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Study on wage rigidity in Brazil

Estudo sobre rigidez salarial no Brasil

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Dissertação apresentada ao Programa de Pós-Graduação em Economia do Departamento de Economia da Faculdade de Economia, Administração, Contabilidade e Atuária da Universidade de São Paulo, como requisito parcial para a obtenção do título de Mestre em Ciências.

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Abstract

JEONG, Hyeon Jin. Study on wage rigidity in Brazil. 2022. Dissertação (Mestrado em Economia) - Faculdade de Economia, Administração, Contabilidade e Atuária, Universidade de São Paulo, São Paulo, 2022.

This study investigates the nominal and real wage rigidities in the Brazilian formal labor market. It explores two features of nominal wage rigidity: first, the existence of a certain nominal wage raise rate in which a great number of employees experience in each year; and, second, the stickiness of nominal wage. It uses three different indicators to calculate nominal wage rigidity and survival analysis is conducted to analyze nominal wage stickiness. This study provides empirical evidence for the benchmark used by collective bargaining negotiators to nominal wage raise. One additional finding is that different entities - unions and firms - do not influence the collective negotiation results.

Keywords: nominal wage rigidity, real wage rigidity, nominal wage stickiness, wage adjustment

Resumo

JEONG, Hyeon Jin. Estudo sobre rigidez salarial no Brasil. 2022. Dissertação (Mestrado em Economia) - Faculdade de Economia, Administração, Contabilidade e Atuária, Universidade de São Paulo, São Paulo, 2022.

Este estudo investiga a rigidez do salário nominal e do salário real no mercado formal de trabalho brasileiro. Quanto à rigidez de salário nominal, são exploradas: a existência de um ponto focal de variação salarial em que muitos trabalhadores experienciam; a persistência do congelamento salarial. Foram usados três diferentes indicadores para calcular a rigidez de salário nominal e a análise de sobrevivência foi realizada para analisar a persistência do congelamento salarial. Este estudo providencia a evidência empírica para a referência de aumento salarial adotada por sindicatos e empregadores durante a negociação coletiva. Foi encontrado que os sindicatos e os empregadores são indiferentes em relação ao resultado da negociação coletiva.

Palavras chaves: rigidez de salário nominal, rigidez de salário real, persistência do congelamento salarial, reajuste salarial

1 Introduction

Wage rigidity has been pointed out as one of the factors that explain why nominal shocks can cause impact on real variables, such as unemployment and output. Despite its relevance to modern macroeconomics, there have been attempts to understand it only in relatively recent times. Regardless of the consensus on its existence in real world, the discussion on how to measure wage rigidity is still ongoing. Indeed, different empirical strategies are used to measure it. Consequently, there are often divergent results. Not only the lack of consensus on measurement makes it difficult to understand, compare and analyze, but also there is another obstacle to overcome: mostly, studies have been conducted using self reported surveys, rather than administrative records, in this case measurement error can cause problems to the estimation.

Wage rigidity describes the situation in which it is not possible to adjust wage to the optimal level. Two characteristics can be used as signals to recognize it: a great number of observations around some certain point, for example, around 0 nominal wage variation, and the persistence of no wage change for several periods. The first feature is often observed when faced with the resistance to have wage cut, called downward nominal wage rigidity. The second feature is known as staggered wage setting or sticky wage setting.

This study investigates the existence of wage rigidities and its extent in the Brazilian formal labor market. The study answers four questions related to nominal and real wage rigidity: firstly, I want to investigate how rigid nominal wage is for job stayers; then the second feature of wage rigidity leads me to assess how sticky nominal wages are; regarding real wages, I want to identify which benchmark is used for wage adjustment in collective wage bargaining; finally, I want to evaluate real wage rigidity.

The first question is answered using RAIS, Brazilian administrative records on employees, reported by employers. I identify job stayers and separate into 3 categories: hourly wage freeze, hourly wage cut and hourly wage increase. Then three different indicators are calculated in order to have an overview on the labor market. The share of each category is stable over the studied years, even under economic turbulence. Annually, about 17.5% of job stayers are expected to experience wage freeze. In Brazil, nominal wage cut requires a legal process to be implemented, so it ends up creating an extra barrier to employers. Due to all this difficulty to overcome, wage cuts are rare, experienced by about 3% of job stayers, however, they are observed in every year.

The second question is concerning the stickiness of nominal wage. This problem requires survival analysis approach. Survival function for each year is estimated using KM survival estimator. As the main finding of this part, I found that employers in Norte and Nordeste have the stickiest wage, while employees from Sul and Sudeste have the least sticky wages. Heterogeneity across income groups is found as well: the higher is the wage, the stickier it is. As the final task of this part, the survival regression is estimated using Maximum Likelihood Estimator. The estimation results show that the heterogeneity across regions and income groups is significant at 1%.

Before answering the questions regarding real wage rigidity, I adopt two ways to calculate real wage change: firstly, I discount retroactive inflation rate equivalent to the duration of the contract; secondly, I discount the inflation rate during the contract duration. Basically, in the first case, employees are compensated for their loss in real wage in the past, while in the second case negotiators' prediction is perfectly accurate and employees have in fact real wage increase.

To answer the questions related to real wage rigidity, I used the database Salariometro,

which contains data on collective bargaining agreements (CBA), besides RAIS. To identify the benchmark for wage adjustment during collective negotiation, Salariometro is reset in a panel setting in order to identify whether past inflation rate is more relevant in CBA than the inflation rate during the contract period. To accomplish this goal, pooled OLS model, 3 fixed effect models - allowing for individual, time effects and both - and 3 random effects models are estimated. The estimation results indicate that past inflation rate is more relevant in all estimated models; and the random time effect model is considered to be the efficient one.

When it comes to evaluate real wage rigidity, with past inflation rate discounted from the nominal wage change (NWC), I can interpret how resistant unions are to recover the lost real wage in previous period. When the past inflation is used as the benchmark, I understand that in fact workers want to regain the lost part of the real wage, but they do not aim at having the real wage increase. And the second inflation type, 'current' inflation rate, is considered to accurately calculate real wage at that time. Results show that efforts to regain the lost part are very high, with the estimated density highly concentrated around 0 real wage gain (from the past inflation). Meanwhile, regarding the current inflation rate, employees and unions are shown to be quite indifferent and flexible.

This study has three main contributions to the literature. First, this study provides empirical evidence of the nominal wage rigidity for Brazilian formal labor market. So this finding could be used in further studies which need a prior for the value of nominal wage rigidity. Second, I found empirical evidence that the main concern of negotiators involved in collective bargaining for wage raise is recovering the lost real wage in the past, and they do not seem very interested in real wage increase. Third, the panel estimation results indicate that difference in entities - firms and unions - does not result in different nominal wage increase.

2 Brief literature review

Most economists agree on instant wage adjustment in response to any type of shocks being unrealistic assumption. Most mainstream models point to the nominal price and wage rigidity as the cause to possible linkage between nominal shocks and impacts on real variables. This so called nominal wage rigidity is present in theoretical models, however, little is certain about what defines it nor how to measure it or even the existence in the real world. Basically, there are two characteristics that identify the existence of nominal wage rigidity (NWR). Inspired by the idea of not being able to reduce wage to the equilibrium level, the first feature to describe NWR is the resistance to have wage cut. As a consequence, it would be recognized by a considerable number of employees who have wage frozen, 0 wage change. The second feature that describes NWR is inspired by the time it takes to adjust nominal prices and wages in response to monetary shocks.

Based on the observation made by Fallick et al (2016), despite the concept being quite old, this theme has been explored only recently, mainly because inflation rate in the US was high enough to keep this problem far away from the reality. Indeed, as noted by Taylor et al. (2016), the introduction of rational expectation became a turning point for macroeconomists and since then the theme has been extensively investigated, developing several models that incorporate the idea, such as Calvo model of pricing, developed by Calvo (1983), to introduce a random duration of a contract.

There is relative consensus concerning the problem that NWR would cause to the economy, in the theoretical literature. So there have been many attempts to examine especially downward nominal wage rigidity using different empirical approaches (McLaughin, 1994; Dickens et al., 2007; Elsby, 2009, Bauer et al., 2003, Babecky et al., 2009). However, Goette

et al. (2007) observed that there is not consensus on the extent of DWNR in the empirical literature, nor consensus on how to measure it, as noticed by Deelen et al. (2015). Also, other studies have looked for reasons for wage rigidity, by surveys and questionnaires responded by firms. Besides labor regulation, collective bargaining, union density, and many other labor related variables that affect decision to wage cut, as reported in Du Caju et al. (2014), employees' morale is found to be one of the relevant factors that employers consider, as Bewley (2004) reports.

As stated above, how to measure wage rigidity has become a very important issue in this branch of the literature. There have been numerous attempts to create an indicator that would lead to precise measurement. One of the first and the most intuitive indicator is the number of employees who experienced wage freeze, as used in McLaughin (1994). Dickens et al. (2007) proposes the ratio between the fraction of employees with wage freeze and the sum of the fraction of employees 'at risk': those who had wage cut and those who had wage freeze. Concerns on the reliability of the data have surged as an important point to consider prior to analysis, as a variety of empirical studies used individual reports, as remarked by Elsby et al.(2019). So, as an attempt to correct measurement error, many works have used assumptions on errors in the theoretical wage change distribution. Deelen et al. (2015) finds that the assumptions on the wage change distribution under flexible wage setting may be the sources that result in different levels of wage rigidity, even when the same dataset is explored.

On the other side, real wage rigidity (RWR) is less explored in the literature as Babecky et al (2009) observed. In their study, using multinomial logit models, the wage indexation mechanism is found to be more frequently used among the EU members than the observation of nominal wage freeze in the economic block. They still found that DNWR is positively associated to firing costs, for example, relatively rigid labor regulation regarding layoff and the share of permanent employees in the firm. In an economy with extreme NWR, study on the behaviour of wages is conducted by Portugal (2006). The investigation makes two important observations prior to the analysis: in Portugal, employers face with regulatory barrier to cut nominal wages and the wages are higher than the minimum established via collective bargaining. Nonetheless, as under high inflation rate nominal wages increase and at the same time real wage are reduced, the wage cushion - difference between the actually paid wage and the minimum level established by agreement - also enables this manipulation, even under low inflation rate.

Regarding Brazilian labor market, there have not been many attempts to explore this theme, possibly because during times of relatively high inflation rate, DWNR is not a relevant restriction. whereas wage indexation is a more complicated problem faced by policy makers. Messina et al (2014) explores how the reactions of employers and employees changed during the period of a speedy disinflation process. Using RAIS of Minas Gerais for the period of 1995-2002, they find out that the employees in the state do not face DWNR, but wage indexation persists even after the disinflation, partly attributed by the high union density in Brazil. This study also points out that the focal point moved from the changes in the national minimum wage to the inflation expectations, after the Central Bank introduced inflation targeting. Mazali et al.(2010) estimates New Phillips curve in the theoretical model proposed by Blanchad and Gali (2007), using the national inflation rate, IPCA, and the unemployment at in Sao Paulo, from 1995 to 2008. The results derived from GMM estimation show that the real wage rigidity in Brazilian economy is about 92% in the sample period, similar to 90% found by Blanchard and Gali (2007) for the US economy. However, Schumanski (2015) claims that there is not empirical study to provide evidence for nominal wage

rigidity in Brazilian market.

3 Data

This study has two main objectives: checking the presence of nominal and real wage rigidity via collective bargaining agreement and estimating the extent of each type of rigidity in Brazilian labor market. In this section, data sets are described and explored in order to understand better which strategy is used to reach each goal.

3.1 Relação Anual de Informações Sociais - RAIS

The main dataset used to accomplish the first goal is the Brazilian annual administrative record regarding employer-employee relationship, Relação Anual de Informações Sociais (RAIS, Annual Report on Social Information). Collected by Ministério do Trabalho e Emprego (MTE, Ministry of Labor and Employment) it was created in the '70s to monitor over formal labor market, by gathering employers' annual update regarding their staff.

This employer-employee matched dataset contains information on base wage, individual identification, contracted working hours per week, employee's characteristics, job features, firm characteristics, employer-employee relationship, employer's leaving during the base year, as of 31st December of each year. Since it is a huge database, only variables considered relevant to the analysis are extracted: municipality, separation date if applicable, admission date, contracted working hours, base wage, type of wage, PIS/Pasep (individual identification), CNPJ/CEI (firm identification), position, classification of economic activities. Also, RAIS shows not only the active staff at the base date, but in-year-separated employees' information is available as well. The procedure of filing is compulsory for all registered employers in Brazil with the possibility of penalties foreseen in law in case they do not meet the deadline, omit information or provide incorrect statements. Based on the estimation made by Instituto Brasileiro de Geografia e Estatística (IBGE, Brazilian Institute of Geography and Statistics), the dataset covers about 97% of the formal labor market.

The unit of observation is employee associated to each employer. So an individual may appear more than once in the dataset. In this situation, they are treated as different cases. As all the information is as of December 31st, if there was any change over the year, only the last updated information is available. Also, it does not bring information regarding when variables suffered change and if variables suffered change more than once over the year. For this reason, this study focuses on job stayers, defined as the ones associated to the same employer with the same position as in the previous year. In this dataset, job stayers are identified by individual identification (PIS/Pasep), position (CBO) and employer identification (CNPJ/CEI).

