degrees of freedom. The calculated value is 115.29 (for a table value of 11.07).

Where the stratification is represented by:

$$\begin{cases} g = 1 : \text{period before the 1988 Federal Constitution;} \\ g = 2 : \text{subsequent period.} \end{cases}$$

For comparison purpose, table 7 presents the estimations of the Cox model separately. The results show different coefficients in the distinct periods, especially for the unemployment rate (where the reduction of the hazard ratio represents a propensity to more extensive strikes) and São Paulo dummy variable (with an increase in the proportional hazard). In turn, the inflation rate in the previous period has a significant relationship only in the pre-constitutional, with negative effect.

Table 7 – Stratified Cox proportional hazard model estimation – by period

Variable	1983-1988			1989-1991		
	Coefficient	Hazard ratio	P>|z|	Coefficient	Hazard ratio	P>|z|
Number of strikers - 301 to 1000	-0.0458	0.9552	0.098	-0.0564	0.9452	0.066
Number of strikers - more than 1000	-0.0851	0.9184	0.005	-0.0916	0.9125	0.004
Unemployment rate in the industry	0.1094	1.1156	0.000	0.0360	1.0367	0.000
Inflation rate in the previous period	-0.0152	0.9849	0.000	0.0008	1.0008	0.232
State of São Paulo	0.1396	1.1498	0.000	0.2124	1.2366	0.000
	Observations: 6041			Observations: 5559		
	Log likelihood: - 46899.31			Log likelihood: - 42659.31		

Source: elaborated by the authors

The adjustment of the model is analyzed by plotting the Cox-Snell residuals. If the model is correct, the graph of cumulative hazard in respect to residuals should approximate of a straight line with unitary slope. Considering that the values up to 3 accounts for more than 95% of the data, we can conclude that the model Cox has a satisfactory level of adjustment. Our procedure confirms previous results and provides a more comprehensive analysis of the determinants of strikes in Brazil, allowing the comparison between the distinct periods.

According to figure 5 we have an initial reduction in the slope of survival curves, indicating greater probability that a strike ends in the first days. A brief comparison between periods shows that after 1988 there is an increasing trend in the duration of stoppages, demonstrated by the upper survival curve.

Figure 5 –Cox survival function
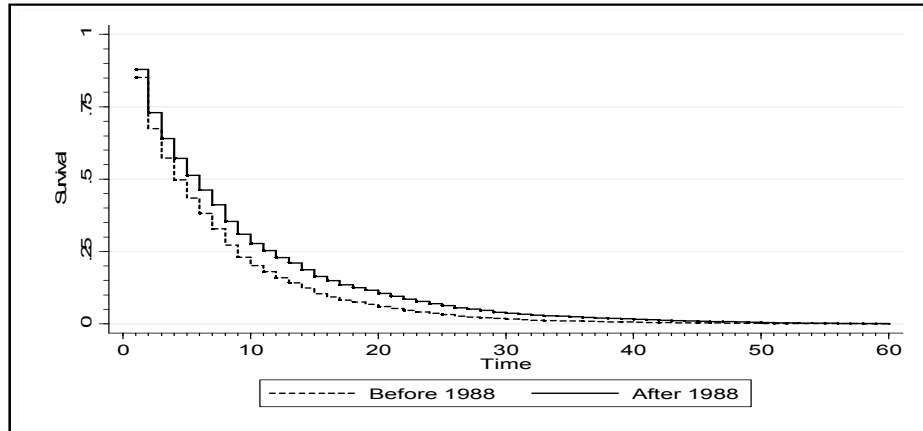
Source: elaborated by the authors

Figure 6 shows the proportional hazard function (smoothed). The curves for the periods before and after Constitution are parallel, and the first has a higher failure rate – showing that**, for a given duration, the probability of ending a strike is lower after 1988, i.e., mean duration is higher.** Also the shape of the function indicates that the hazard is increasing in the initial period, starting to decrease around the 14th day and increasing again from 34th day of stoppage, with subsequent expressive raise in their rates.