Employers should inform base pay and the type of wage as in employment contract.[1] Since wages could be informed on daily, weekly, monthly or any other frequency - as long as it is what the employee contract says - , it seems that standardization is required. Yet, type of wage is not the information that employers change annually. Besides, when changed from one basis to another one, wage change will be out of the considered range, so it would be

[1] According to the official RAIS guide, type of wage is understood as how wage is calculated, not the frequency of payment. For example, considering an individual who was hired for 20 hour-a-week job, with monthly wage of R$ 4000.00, paid weekly, employer is required to inform that the wage is on monthly basis. However, this guide does not provide details concerning how the value of wage should be informed. Although, most employers inform values on monthly basis, values on other bases could be found.

filtered. Thus, this variable would not cause issues by any means when calculating hourly wage change.

Table 2 shows a summarized look at RAIS. As displayed in the column (2), about 60% of employees are job stayers: this share of workers remain at the same firm as in the previous year, with the same job. The dataset was trimmed by removing cases with wage change greater than 50% or less than -50%. It reduces the number of observations by about 5%, as indicated in column (3) of table 2. This procedure filters not only outliers, but it also avoids inaccurately informed cases.

In 2015, 2016 and 2017, some records are apparently inconsistent as illustrated in table 1. However, records as the first row of the table suggest that it would not affect analysis if properly modified. Indeed, it looks more likely that there has been some mistake during the data entry process. If this inconsistency is kept, it would result in the dataset being reduced by about 30%, because wage change is out of the considered range. [2] For this reason, an adjustment was made for these observations following the next steps: 1) if wage change is less than -50%, then wage in t + 1 is multiplied by 100; 2) if wage change is more than 50%, then wage in t is multiplied by 100. Once this adjustment is done, trimmed dataset reaches similar level as in previous years.

Figure 1a shows percentiles of wage changes in 2007. Figures for other years are available in the Appendix. Wage changes sorted in ascending order look quite similar across years. It suggests that the proportion of each group - wage cut, wage freeze and wage increase - is almost constant. This is also observable by column (4) and (5) of table 2: the share of each wage change type is almost steady across the years. It is even more unequivocal when wage cut is observed: about 3.5% of job stayers experienced wage cuts, and this share ranges very little during the examined period. Only in 2015, there is considerable increase: 4.5% of workers had wage cuts, corresponding to 1.9 million of employees - increase of 0.5 million of cases, compared to 2014. However, there are less employees who had wage freeze, about 15% of job stayers, while in the previous years it remained at the level of 18%.

Still referring to figure 1a, it hints about the likelihood of asymmetry of the distribution, mainly due to the amount of employees experiencing wage freeze. But it is not only this share of employees that contributes to the asymmetry. Comparing the lift in the interval between wage freeze and wage increase and wage changes from 5% to 10% , in figure 1b, it is clear that wage changes are not uniform. Also, besides wage freeze, it seems that there is another focal point - about 9% of wage increase.

Indeed, in figure 2, we can identify that a great number of employees had 9% - 10% of wage increase in 2007-2008. Moreover, the size of spike at 0 indicates not only that about 18% of employees had wage freeze, but also that there is no other bar - a certain percentage of wage change - that accumulates such a great number of employees. When considered larger intervals than 1% of wage change, we can find another focal point - around past accumulated inflation rates. Figure 1a and the histogram in figure 2 are enough to affirm that the inflation rate is a very important indicator for wage increase. But it is not possible to be assertive regarding the considered period of inflation rate. For example, in figure 2, it is still unclear which period of inflation rate is prevailing as benchmark in the wage adjustment process.

Table 3 shows descriptive statistics of RAIS per income group. Table 15 displays how each group is defined. Employees' wage in the base year is divided by minimum wage in force in the base year. As commented previously, the official guide does not specify whether informed base wage should necessarily be in accordance to the type of wage or not. So it was

[2] When this inconsistency is kept, total wage change observations for 2016 and 2017 are reduced to 65% and 85%, respectively.

necessary to adjust and filter some cases: 1) as the majority of cases are reported on monthly basis, hourly wage is calculated in order to check if it is greater than hourly minimum wage[3]; 2) if it is less than hourly minimum wage, then, assuming that the informed wage in on hourly basis, it is compared directly to hourly minimum wage; 3) those cases that do not attend neither of the 2 criteria above are filtered and removed from this data base.

Based on table 3, in almost all years, lower groups are the ones whose wage increased the most, with the least variation among them. On the other side, the upper group is the one with the least wage increase but with the biggest divergence. It may be explained by the way how each group negotiates a raise: employees of lower groups have wage raise by collective bargaining and employees with higher income are more likely to ask for a raise individually than collectively. As the latter is more dependent on individual negotiation skills and its resulting raise applies to that specific employee, it is understandable that wage change of this group varies more.

Other relevant feature is the selection of economic variable considered relevant to each income group as a benchmark for their wage raise. In 2015, when in-year accumulated inflation rate was much higher than previous years, lower and middle groups had higher wage raise than previously. At the same time, in this year, Brazilian GDP growth rate was negative. And the upper income group had lower wage raise in 2015-2016. It seems that lower and middle income groups are more responsive to inflation rate, while upper income group is sensitive to other economic activity variables.

3.2 Salariometro

Before introducing the dataset used to achieve the second objective, it is worth mentioning the Brazilian labor regulation regarding collective bargaining. The participation of workers' union/s in the collective negotiation is required to formalize its contract. Also, the resulting contract must be registered by MTE to come into force. A collective bargaining agreement (CBA) in Brazil can be classified into 2 categories: convenção (convention) and acordo (agreement).[4] The main difference is the counterpart of the workers' union and the extent of its effect. Convenção involves both workers' and employers' unions, having its effect on the whole professional category.[5] Acordo is the contract resulting from negotiation between the workers' union/s and the employer/s and it affects only the participating firms' employees. In this study, only acordos are considered to examine real wage rigidity via CBA for 2 reasons: firstly, it is not identifiable which convenção bargainers used for wage raise; secondly, if employees have both convenção and acordo, it is more likely that their wage raise is based on acordo, since it offers higher raise.

To investigate the real wage rigidity via collective bargaining, RAIS and the dataset Salariômetro are used. This newly introduced dataset is collected and developed by FIPE, gathering all the registered collective bargaining contracts, publicly accessible through Sistema Mediador. [6] It focuses on relevant information regarding working conditions and pay, such as wages, wage-related benefits, benefits unrelated to wages, working hours, collective vacation, etc. Extracted variables are:
a) contract identification

[3] In most cases, about 90% of the dataset are on monthly basis.

[4] Convenção and acordo are contracts resulting from voluntary negotiation. If parts cannot resolve conflicts, the Labor Court may intervene. In this case, the final contract is called dissídio.

[5] In theory, an employee may benefit from convenção of the workers' union related to his professional category, even if his current job does not fit in the category.

[6] All registered contracts are available at http://www3.mte.gov.br/sistemas/mediador/ConsultarInstColetivo.

b) date of registry
c) period of contract in force: the date when contract came into force and when its validity ended, in this study, only month and year are used
d) wage change: this number may be in percentage or in absolute number. In the latter case, it is usually related to lower wage limit, so it is mannually calculated when previous contracts are available.
e) graduated wage raise: as an instrument to cushion immediate impacts, employers may negotiate that wage is gradually increased.
f) upper limit of wage raise: in case of wage raise in percentage, there may be a limit from which wage raise is in absolute number.
g) lower wage limit: minimum wage established for the professional category
h) employer identification
i) workers' union identification
j) existence of multiple participants: there could be more than one employer or workers' union involved in a contract.

The unit of observation in Salariometro is a contract. As the focus of this study is wage change, only contracts with wage adjustment clauses are considered. Additionally, the dataset is trimmed by restricting the wage change interval to [-30%, 30%]. Descriptive statistics are shown in table 4. It is worth highlighting that in this investigation wage cut contracts are considered to have 3 months of validity, counted as of the starting date, for 2 reasons: wage cut contract may contain other features such as collective vacation, work shifts, rest periods and, in this case, the contract period may be different for wage cut clauses and others benefits clauses; secondly, the dataset does not provide specific information about wage cut period.[7]

In order to compute how many workers are affected by each CBA, Salariometro and RAIS are merged by matching employer identification and federation unit for each calendar year. In case there are multiple contracts for an employer, the contract with the greatest wage raise is considered for all employees of that firm, because it is not possible to identify which employees are covered by each union.[8] For the same reason, all employees were considered to be covered by CBA.

Basic statistics of this merged database are shown in table 4, including wage cut contracts. Column (1) refers to the year when contracts came to force. It seems that average contract duration is almost constant across the studied years. It is likely that the contract duration is not the focus of negotiators, except if the object of discussion is temporary wage cut, as seen in table 5. Comparing it with table 5, it seems that the dispersion among contracts is relatively low, and when there is high frequency of wage cut contracts, then high dispersion is observed too, for example, in 2009 and 2016. It hints that negotiators have the same primary aim and only when certain firms have real needs to cut wages, then their target diverges. Besides, in 2009, 2015, 2016 and 2017, the years with the greatest number of wage cut contracts, it seems that the main goal of agreement was indeed wage cut, since average contract duration was much shorter, compared to the other years.

This study focuses on the period from 2007 to 2017. As in 1980s and early 1990s Brazil

[7]The treatment regarding temporary wage cut agreement is different from other collective agreements. It is limited to 3 months with the possibility of extension for more 3 months, besides the approval of labor court to understand the real needs for wage cut.

[8]An employee's job could not be one of those covered by certain union, because his job is not primary economic activity of the firm or there is not an active union covering his job in the neighborhood, etc. In this case, it is likely that he ends up included in the CBA, represented by the participant union.

experienced hyperinflation episodes, Plano Real was established in 1994 to stabilize the economy. As documented in the literature, Plano Real had immediate effects on inflation, as shown in figure 3. Still, it was considered better not to include 1990s nor early and mid 2000s due to reasonably big range of inflation rate. On the other side, new Labor Reform was approved by Brazilian government in July 2017 and in November it came to force. Since there are several clauses that would affect the analysis, 2017 was considered suitable as the last year to this study. [9] In addition, 10-year observation was considered to be enough to meet the goals of this study.

Figure 4 offers an outlook for how wage change varies yearly. At first sight, several peaks are found in each year, suggesting that there are certain wage change rates that a great number of negotiators agreed on. As reported in France[10], wage changes in Brazil via CBA do not seem to be symmetrical around some certain point, for example, median or mean.[11] Also, it seems that there is not a pattern over years. As mentioned earlier, a firm faces a complicate procedure to cut wages. However, in every year there is at least one wage cut contract, except in 2011. It seems that the whole distribution shifts slightly to the right until 2017, but it is not clear if there is any pattern or a trend.

At least in 2011, 2015, 2016 and 2017, there are wage freeze contracts by figure 4. Figure 5 shows that there are wage freeze contracts in all years. Those 4 years with the greatest numbers of wage cut contracts were also the years with the most wage freeze contracts. It suggests that wage freeze contracts may be an alternative to wage cut, as literature reports that wage cut has bigger impact on employees' morale compared to wage freeze.

With chart 6, it turns out to be clear that there is an upward trend in median, with little oscillation between years until 2016. Even though there are some wage change rates that a great number of contracts agreed on, light upper tails hint about the dispersion of wage changes. However, this pattern is not observed in 2014: it seems that a great number of contracts raised between 7 and 8% and its heavy tails hint that contracts are more concentrated than in other years. As mentioned before, there is at least 1 peak in each year, and in 2010, 2011 and 2013 one of the peak corresponds to the median. Apparently, there is not a pattern regarding peaks or the distribution over years.

As shown in figure 7, nearly 60% of all contracts are concentrated in Sudeste and less than 1% of all are the contracts affecting the whole country. Considering that Sudeste is responsible for more than half of Brazilian GDP, this difference is not surprising. Apparently, figure 23 in the Appendix shows that there is not much difference across regions, except those affecting Brazil.

Figure 8 clarifies the relationship between contract duration and wage changes. It shows that a great number of contracts are valid for 12 months or 24 months. Also, it suggests that inflation rate has an important role to the bargaining. As the chart exposes, contracts are highly concentrated around the average inflation rate and this is even more evident when we observe contracts grouped by year, as shown in figure 24 in the Appendix. Additionally, contracts valid for 12 months range more than any other contract duration.

Figure 9 shows number of contracts that come into force for each month. Interestingly, May is the month when a great number of contracts become valid. However, it does not seem to have meaningful effect on wage changes when compared to other months, as shown

[9] Voluntary contribution to unions, possible arrangement of internal committee for negotiation - applicable only for the firms with more than 200 employees - are the examples of relevant modifications that could influence the analysis.

[10] See Avouyi-Dovi (2013).

[11] See Ayouvi-Dovi et al. (2011)

in figure 10. Although May is when about half of all contracts come into force, it is unlikely that difference in wage change is due to the month. Even when contracts are grouped by year, figure 25 in the Appendix shows that it remains unchanged, except some minor differences in 2007, 2014, 2015.

Figure 11 shows whether difference in the number of unions and number of employers involved in negotiation has impact on wage raise. Most contracts have no difference in these numbers, whether there is only one participant for each side or multiple players. Comparing no-difference-type and more-employers-type, when there are more employers, it seems to reduce wage change rate. However, when the wage raise is big enough, then it seems that they are not different. Comparing upper and lower panels, if there are more unions, then it suggests that this difference has ambiguous effects on the first 50% of wage changes: while it has negative impact for the first 25%, its median is greater than no-difference-type, on the other hand, its third quartile is slightly bigger.

3.3 Tables

Table 1: Example of inconsistency in RAIS 2015, 2016 and 2017

PIS	CNPJ	CBO	Wage in t	Wage in t+1
1	11	11111	21.5000	2150.00
2	22	22222	42.5000	4400.00
3	33	33333	1500.00	18.0000

This table show simple examples to describe the inconsistency found in the database. PIS and CNPJ refer to the employee and employer identification, respectively. CBO refers to the employee's job.
Source: original creation

Table 2: Descriptive statistics - RAIS

	(1) Total	(2) Job stayers	(3) Trimming	(4) Wage freeze	(5) Wage cut	(6) Mean	(7) SD	(8) 1Q	(9) Median	(10) 3Q
2007-2008	54,649,133	31,882,955	29,588,261 (0.9280)	5,389,304 (0.1821)	1,029,908 (0.0348)	8.50	10.190	3.920	7.895	10.632
2008-2009	59,706,419	34,882,609	33,143,826 (0.9502)	6,283,993 (0.1896)	1,102,968 (0.0333)	8.00	9.646	3.012	7.000	11.805
2009-2010	61,126,896	36,938,363	35,120,895 (0.9508)	6,160,989 (0.1754)	1,125,585 (0.0320)	8.35	9.864	4.061	7.500	10.377
2010-2011	66,747,302	38,279,049	36,019,824 (0.9410)	6,223,547 (0.1728)	1,269,978 (0.0353)	9.38	10.605	5.074	8.795	12.222
2011-2012	70,971,125	41,891,960	39,871,838 (0.9518)	7,024,969 (0.1762)	1,241,730 (0.0311)	9.40	10.027	4.970	8.150	14.128
2012-2013	73,326,485	42,105,076	40,374,389 (0.9589)	6,902,283 (0.1710)	1,327,314 (0.0329)	8.41	9.621	5.000	8.325	10.069
2013-2014	75,400,510	44,719,068	43,030,354 (0.9643)	7,082,998 (0.1646)	1,381,239 (0.0321)	7.90	9.329	5.263	7.293	9.543
2014-2015	76,107,279	45,722,136	44,214,656 (0.9670)	8,534,949 (0.1930)	1,430,675 (0.0324)	7.74	8.729	2.920	8.468	10.000
2015-2016	72,175,102	44,579,138	42,986,317 (0.9643)	6,511,984 (0.1515)	1,935,961 (0.0450)	8.41	9.024	4.155	9.800	11.361
2016-2017	67,144,598	41,925,026	40,509,249 (0.9662)	7,644,310 (0.1887)	1,504,821 (0.0371)	5.19	8.114	1.730	5.000	7.000

This table shows basic information on job stayers of each year. A job stayer is defined as the employee who has the same job at the same employer as in previous base year. Column (1) refers to the total number of observations in RAIS of year t. Column (2) counts job stayers in each year. Column (3) shows how many job stayers are considered to the analysis - those with wage change ranging between -50% and 50%. Column (4) and (5) count how many job stayers experienced wage freeze and wage cut, respectively. Columns (6) and (7) refer to mean and standard deviation of nominal wage changes for each group. Columns (8), (9) and (10) contain values of 1st, 2nd and 3rd quartiles of nominal wage changes.
Source: RAIS

Table 3: Descriptive statistics - RAIS per income group

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
N_1	17,455,005	19,512,108	21,926,856	22,505,459	24,138,743	25,032,552	26,586,735	25,345,460	26,045,879	24,390,187
N_2	6,699,172	7,465,684	7,474,832	7,568,568	8,834,371	8,533,730	9,408,874	8,983,935	9,613,151	8,221,024
N_3	3,399,767	3,938,176	4,000,609	4,185,924	4,640,654	4,562,187	4,826,086	5,026,678	5,002,325	4,657,398
N_4	893,930	1,054,039	903,946	1,056,081	1,106,640	1,013,879	1,067,531	1,157,180	1,121,906	1,213,570
N_5	345,211	410,995	360,800	360,800	409,177	371,837	374,722	397,569	389,262	411,491
$Mean_1$	8.56	8.42	8.56	9.48	10.00	8.61	8.00	8.11	9.06	5.48
$Mean_2$	8.13	7.37	8.04	9.86	8.81	8.28	7.65	7.24	7.77	4.75
$Mean_3$	8.88	7.83	8.12	8.77	8.45	8.09	8.44	7.44	7.15	4.68
$Mean_4$	8.46	6.41	7.04	7.70	7.00	7.78	7.29	6.95	6.98	4.93
$Mean_5$	7.36	5.57	5.72	5.98	5.50	6.73	6.31	6.76	5.37	3.88
SD_1	9.03	8.61	8.69	8.52	8.94	8.45	8.21	7.68	7.62	6.74
SD_2	11.20	10.40	11.10	12.00	11.20	10.70	10.70	9.92	10.00	9.43
SD_3	11.80	11.50	11.90	13.00	11.60	12.00	11.30	10.50	11.80	10.45
SD_4	12.00	10.70	12.00	13.00	10.90	11.20	10.40	10.20	10.90	11.34
SD_5	12.80	11.00	11.90	12.40	10.70	9.93	10.30	10.50	10.40	11.90
$Median_1$	8.18	7.58	8.00	8.52	9.61	8.80	7.20	8.80	9.98	5.40
$Median_2$	7.15	6.43	7.00	8.91	7.54	8.00	7.50	8.17	9.14	4.30
$Median_3$	7.58	6.30	7.00	8.80	7.50	8.00	7.52	8.13	8.28	4.44
$Median_4$	7.67	6.01	6.50	8.25	6.98	7.60	7.00	7.68	8.00	4.86
$Median_5$	7.01	5.79	5.60	7.12	5.50	6.77	6.45	7.00	5.59	4.57
$Q1$-$Q3_1$	3.75-10.20	3.33-12.00	4.28-10.20	5.50-12.10	5.11-14.10	5.05-10.00	5.32-9.24	4.64-9.90	6.00-11.70	2.00-7.00
$Q1$-$Q3_2$	3.75-10.20	3.00-9.65	4.11-10.20	5.93-12.90	4.88-11.60	5.00-10.00	5.00-9.62	0.00-10.00	2.46-11.00	0.01-7.00
$Q1$-$Q3_3$	4.69-12.80	3.30-10.50	3.66-12.50	4.30-13.00	4.47-12.10	5.58-11.40	5.82-11.5	2.95-10.40	1.67-11.20	0.68-7.64
$Q1$-$Q3_4$	4.72-13.30	1.61-9.38	3.04-10.80	2.99-11.20	1.98 - 10.00	5.25-10.60	5.20-10.00	2.28-10.00	1.18-11.00	0.62-8.15
$Q1$-$Q3_5$	1.24-12.30	0.47-9.12	0.20-9.30	0.00-9.96	0.00-8.53	4.90-9.38	4.80-9.00	2.16-10.50	0.00-10.00	0.00-7.64

This table shows basic information on job stayers per each income group. N_i represents number of observations for each group. $Mean_i$, SD_i and $Median_i$ are respectively mean, standard deviation and median of nominal wage change for each group. $Q1 - Q3_i$ represents first and third quartiles of nominal wage changes, separated by income groups.
Source: RAIS

Table 4: Salariometro - Summary statistics - All contracts

Start date	Quantity	Mean	Median	SD	Average contract period
2007	1,849	5.85	5.50	2.131	13.06
2008	6,899	7.52	7.26	2.016	13.16
2009	13,778	6.45	6.50	3.608	13.14
2010	13,549	6.98	7.00	2.058	12.92
2011	14,971	8.12	8.00	1.858	13.15
2012	16,852	7.85	7.50	2.382	12.97
2013	16,276	8.10	8.00	1.622	13.12
2014	17,272	7.69	7.50	1.570	12.90
2015	17,914	8.32	8.68	3.492	12.77
2016	17,860	8.56	9.62	4.214	12.92
2017	17,913	4.70	4.76	2.750	13.05
Total	155,133	7.42	7.50	2.99	13.00

This table shows descriptive statistics on contracts per year when contracts came into force. Quantity refers to the number of contracts that started in the year. Mean, median and SD are respectively mean, median and standard deviation of nominal wage adjustment.
Source: Salariometro

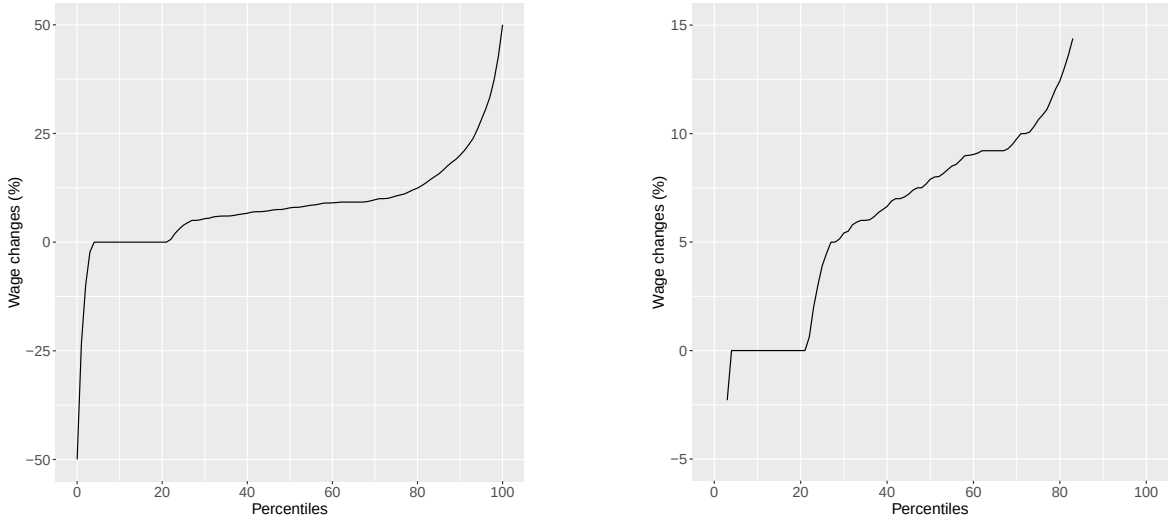
Table 5: Salariômetro - Summary statistics - Wage cut contracts

Start date	Quantity	Mean	Median	SD	Average contract period
2007	1	-20.00	-20.00	-	24.00
2008	6	-12.38	-11.65	7.181	10.50
2009	207	-17.24	-16.65	4.742	4.75
2010	10	-16.38	-15.00	5.971	22.80
2011	0	-	-	-	-
2012	14	-18.43	-15.00	5.084	15.93
2013	1	-5.70	-5.70	-	4.00
2014	4	-17.03	-20.00	7.637	4.55
2015	264	-16.27	-15.45	4.344	5.19
2016	361	-16.92	-18.18	5.027	5.60
2017	136	-17.03	-18.00	5.664	6.50
Total	1004	-16.81	-16.66	4.95	5.81

This table shows descriptive statistics on wage cut contracts per year when contracts came into force. It contains the same variables as in table 4
Source: Salariometro

3.4 Figures

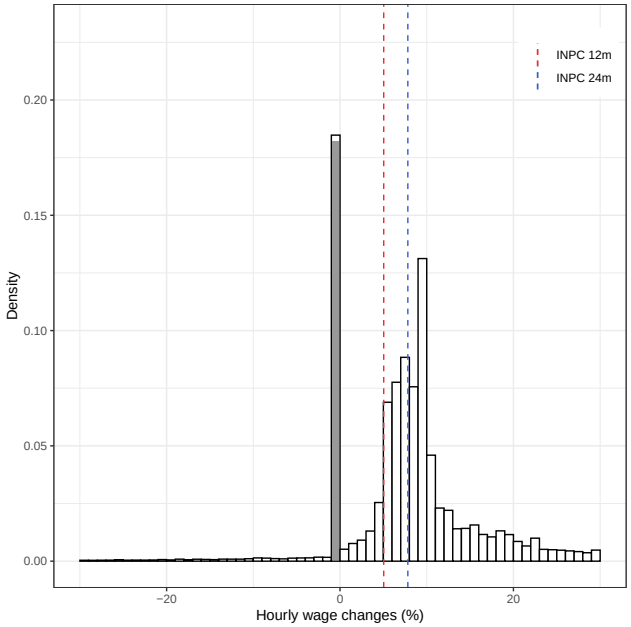
Figure 1: Nominal wage changes in ascending order - 2008-2009