Figure 6 –Proportional hazard function (smoothed)
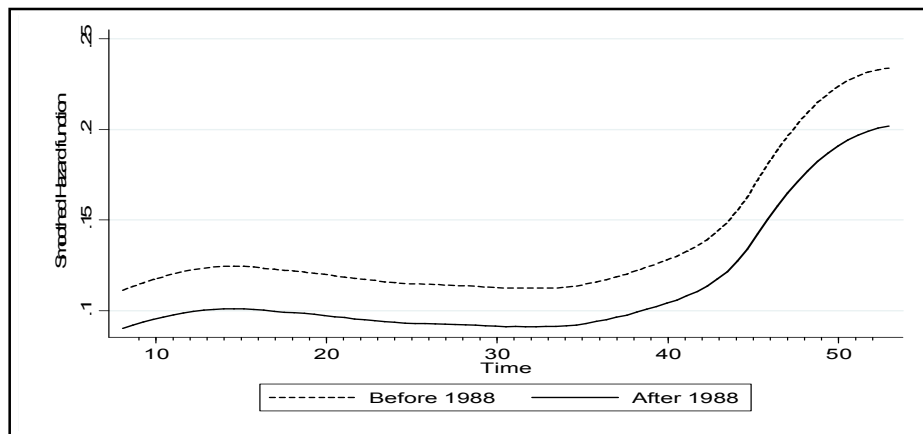
Source: elaborated by the authors

5.   Final Considerations

The main difference between characteristics of strikes that occurred in Brazil and those in other countries is the time of the stoppage –Brazilian work stoppages are usually shorter. The database used in this paper includes information about approximately 15,000 strikes, and only about 2% were longer than 45 days and 1% than 60 days. While in Brazil strikes have an average only of 8 days and a

median of 5 days, the average duration of strikes in the manufacture sector in the United States and in Canada ranges from 40 to 50 days, and the median ranges from 25 to 40 days [Card (1990)]. According to Picchetti (2002), this fact is due to the Brazilian legislation (which avoids conflicts on negotiations) and by the significant role of trade unions to support strikes – more bargaining power means reduction of time stoppages. Duration of strikes in Brazil is similar to those values observed in Spain, where the mean duration is 5.75 days and the median is 3 days [Pérez et al. (2006)], in the Netherlands, where the mean range from 2 to 12 days and in France, from 1 to 8 days [Butter and Koppes (2003)].

This paper evidences differences in characteristics of strikes before and after the 1988 new constitutional law. Besides the distinction between the non-parametric survival curves between periods, tests of equality of survival function confirm the appropriate use of the variable representing the post Federal Constitution in the model. The initial results of the Cox model estimation showed a significant proportional reduction in risk, indicating that the strikes starting after 1988 have a propensity to be longer. The violation of the proportional hazards assumption – indicating that the coefficient of the post constitutional dummy is not constant over time – can be attributed to differences in the characteristics of strikes in the two periods, which requires a stratified Cox model to capture the distinct effects. In addition, the final specification by stratified Cox model with interacted covariates also specifies the difference between the coefficients of the estimations according to considered period.

Results indicate that the number of strikes is positively related to the duration of stoppages, consistent with found by Harrison and Stewart (1993) for Canadian strikes for wage claims up to 500 strikers, but different to verified in Spanish strikes by Perez et al. (2006) and Canadian strikes by Cramton et al. (1999). However, there is not a significant difference in mean durations between the cohorts of strikers considered in this research, resulting in 7.6 days in the case of stoppages up to 300 strikers, 8 days for the stoppages with 300 to 1.000 strikers and 8.8 days for the stoppages with more than 1.000 strikers.

In turn, the inflation rate is positively related with strikes duration only in the pre-constitutional period[11]. Vroman (1989) finds a negative relation, suggesting that although the agents involved in the negotiations have common understanding regarding the need to an update on wages, they disagree on the level of adjustment to be accomplished – and as larger the inflation, larger the differences between the values negotiated. Perez et al. (2006) finds a positive relationship between inflation and strikes duration for the negotiations that do not result in agreement, while it is negative in strikes that result in agreement; but in the full sample, the variable does not demonstrate statistical significance.