(a) RAIS 2007-2008 (b) Zoom in on NWC from -5% to 15%

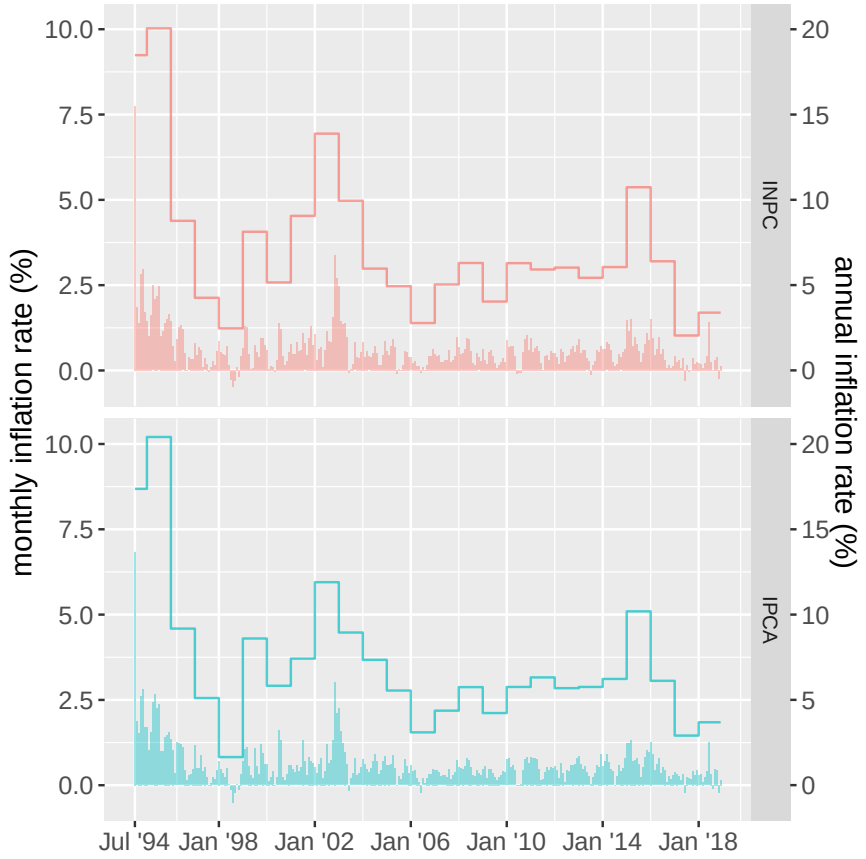
This chart represents linear interpolation of wage changes observations in 2007-2008. Wage change is on y-axis and the percentile of wage change is on x-axis.
Source: RAIS 2008-2009

Figure 2: Histogram of hourly wage change - 2007-2008



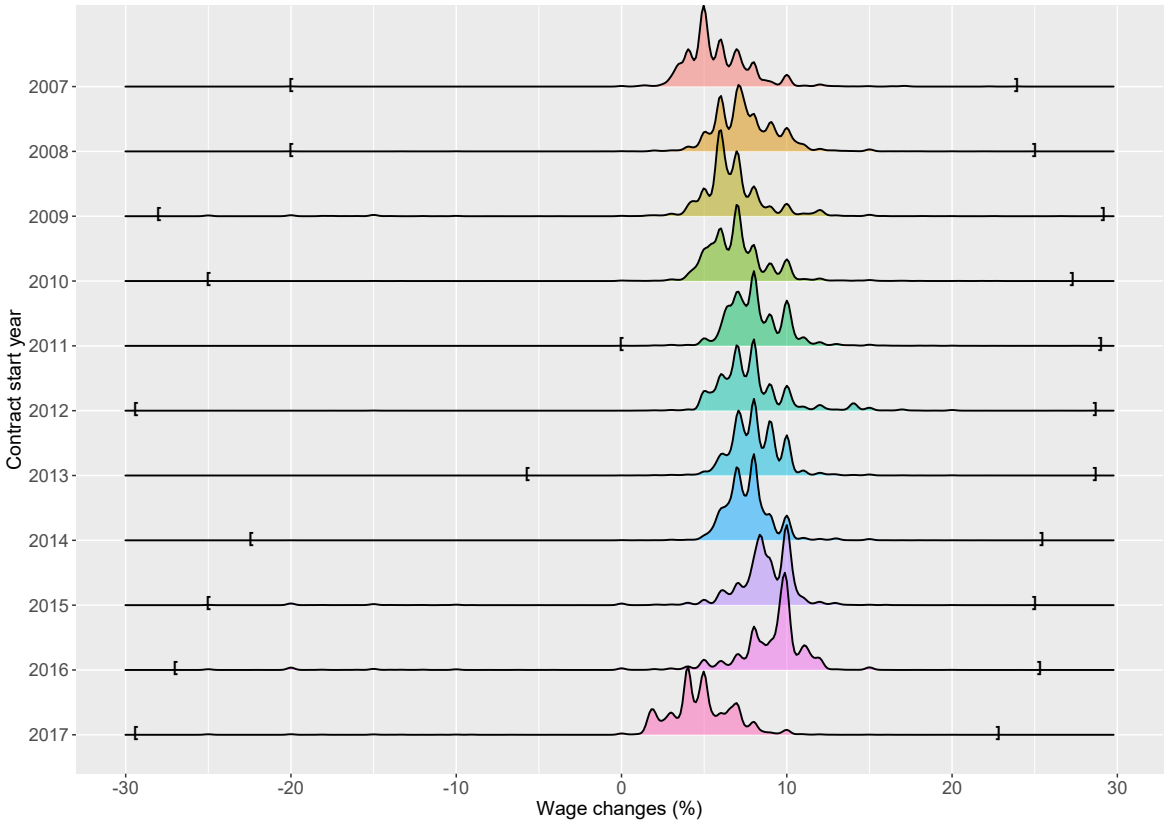
The chart shows the wage changes of job stayers for the period of 2007-2008. On x-axis we have percentage changes in wage and on y-axis we have relative frequency of wage change. Each bar represents 1% of wage change, ranging from -30% to 30%. Gray part of the bar at 0 represents the number of employees who experienced wage freeze. Red dotted line indicates accumulated inflation rate during last 12 months - in this case, during 2007 - and blue dotted line refers to accumulated inflation during 24 months - from January 2007 to December 2008.
Source: RAIS 2007-2008

Figure 3: Monthly/Annual inflation rate - post Plano Real



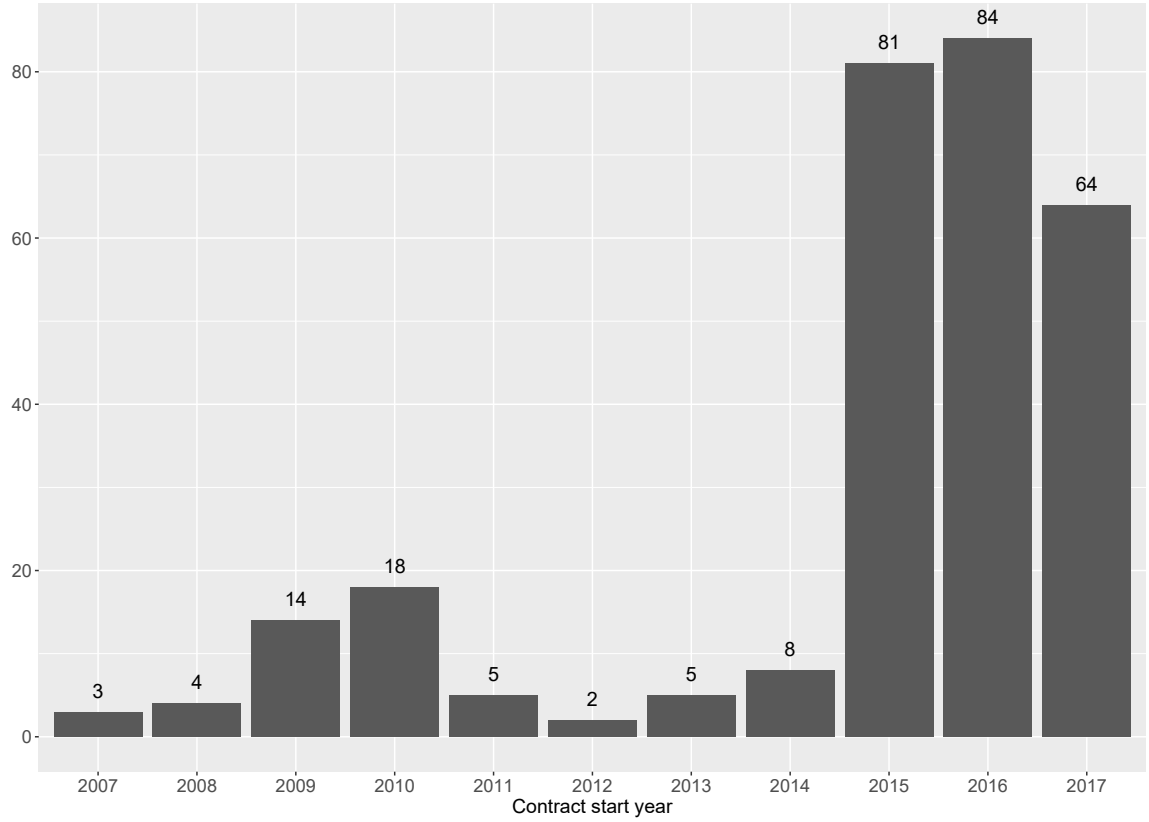
This chart shows inflation rate history in Brazil after implementation of Plano real. Time is shown on the x-axis and inflation rate is on the y-axis. Each bar refers to monthly inflation rate, measured by primary y-axis and each step refers to annual inflation rate, measured by secondary y-axis. Upper panel shows INPC and lower panel refers to IPCA.
Source: IBGE

Figure 4: First look at Salariometro



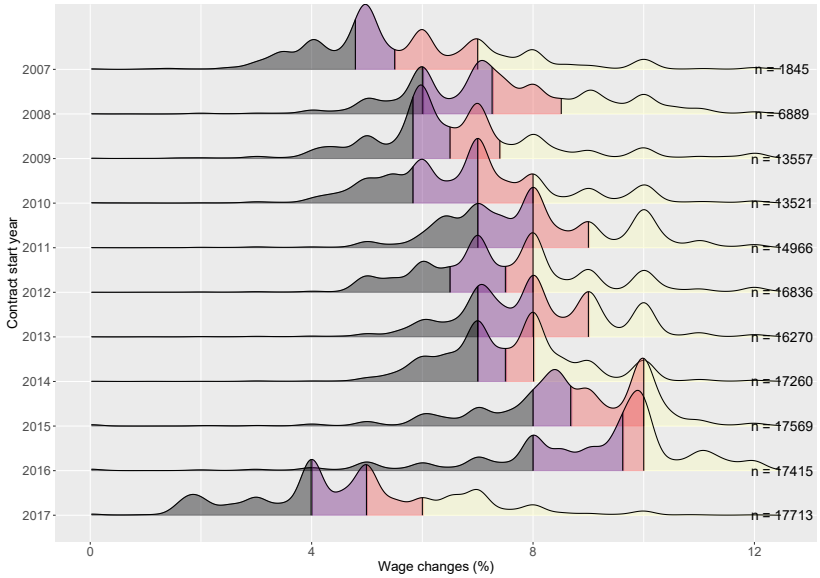
The chart shows how wage changes via CBA are distributed, estimated using kernel density estimation method for the period of 2007 to 2017. The joint bandwidth used is 0.206. On x-axis, we have percentage changes in wage. On the y-axis, we have estimated density of wage changes for each year. The brackets on the x-axis represent maximum and minimum of wage changes for each year.
Source: Salariometro

Figure 5: Wage freeze contracts per year



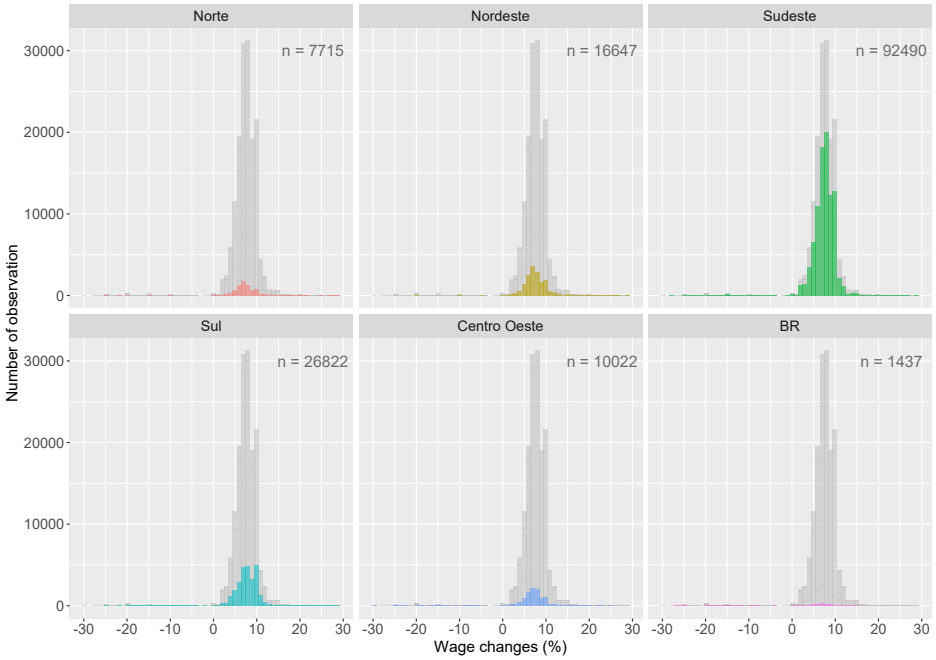
Wage freeze contracts are counted for each year and represented in this chart. On x-axis, we have contract start year, as defined in the beginning of the subsection ”Preliminary Data Analysis”. The number of observation is on y-axis, with the exact number above each bar.
Source: Salariometro