The unemployment rate presents an inverse relationship with the strikes duration in both periods. This results are consistent with the ones obtained by Card (1990), McConnell [apud Card (1990)] and Picchetti (2002), but different to the ones reported by Vroman (1989) and Cramton et al. (1999); also,

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[11] Although statistically significant, inflation showed no effect on the strikes duration in the post-constitutional period, because the coefficient is close to zero (proportional hazard close to one).

no statistical significance was found by Pérez et al. (2006). The economic literature shows that the impact of unemployment on the strikes duration is ambiguous – the final effect is the result of specific conditions of each economy.

In Brazil, the negative relationship between unemployment and strikes duration may reflect larger bargaining power of firms relative to the unions – when unemployment rates rise, the difference between the wages offered and demanded tends to be lower, increasing the probability of reaching an agreement and thus reducing the time of the strikes. The reduction of hazard rate in the post-constitution period can be the effect of increased organizational level and greater bargaining power of unions, which implies in reduction of the impact of changes in unemployment on the wage differential proposed in the negotiations, increasing the duration of stoppages.

The State of São Paulo is historically the place of the most important and largest strikes in the country, and also where most unions and workers associations originated. The inclusion of a dummy variable representing the state demonstrate a significant and higher hazard rate, that is, the strikes started in companies or institutions in São Paulo have a propensity to lower durations – mainly due to the role of unions in strikes and to the important characteristic of Brazilian legislation supporting the negotiations realized by unions and labor organizations [Picchetti (2002)]. In the post-constitutional period, the hazard rate is smaller, but still demonstrates a shorter duration of strikes relative to other states. This result can be interpreted as the effect of stricter regulatory laws in the labor relations, inducing to more organized strikers and the development of clearer rules. The main strikes were initiated in São Paulo, thus this effect tends to be more evident in that state.

Strikes are usually the result of collective bargaining between firms and workers in periods of contract renewal or under economic instability or also when the parties do not reach an agreement, being induced by improvements in economic or working conditions. The economic literature suggests that the main cause of strikes is asymmetric information – for example, the relationship between wages and remuneration with the productivity can be more directly observed by firms than by workers. Our results point out that strike size, dummies for São Paulo state and the period after the Federal Constitution play the most significant roles on strikes duration. Thus, this study found that patterns of strikes duration have changed between pre and post-constitutional periods, concluding that the promulgation of the new federal legislation had non-negligible impacts on duration and characteristics of strikes, yet to be fully understood.

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Appendix

Table 8 – Duration of strikes

Duration (days)	Number	%	Cumulated
1	2342	16.06	16.06
2	2310	15.84	31.91
3	1320	9.05	40.96
4	995	6.82	47.78
5	803	5.51	53.29
6	691	4.74	58.03
7	705	4.84	62.87
8	758	5.20	68.07
9	572	3.92	71.99
10	408	2.80	74.79
11	318	2.18	76.97
12	300	2.06	79.03
13	232	1.59	80.62
14	283	1.94	82.56
15	303	2.08	84.64
16	189	1.30	85.93
17	167	1.15	87.08
18	122	0.84	87.91
19	113	0.78	88.69
20	141	0.97	89.66
21	105	0.72	90.38
22 a 30	716	4.91	95.29
31 a 60	524	3.59	98.88
61 a 64	21	0.15	99.03
61 a 80	69	0.47	99.50
81 a 211	73	0.50	100.00

Source: elaborated by the authors based on CIS

Table 9 – Number of strikers

Grevistas	Observações	Percentual	Acumulado
Até 50	1166	8.34	8.34
50 a 100	1411	10.09	18.43
101 a 200	2044	14.62	33.05
200 a 300	1264	9.04	42.09
301 a 450	1130	8.09	50.18
451 a 500	441	3.15	53.33
501 a 740	1373	6.67	60.00
741 a 1000	936	6.69	66.69
1001 a 1500	921	6.59	73.28
1501 a 2000	603	4.31	77.59
2000 a 2500	372	2.66	80.25
2501 a 4000	817	5.85	86.10
4001 a 6400	547	3.91	90.01
6401 a 17000	708	5.06	95.07
17000 a 90000	549	3.93	99.00
89001 a 7000000	140	1.00	100

Source: elaborated by the authors based on CIS