Figure 6: Closer look at positive wage changes



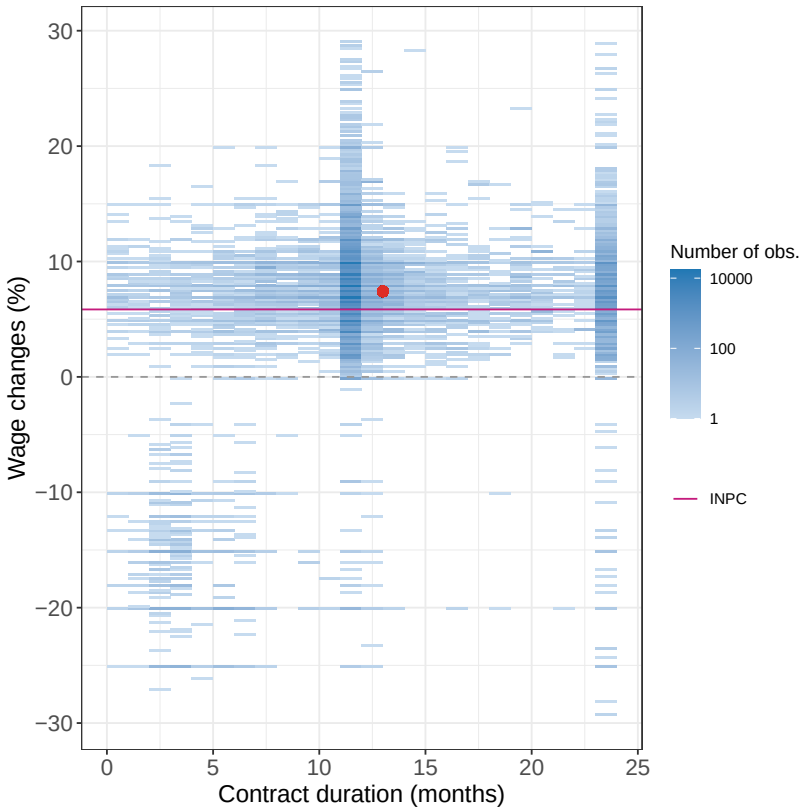
The graph shows the same distribution as Figure 4 with focus on positive wage changes. The joint bandwidth used is 0.197. Three vertical bars represent first, second and third quartiles and each colored area represents 25% of the whole distribution. ”n” is the number of observations for each year.
Source: Salariometro

Figure 7: Histogram of wage changes via CBA per region



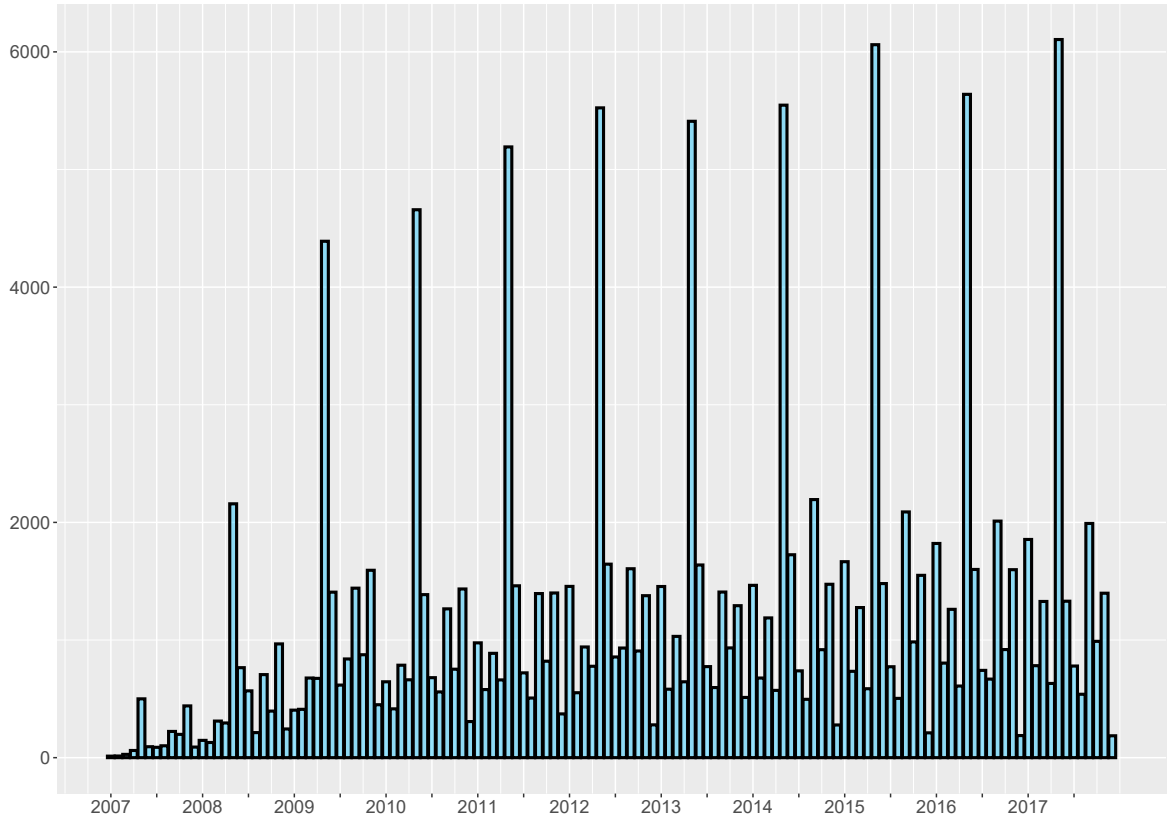
This histogram shows wage changes via CBA, separated by regions. We have percentage wage changes on x-axis and the number of observation for each region is shown on y-axis. The bin size is 1% and ”n” is the number of observations for each region. Last panel ”BR” refers to the contracts that specify its effect on the whole territory.
Source: Salariometro

Figure 8: Wage changes and contract duration



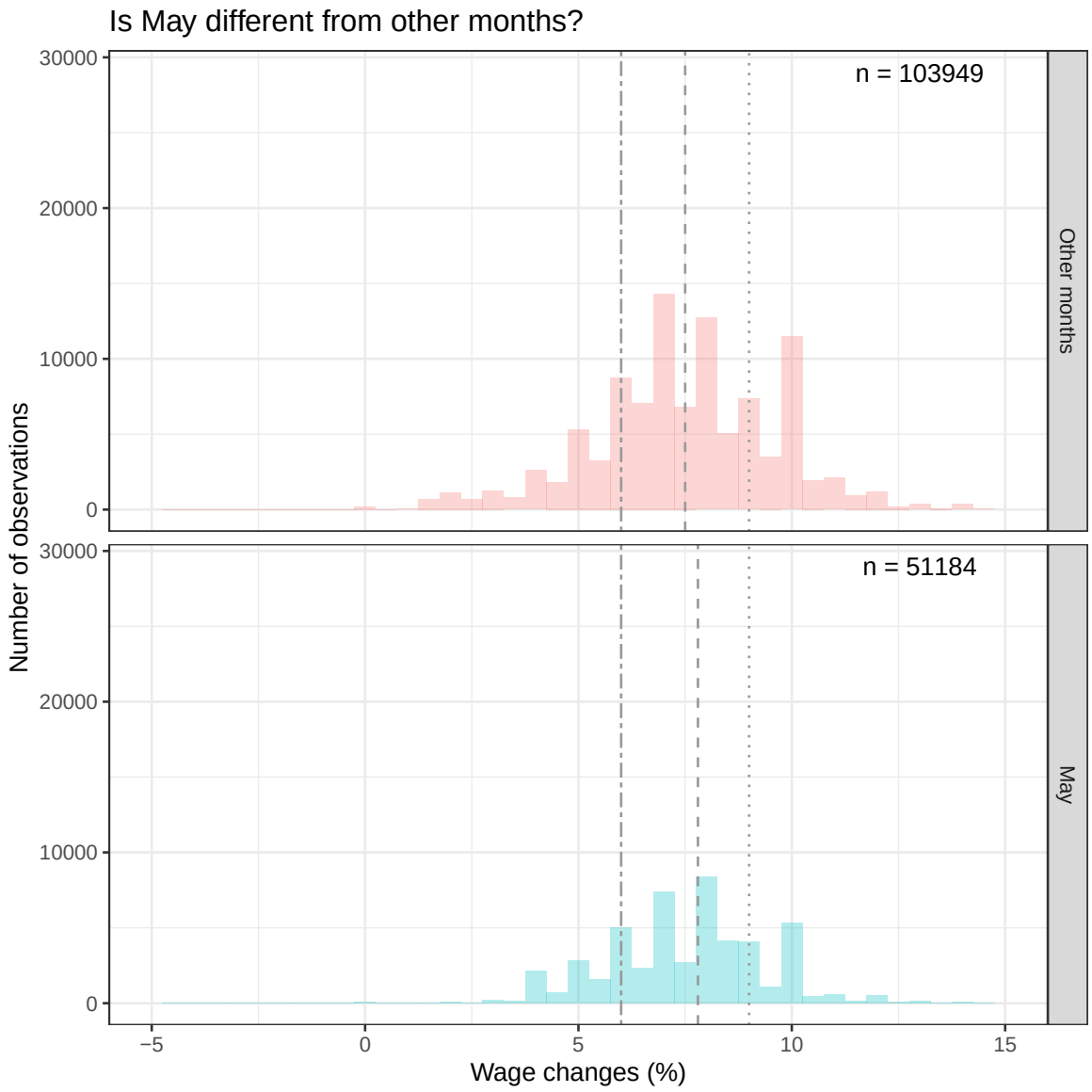
This heatmap shows contract duration on x-axis and percentage wage changes on y-axis. Each bin represents the presence of contracts with matching features; the darker is it, the greater is the number of observations with these characteristics. Red vertical line represents average inflation rate, 5.42%, for the period of 2007-2017. Red dot is the average contract - its x-coordinate represents average duration and y-coordinate represents average wage changes.
Source: Salariometro

Figure 9: Quantity of contracts per month



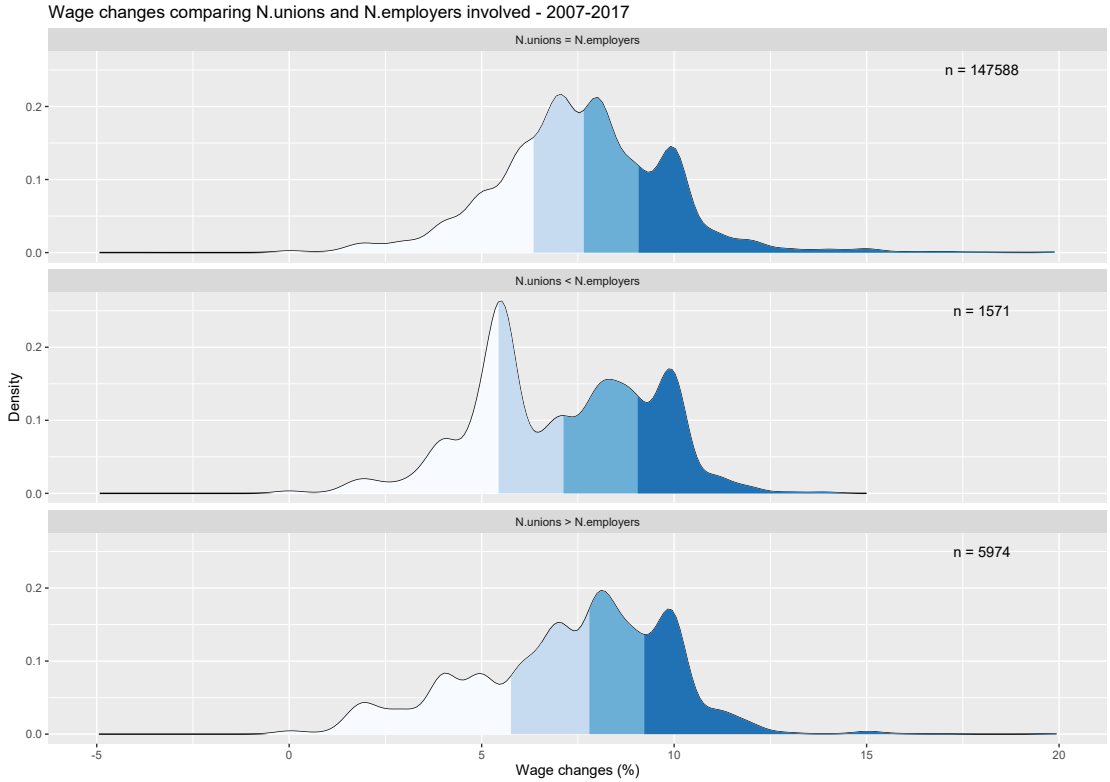
This chart shows number of contracts per month for the period of January 2007 to December 2017. We have months on x-axis and number of observations on y-axis.
Source: Salariometro

Figure 10: Comparison between May and other months



This panel compares histograms of number of contracts that come into force in May and in other months. Upper graph refers to the contracts which come into effect in other months and lower chart refers to those coming into force in May. Wage changes are shown on x-axis and number of observations are on y-axis. Three dashed lines are 1st, 2nd and 3rd quartiles and ”n” is the number of observations for each group.
Source: Salariometro

Figure 11: Does difference in n. unions and n. employers have impact on wage increase?



This panel compares how wage change rate reacts to the difference in number of participants. Wage changes are on x-axis and estimated density is on y-axis. Upper panel shows the cases that there is no difference in number of participants of both parties. Middle panel shows the cases with the number of employers greater than the number of workers' union. Lower panel shows the cases with number of workers' union greater than the number of employers. The estimated density is divided into 4 parts, each part representing 25%. "N" in the upper right is the number of observations for each type.
Source: Salariometro

4 Methodology

In this section, how the goals of this study are achieved is described. It is divided in 2 subsections to describe how the extent of nominal and real wage rigidity are calculated. Both types are identified based on two criteria, widely used as signals of wage rigidity: spike at certain point and asymmetry.

4.1 Nominal wage rigidity

In the case of nominal wage rigidity, as mentioned previously, the exact time when wage changed is unknown. So the whole analysis on nominal wage rigidity is based on annual update, with an additional assumption that everyone who had wage change experienced it at the same time. Also, the trimmed RAIS is the only dataset used in this part. As seen in the previous section, labor market faces nominal wage rigidity, observable by the size of spike at 0. So, this study focuses on how to measure the extent of nominal wage rigidity.

The size of spike at 0 is a good starting point as a measure of wage rigidity. Actually, the reason why an employee experienced wage freeze is not observable: the wage could have been optimal at the time or the employer was not allowed to optimize by cutting or increasing wages. In theory, only the last case should be considered as wage rigidity, since the wage was optimized in the first case. However, in this case, the size of spike could be understood as the upper limit of nominal wage rigidity. This measure corresponds to the column (4) of the table 2.

As an attempt to decompose the wage rigidity into downward and upward rigidity, spike at 0 is broken down into 2 parts, weighted by wage increase and wage cut, as shown in expressions 1 and 2.

$$DNWR_t = \frac{WC_t}{WC_t + WI_t} \cdot WF_t \tag{1}$$

$$UNWR_t = \frac{WI_t}{WC_t + WI_t} \cdot WF_t \tag{2}$$

where WC_t is the share of wage cut in t, WI_t is the share of wage increase in t and WF_t is the share of wage freeze in t. Another measure for downward nominal wage rigidity is proposed by Dickens et al. (2007):

$$DNWR'_t = \frac{WF_t}{WF_t + WC_t} \tag{3}$$

This measure supposes that all the wage freezes are due to nominal downward rigidity. So, under the assumption of flexible wage setting, the employees who had wage freeze would have experienced wage cut.

Also, understanding the behavior of wage freeze over the years is an important task, especially in the context of staggered wage setting with random duration models. In this case, survival analysis on wage freeze is helpful to accomplish this task. Survival analysis requires that the event, survival and censoring to be defined to estimate survival probability. As wage change is not a traditional example of survival analysis, it is necessary to take a careful look at the population.

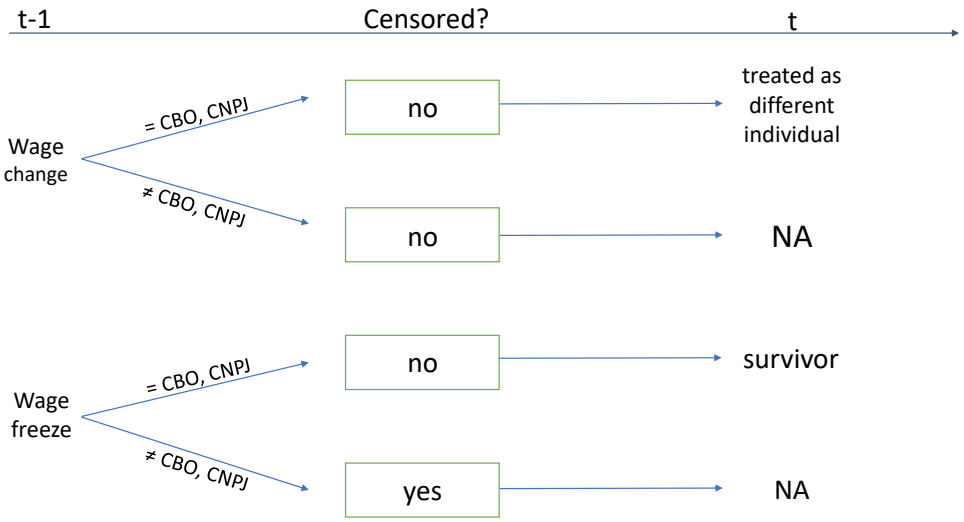
Hereafter in t:

A) the event is defined as wage change in t;

B) the survival is who had wage freeze in t-1 and remains at the same job, associated to the same employer in t;

C) employees are censored if they changed their job or/and they are not associated to the same employer in t.
Figure 12 summarizes 4 possible scenarios. If the event and censoring happened at the same time, the event is considered to have occurred before the censoring: this case is considered as not censored and counted as the event.

Figure 12: Possible scenarios in survival analysis



This diagram shows 4 possible scenarios in this survival analysis, depending on the status in t-1 and if it was censored or not. The condition of censoring is wage freeze in t-1 and not finding the same individual with the same job at the same employer as in t-1. However, if the event happened in t-1, changing employer or job does not imply censoring, since the event is considered to have happened before leaving job.
Source: original creation

Once survival time is calculated and censored data is verified, the survival function is estimated using the Kaplan-Meier method, as in expression 4.

$$\hat{S}_t = \frac{WO_t - WC_t}{WO_t} \tag{4}$$

where WO_t is the total number of wage observations in t. Besides, fitting the exponential model to the data is the final exercise of this subsection. It offers an indirect estimation to the extent of nominal wage rigidity as in the staggered wage setting a la Calvo.[12] The generic survival regression in the following expression is estimated using Maximum Likelihood Estimation (MLE):

$$S_t = exp\{-\lambda_i \cdot t\} \tag{5}$$

where λ_i is a hazard function. When applied to all job stayers in Brazil for the whole studied

[12]Since exponential distribution may be considered as the continuous form of geometric distribution, we have the following relationship between two distributions: $\lfloor X \rfloor \sim Y$, where $X \sim Exp(\lambda)$ and $Y \sim Geom(p)$, with $p = 1 - exp\{-\lambda\}$.

period, then $\mathbf{x}\beta$ becomes a simple constant, λ. So expression 5 is rewritten as:

$$S_t = exp\{-\lambda t\} \tag{6}$$

Heterogeneity across regions is also analyzed by estimating:

$$\lambda_i = exp\{\beta_0 + \beta_1 x_{NE} + \beta_2 x_{SE} + \beta_3 x_S + \beta_4 x_{CO}\} \tag{7}$$

where β_0 is the constant and it measures the baseline risk - when the employee is from Norte in this case -, x_i with $i \in NE, SE, S, CO$ are the binary variables to identify the location associated to the job stayer, with NE being Nordeste, SE being Sudeste, S for Sul and CO for Centro Oeste. In the analogous way, how wage stickiness is different across income groups is explored by estimating:

$$\lambda_i = exp\{\beta_0 + \beta_1 IG_2 + \beta_2 IG_3 + \beta_3 IG_4 + \beta_4 IG_5\} \tag{8}$$

where β_0 is the constant and it captures the wage stickiness of the lowest income group, IG_j with $j \in 2, 3, 4, 5$ are the binary variables to identify which income group employee belongs to.

4.2 Real wage rigidity

Firstly, it is necessary to define how real wage change is defined, i.e, which inflation rate is discounted from nominal wage change. In this study, real wage change is calculated in 2 ways: discounting retroactive inflation rate equivalent to the duration of the contract, as in expression 9, and discounting subsequent inflation rate as expected inflation in the period when the contract is in force, as in expression 10.

$$RWC_i = NWC_i - \pi_{-i} \tag{9}$$

$$RWC_i = NWC_i - \pi_i \tag{10}$$

where RWC_i is real wage change in t, NWC_i is nominal wage change, just as in the wage raise clause of the contract, π_{-i} is the inflation rate in the last i months and π_i is the actual inflation rate in the following i months. In the first case, actually, negotiators compensate for past inflation rate, so on the first day of the contract, employees would have the same real wage as i months ago. In second case, their prediction is perfectly accurate and on the first day of the contract employees would have real wage increase. And this raise is reduced over time, so at the end of the contract their real wage is the same as immediately before the contract coming into force.

The second step involves counting the employees who are covered by CBA in force. This task requires a new variable that counts how many months each employee worked and is covered by CBA in force. This variable, beneficiary-month, discriminates those who worked during the CBA period and who did not, also it allows giving different weights to the employees who worked the entire CBA period and to those who worked partially. For example, considering a CBA in force for the period of 2015 June to 2016 May and the staff of the employer A as in table 6, the last column indicates how many beneficiary-months (BM) were covered by this CBA in 2016. For employee A1, as he was separated from the employer in 2016 February, he was covered for only 2 months in 2016.[13] For A2, as he was hired in

[13] Using the same idea, in 2015, 7 BM were counted for this employee.

2016 May and the contract ended in 2016 May, he was counted as 1 beneficiary-month.[14] For A3, as his employment contract began after the end of the contract, in this case, he is not considered as covered by this contract.

Table 6: Example of beneficiary-months

Employee ID	Admission date	Separate date	Beneficiary-months
A1	2014 November	2	2
A2	2016 May	-	1
A3	2016 September	-	0

Before estimating the real wage change distribution, looking at what negotiators use as benchmark for wage adjustment brings an important insight to interpret the results. The main question to be answered here is which inflation rate is more important to CBA. More explicitly, it is desirable to know if unions and employers focus on raising real wage or compensating past inflation.

In an attempt to answer this question, Salariometro is rearranged in a panel setting to estimate the impact of each inflation rate on nominal wage change, via Pooled OLS (POLS), fixed effect model (FE), random effect model (RE). Control variables used in these models are region covered by the contract, existence of more than one employer per contract, existence of more than one workers' union per contract, if the wage increase is graduated, the existence of floor, the lower limit for wage for employees at the firm, the existence of upper limit for percentage wage change, if contracts started in May. Projected inflation rate here uses the same concept as explained in the previous section. As the rearrangement requires an identification for each group and there are multiple contracts for some employers, a new variable was created for unique identification: Employer ID paired with Union ID. In case there are more than one contract for the new ID, the contract with greater wage increase is considered. The variable Region is treated as time invariant variable here, even though in theory varying over time is possible. However, at least in this dataset, there is not an ID that changed region over time. Expression 11 is the econometric model to be estimated:

$$NWC_{it} = \beta_0 + \beta_1 \pi_{-it} + \beta_2 \pi_{it} + \sum_{l=3}^{10} \beta_l X_{it}^l + \sum_{j=1}^{5} \alpha_i^j reg_i^j + Z_{it} + u_{it} \tag{11}$$

where β_0 is the constant, β_l, $l \in \{1, ..., 10\}$ are the parameters, π_{-it} is the past inflation rate, π_{it} is the inflation rate during the contract period, X_l, $l \in \{3, ...10\}$ are the control variables,α_i is the parameter for the time-invariant variable, region where the contract is valid, reg_i and u_{it} is the idiosyncratic error term. Z_{it} is a general term to include unobservable variable. It could be entity specific effect, then it will be Z_i, or time fixed effect, Z_t, or both effects (two ways effect), depending on which model is to be estimated.

Once real wage change is calculated and beneficiary-months are counted for each base year, the distribution is estimated using Kernel density estimation (KDE). Since theoretical distribution of wage changes is unknown, it is not possible to make distributional assumptions. Even though histogram has the advantage of being simple to implement and easy to

[14] In this study, as the smallest time variable is month, if the employment event, such as hiring and separation, and the contractual event happened in the same month, beneficiary-month is calculated in the way that favors the employee. For example, in this case, separation is considered to have happened after the end of the contract.

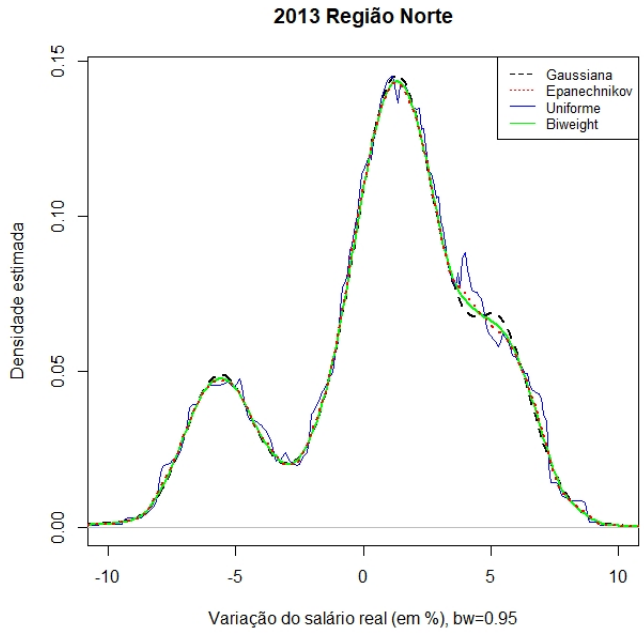
read, it has a problem of dependence on bin size. KDE still has the problem of dependence on smoothing factor, similar to the bin size problem of histogram. However, it can deal better with this problem and it also removes the discontinuity problem. Formally, kernel estimation is defined as:

$$\hat{f}(x;h) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{X_i - x}{h}\right) \tag{12}$$

where $k(.)$ is a kernel function and h is the bandwidth - a smoothing factor. So, in this method, 2 components are required: kernel function and bandwidth value.

A kernel function is defined as any real function that satisfies $\int Rk(x) = 1$. As the problem of estimating real wage change is not subject to bounded support, any symmetric and non-negative function could be used as kernel here. The literature documents that in theory Epanechnikov is the asymptotically optimal function. In this case, it seems that the selection of kernel function makes some minor differences, as shown in figure 13, but it is unlikely to lead to different conclusions. In this study, Normal is used as kernel function.

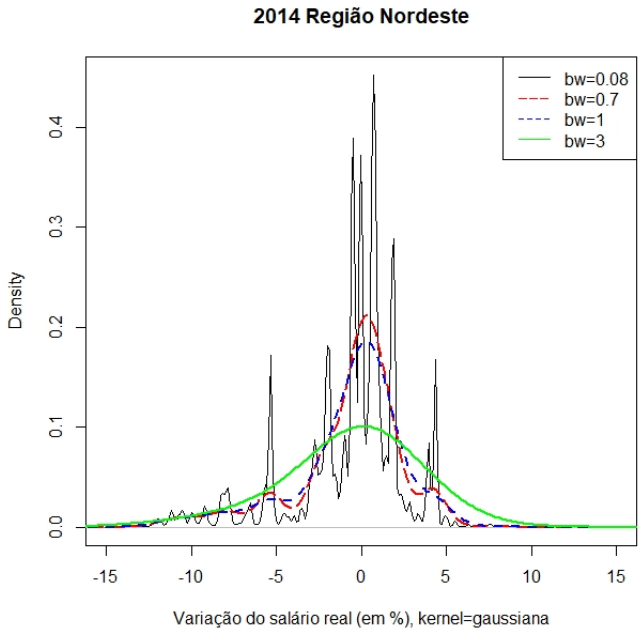
Figure 13: Estimated real wage change distribution using different kernel functions



This chart shows estimated density for real wage change, in beneficiary-months, in 2013, for Norte. Each linetype represents different kernel function, as described in the legend. Estimated density is on y-axis and real wage change, considering retroactive inflation rate, is on x-axis. The estimation considered 0.95 for bandwidth. Source: RAIS 2013 merged with Salariometro, original creation

While kernel function selection is not relevant, bandwidth is a very important factor in this method, as shown in figure 14. Using different values the estimation may lead to completely different conclusions or it even could make it impossible to read properly the whole estimated distribution. In the chart, $h = 0.08$ results in an undersmoothed estimation, with many spikes, and it is hard to identify which points are important - in this case, it is difficult to recognize which point is the rigid point. Meanwhile, $h = 3$ has the oversmoothing problem and it ends up hiding most information: it seems almost symmetric around 0, with

Figure 14: Estimated real wage change distribution using different bandwidth values



This chart shows estimated density for real wage change, in beneficiary-months, in 2014, for Nordeste. Each linetype represents estimated density using different bandwidth value, as described in the legend. Estimated density is on y-axis and real wage change, considering retroactive inflation rate, is on x-axis. The kernel function is Gaussian.
Source: RAIS 2014 merged with Salariometro, original creation

no other point with spike, strictly increasing on $(-\infty, 0]$ and strictly decreasing on $(0, \infty)$. But estimation with $h = 0.7$ and $h = 1$ refutes these remarks - for example, it seems that -5% and 4.5% are local maxima, disproving that the estimated pdf is strictly increasing or decreasing on these intervals.

Given the trade-off between smoothing and loss of information, it is necessary to adopt an optimization rule in order to choose bandwidth. In this study, biased cross validation by Scott and George (1987) is used to choose optimal bandwidth. The idea of this method is based on using part of the sample to estimation and another part evaluates the efficiency of the estimation. The measure to assess the performance of estimation is mean integrated squared error, defined as:

$$MISE[\hat{f}(.;h)] = \frac{1}{4}\mu_2^2(K)R(f'')h^4 + \frac{R(K)}{nh} + o\left(h^4 + \frac{1}{nh}\right) \tag{13}$$

where $\mu_2(K) = \int x^2 K(x)dx$ and $R(K) = \int K(x)^2 dx$. For symmetric kernel functions with finite variance, expression 13 can be rewritten as:

$$MISE[\hat{f}(.;h)] = \frac{1}{4}\mu_2^2(K)R(f'')h^4 + \frac{R(K)}{nh} + o\left(h^4 + \frac{1}{nh}\right) \tag{14}$$

With the last term removed out asymptotically, we need an estimation for $R(f'')$. In this case, Scott and Terrell (1987) propose:

$$\widehat{R(f'')} = R(\hat{f}''(.;h)) - \frac{R(K'')}{nh^5} = \frac{1}{n^2}\sum_i \sum_{j \neq i} (K_h'' * K_h'')(X_i - X_j) \tag{15}$$

So, back in the expression 13, replacing the term for $R(f'')$, we have:

$$h_{BCV} = \arg\min_{h>0} \frac{1}{4}\mu_2^2(K)\widehat{R(f'')}h^4 + \frac{R(K)}{nh} \tag{16}$$

Besides this optimization method, an additional restriction was imposed in order to avoid oversmoothing problem. Since the object of this study is wage change, it would not be interesting if the resulting estimation is oversmoothed. So h_{BCV} is to be limited to $[0.4, 0.6]$.

As the estimation is on continuous scale, it is necessary to modify what the literature considers as signals of wage rigidity. As comparable to spike at 0 in a histogram, concentration around 0 is calculated with slight margins of error:

$$C_m = \int_{\frac{-m}{2}}^{\frac{m}{2}} \hat{f}(x; h^*)dx \tag{17}$$

where $h*$ is the optimized bandwidth and $m \in \{0.01, 0.03, 0.05\}$.

Since the true distribution is not known, the literature compares asymmetry around the median in histogram in an attempt to understand how wage changes behavior diverge. Similar to this measure, the difference between hypothetically symmetric curve and the estimated curve is calculated as in expression 18:

$$ASM = \int_{-\infty}^{median} |\hat{f}(x; h^*) - \hat{f}(-x; h^*)|dx \tag{18}$$

If the estimated distribution is perfectly symmetric, then this measure will be 0. On the other hand, if it is completely asymmetric, the measure reaches its maximum of 1.

The last measure is the range between selected quantiles, as shown in expression 19. It is similar to the first measure, concentration around 0, but it also allows visualizing how the whole distribution is concentrated, not only around the median.

$$Q_p = q_{50+\frac{p}{2}} - q_{50-\frac{p}{2}} \tag{19}$$

where q_x is x-quantile, with $p \in \{20, 50, 80\}$. It could be considered as a more general version of interquartile range - more specifically, when $p = 50$, it turns out to be interquartile range.

5 Results

This section is divided in 4 subsections, each one has a question to be answered. The first subsection refers to the extent of nominal wage rigidity, based on the concept of impossibility to increase or reduce wages. The second subsection presents the evaluation of nominal wage rigidity using the idea of wage stickiness. In the third subsection, the benchmark used for wage adjustment is studied using panel models. And the last subsection shows the existence of real wage rigidity, based on CBA. In this section, only the relevant results are exhibited, the remaining results are available in the Appendix.

5.1 How rigid are nominal wage?

Section "Data" showed that there are signs of nominal wage rigidity in Brazil, noticeable by the the number of wage freeze. In this subsection, the results of the proposed measures in

the previous section are shown. Hereafter, year refers to the base year, i.e, 2013 refers to 2013-2014, the period of 2008-2010 refers to 2008-2009, 2009-2010 and 2010-2011.

The analysis on nominal wage rigidity begins with comparing the size of spike at 0, shown in column (1) of table 7. It counts how many employees experienced wage freeze from base year to the following year, expressed in relative term. Also, this number corresponds to the gray bar in figures 15, 16. Except for 2014 and 2015, the observation of wage freeze is certainly bigger than other nominal wage changes. These histograms make it clear that nominal wages are downward rigid, not only based on the size of spike at 0 NWC, but enhanced by asymmetric form as well. As shown in table 7, this share of employees is quite stable over time, about 18%. Only in 2013-2015, this measure suffers noticeable oscillation: in 2013, it shrinks to 16.46%, then it rockets to 19.30% in 2014 and it plunges again to 15.15%; these two last numbers are the relative maximum and minimum during the studied period.

However, looking at this indicator requires extra attention, since it takes into account only the share of wage freeze. Back to table 2, the difference in total number of job stayers between 2014 and 2015 is smaller than the difference in the number of employees who experienced wage freeze between two years. So it is suggestive that the shrinkage in the number of employees with wage freeze is more strongly associated to lower employment and less job stayers than more employees with wage cut in this year. Also, the decline in this measure is not necessarily related to more flexible wage setting, but it may just reflect changes in absolute numbers of wage cut and wage freeze. When considered a longer period, for example, the whole studied period, it gives a straightforward answer regarding the existence of the nominal wage rigidity: annually at least 15% of job stayers experience nominal wage freeze and the stability in this number over time is a strong evidence of the existence of a barrier to flexible wage adjustment, especially, it shows that workers are strongly resistant to nominal wage cut.

Column (2) in table 7 refers to the decomposition of the share of wage freeze into two parts, weighted by the share of wage increase and wage cut. This measure is based on the assumption that wages are both downward and upward rigid. As the optimal wage is not observable, an extra assumption is required: the share of wage freeze that is proportional to the wage increase is attributed to upward NWR (UNWR) and another share corresponding to the weight of wage cut is assigned to downward NWR (DNWR).

As the share of employees with wage cut is very low in the Brazilian formal labor market over time, about 3.5% over the studied period, this measure points to UNWR as the main reason for wage freeze. Based on this measure, the problem of not having wage increase is more present than the problem of not having wage cut in the labor market. As this measure uses all components of the population - wage cut, wage freeze and wage increase -, it is more sensitive to fluctuations in the shares of each component, rather change in the absolute numbers. As seen in table 2, between 2007 and 2008, the number of employees who experienced wage freeze increases by 0.9 million, corresponding to yearly variation of 16.5%, but it does not affect this indicator since the proportion of the components remains unchanged. In 2015, this measure increases slightly, despite the decline in the number of employees experiencing wage freeze.

Column (3) refers to the DNWR measure in expression 3. It supposes that all the employees who had wage freeze would have wage cut under flexible wage setting, implying that DNWR is the only responsible for wage freeze. As wage cut is still much smaller compared to wage freeze, this measure indicates that the DNWR in Brazilian labor market is very high, varying between 77% to 85%. It may not seem to be pertinent to the reality if

only the absolute numbers are analyzed, but evaluating the oscillation in the indicator offers an overview on the behaviour of NWR over time. In fact, as the share of employees who experienced wage cut is very small and the number of observations of wage freeze does not change across years, this indicator ends up being quite stable over time as well. Only in 2015, a sudden plunge is observed due to the decline in the share of wage freeze. Since the total number of employed workers declined in this year, it is likely that they were less resistant to wage cut in order to keep their jobs, resulting in reduced NWR.

Three different simple indicators are seen here. As they use different assumptions, the divergence in results is seen both in the absolute numbers and in the behavior over time. Each one can be useful in different situations. Indicator (1) gives us the most intuitive answer when asked about the extent of NWR. Indicator (2) is sensitive to variation in the 3 components - wage freeze, wage increase and wage cut. Indicator (3) is useful when the economy is under turbulence, so all agents face the trade-off between wage cut and keeping jobs.

5.2 Is nominal wage sticky?

The indicators shown in the previous subsection show how wage behaves in each year, but they do not provide information regarding the behaviour over time. When the idea of duration is embraced in a model, then information on how long it takes to have wage change is required. So survival analysis on wage freeze is conducted in order to assess wage stickiness.

Figure 17 illustrates the KM survival curve of wage freeze for job stayers during the studied period in Brazil. Table 8 shows corresponding survival probabilities. As seen in the table, the probability of not having wage changed by the end of second year is 0.23. And about 11% of job stayers are expected to have wage freeze for 3 years. Observing the number of censored cases, 15% to 20% of job stayers of the previous year are expected to quit or change jobs by the end of the year in the first 4 years.

Now, the same analysis is performed with division per region to check if there is heterogeneity in wage stickiness towards geographic location. Figure 18 is suggestive of some heterogeneity, corroborated by the log rank test result in the same chart. Specifically, employees from Norte and Nordeste have the stickiest wage, while Sul and Sudeste are the regions with the least sticky wages. Also, observing the number of censored cases brings interesting information here. The difference in the share of employees who changed job or employer - censored employees - may reflect the difficulty in finding jobs for workers or in replacing the workforce for employers. For example, in Norte, where labor pool is considered limited compared to other regions, the share of censored employees is smaller than in Nordeste, suggesting that searching new employees and new jobs is relatively more difficult in Norte. Meanwhile, in Nordeste, when employers faced wage increase and workforce replacement, the number of censored hints that employers are more inclined to replace workers and it is less difficult to find new jobs as well, compared to workers in Norte. Workers from Sul and Sudeste, meanwhile, are the most resistant to wage freeze: 16% and 20% of job stayers have wage frozen in the first 2 years, respectively, while in other regions this rate is from 28% to 34%. Also, these are the regions with the highest ratio between the number of wage changers and the number of job switchers. It indicates that here both employers and workers prefer not to change their employment relationship with each other, instead of hiring new workers or searching for new jobs.

Whether there is any difference across income groups is a relevant question as well. Shown in table 11, there is a clear positive association between income and the persistence of 0 wage change. The higher is the wage, the less rigid is the employee regarding base

wage change. As a low income earner is the main target of collective bargaining, his wage depends more on the result of CBA than his direct and individual negotiation with the employer. On the other hand, a high income earner is more likely to have an individual wage negotiation, also it is unlikely that he has an "automatic" mechanism for wage raise, as low income workers. High income employees are more likely to have alternative and non-regular and effort-related earnings besides the base salary, while low income earners' main income source is very likely to be the base salary. In this way, the former group might be more interested in having increase in effort-related earnings, rather than in base salary, while the latter group's focus is base wage raise. Now, comparing the number of those who changed job or employer and the number of those who had wage change at the same employer, the higher income is also associated to higher turnover (per job). Wage increase is certainly a positive factor for all groups to keep the employment relationship, nonetheless this impact is less strong on higher income groups, compared to lower income employees.

As the final result of the survival analysis, exponential distribution is fitted to the dataset using Maximum Likelihood Estimation (MLE), shown in table 10. The estimated values refer to the hazard functions. Model (1) refers to all job stayers of all studied years in Brazil, as described in expression 5. As there is no distinction, all job stayers have the common probability of having wage freeze. Using the relationship between Exponential distribution and Geometric distribution, we have $\hat{p} = 1 - exp\{-0.291\} \approx 0.252$. It leads to the estimation of nominal wage rigidity in random duration setting à la Calvo: the probability of a job stayer to have wage freeze in each period is about 25.2%. Consequently, it is expected that an employee has no wage change for about 1.3 years. Model (2) refers to the exponential regression described in expression 7, including dummy variables for regions. As the baseline risk refers to Norte, the coefficients shown in the table are read as hazard ratio. Wages of job stayers from Norte and Nordeste are expected to be more rigid, while Sul and Sudeste are the most flexible in Brazil. The estimation is significant at the level of 1%, also, the heterogeneity across regions is significant at this level as well. Model (3) is equivalent to the regression in expression 8. The baseline group is IG_1, the lowest income earners. As seen in table 11, the wage of this group is expected to be the least sticky, while IG_5 is expected to have the stickiest wage. Estimated coefficients are significant at 1% and the wage stickiness of income groups is statistically different at 1%.

5.3 What is the benchmark for wage adjustment?

In this subsection, the results from estimating panel models are shown to answer the question in the title of the subsection. The estimation results are in tables 12 and 13. Column (1) refers to estimation using Pooled OLS, columns (2), (3) and (4) refer to individual, time and two ways fixed effect models, respectively. Columns (5), (6) and (7) refer to individual, time and two ways random effect models, respectively. For regions, the base group is Brazil, the group of contracts that affect the whole country.

In all models, past inflation has greater impact on nominal wage change than the inflation projection. It implies that both employers and unions focus on recovering lost real wage due to inflation in the past, trying to get it back to the previous level. Although results from all models indicate that projected inflation is a measure that is considered as well, it does not have great effect. Both types of inflation rates are significant at 1% level.

Now control variables used are analyzed to better understand which factor may be important to the wage bargaining, besides inflation rate. Contract duration, or contract term, brings negative impact on wage raise. It might be confusing, because higher wage increase

being associated to longer contract duration seems more intuitive. However, looking back at the figure 8, in the real world, a great part of contracts are either 12 months or 24 months, with lower average wage increase for the latter case. Contract term is significant at 1% level. The existence of more than one employer has clear negative impact, whereas the existence of more than one workers' union is ambiguous regarding wage increase: all models, except the ones with two ways effect, report that multiple unions participating in the CBA process have negative impact on wage raise. Multiple employers are significant at 1% level for all models, so are multiple unions, except for the models with one way time effect.

Graduated wage raise is an instrument to reduce immediate financial consequences for employers. Negotiators are faced with the trade-off between the time to pay or receive the whole wage raise and the wage raise itself. So when included in CBA, wage change tend to be greater, also this variable is significant at 1% level in all models. The same rationale is applied to the upper limit clause: the existence of a ceiling, from which wage will not increase in relative term, but by an absolute number, reduces labor costs, compared to a scenario without this clause. As expected, by setting an upper limit, it is compensated by bigger wage increase. This variable is significant at the level of 1% in all models as well. The existence of a lower limit term in CBA suggests that the share of employees receiving wages at this level is relevant. Also, these employees are probably the ones covered by unions. In this sense, the existence of a floor may indicate that unions are more actively engaged in the negotiation. Perhaps, it could represent better the union's bargaining power than the number of unions in the negotiation. It is significant at 1% level in all models. The variable May indicates whether this contract came into force in May or not. In figure 25, this variable did not seem to be relevant. The estimation shows that it has minor impact, but still significant at the level of 1% in all models.

Since the estimation of regions diverges among the models, selecting a model would make the analysis more precise. Table 14 shows test results for model selection. First three rows refer to F test for FE models, which verifies if entity and/or time fixed effects are 0, in other words, it tests if Z in expression 11 is a null vector. As shown in the Results column, the null hypothesis is rejected, so all of three fixed effect models are considered better than pooling. In rows (4), (5) and (6), tests for random effects are shown, based on Breusch-Pagan LM test. Results indicate rejected null hypothesis, leading to opt for RE model rather than pooling. Rows (7), (8) and (9) refer to the Hausman test to verify which type of effect would be more suitable. Under the null hypothesis, RE is chosen due to its efficiency; otherwise, FE is a better option due to its consistency. Hausman test results show that RE-i and RE-tw are inconsistent and RE-t is consistent and efficient. Evaluating R^2 and adjusted R^2 of these models might be helpful. As FE models create an unobservable constant for each individual or year, it leads to negative adjusted R^2 for FE-i and FE-tw. Even though, RE-t does not capture much information with this specification, it does not compromise the analysis.

The last piece to complete the analysis is comparison of regions. The base group is Brazil, apparently with lowest average wage change as seen in figure 23. When the CBA covers the whole country, it has the least impact on wage change as expected. With other variables kept at the same level, collective bargaining in Sul is likely to yield the biggest wage increase, while agreements in Centro Oeste would yield the least wage increase among regions. Each region has statistically different impact on wage change at 1% level.

5.4 Real wage rigidity

In this subsection, graphs with the x-axis title ending with P refer to real wage calculated based on past inflation rate and graphs with the x-axis titles ending with D refer to calculation based on inflation rate during contract period.

As seen in the subsection ”What is the benchmark for wage adjustment?”, the majority of wage bargaining focuses on compensation for lost real wage due to the past inflation rate. As a consequence, nil variation in real wage, when considered past inflation rate to discount from nominal wage change, is expected to be expressive. Indeed, as shown in figure 21, the size of median and mean, also the concentration around them are in accordance with the panel result. Also, the estimated distribution does not seem to fit to normal: it is much more concentrated on 0 and left tail is fatter than the other side, leading to asymmetric shape. These two observations lead to conclude that employees' resistance to recover real wage lost due to past inflation is very strong. As the chart is on continuous scale, if margins of 0.5% for each side are considered, about 20% of beneficiary-months are expected to have real wage freeze. This number rockets to 49% when the margins expands to 1.5% for each side.

Graph on the right in figure 21 shows how much Brazilian employees actually had real wage variation during 2007-2016. When applied the inflation rate during the contract period to be discounted from the nominal wage adjustment, employees had slight gain in real terms. The shape of the distribution and the size of median and mean suggest that the real wage is likely to be flexible. As the main concern of negotiators is past inflation, the expected inflation rate - in this case, assumed to be perfectly foreseen by both parties - during the actual contract period does not seen to be a relevant factor.

Considering employees from Norte for the whole period, the bell shape distribution is not observed in any cases. However, the concentration around median and mean is still noticed in the real wage calculated based on past inflation, implying that employees are very sensitive to compensation for lost real wage. The pattern observed in Brazil is present here as well: the fat left tail and the non-regular shape of the distribution. Also, when it comes to the current inflation rate - observed during the contract period -, employees are shown to be less sensitive; it does not have an identifiable format, however, the dispersion and low concentration around 0 lead to conclude that employees are flexible as well.

Regarding employees from Nordeste, apparently, they are much more concerned on past inflation, compared to Brazil, based on the size of mean and median. However, there are more employees with real wage change below the past inflation rate, compared to Brazil and Norte. So, employees are more resistant to past inflation, but strictly limited to compensating it, with very small real wage gain. Both the shape and the size of median and mean in real wage changes by current inflation rate suggest that employees remain flexible. In fact, comparing the concentration around real wage freeze and interquantile distances, employees in Nordeste are shown to be very flexible to real wage change, considering the actual inflation rate.

Comparing Sudeste (except SP) and São Paulo, they look quite similar in both real wage change distributions, when evaluated its shape. Both extent of asymmetry and the shape in real wage change based on past inflation suggest that SP is less downward rigid, however the median in contracts in SP is higher - apparently, employees in SP demand real wage gain, not only recovering their real wage, lost due to past inflation; while in the rest of Sudeste employees' wage raise demand is almost binding on the maintaining real wage at the previous level. Assessing actual real wage gain, similar conclusion is drawn: in SP employees have had higher real wage gain during the contract term than in the rest of the region. Both Sudeste and SP have shown to be flexible regarding the actual inflation. The

median employee in SP had higher actual wage gain, compared to Brazil, while it does not happen to the employees from Sudeste.

Centro Oeste is the only region that the median in real wage change based on past inflation rate is below 0. Their demand to recover real wage loss in the past is observed, by both median and mean being very close to 0 and the concentration around 0 is even higher than the average. And in this region the restriction of having 0 actual real wage change is binding as well, with median and mean being the closest to 0 among the regions. Also, its actual real wage change distribution is the most disperse as well, with lowest values for median and mean. So, similar conclusion is drawn here: while employees are very sensitive to real wage loss in the past, they do not care that much about the current inflation rate, implying that their real wage during the contract period is quite flexible.

5.5 Tables

Table 7: Nominal wage rigidity measures

	(1)	(2)		(3)
		DNWR	UNWR	DNWR
2007	18.21%	0.78%	17.44%	83.96%
2008	18.96%	0.78%	18.18%	85.07%
2009	17.54%	0.68%	16,86%	84.55%
2010	17.28%	0.74%	16,54%	83.05%
2011	17.67%	0.67%	17,00%	84.98%
2012	17.10%	0.68%	16.42%	83.87%
2013	16.46%	0.63%	15.83%	83.68%
2014	19.30%	0.77%	18.53%	85.64%
2015	15.15%	0.80%	14.35%	77.08%
2016	18.87%	0.86%	18.01%	83.55%
All years	17.61%	0.74%	16.87%	83.54$

This table shows nominal wage rigidity measures for each year. Column (1) refers to the size of zero nominal wage. Column (2) is divided into 2 parts: DNWR refers to the downward nominal wage rigidity and UNWR refers to the upward nominal wage rigidity, calculated based on expressions 2 and 3. Column (3) refers to the downward nominal wage rigidity, proposed by Dickens et al (2007).
Source: RAIS

Table 8: Estimation of survival function for job stayers - all years

Time	N.risk	N.event	N.censor	S(t)	SD
1	48,762,885	37,774,275	7,929,048	0.225	0.0003
2	3,059,562	1,571,450	667,740	0.110	0.001
3	820,372	389,150	128,665	0.058	0.001
4	302,557	141,054	36,553	0.031	0.002
5	124,950	46,029	9,463	0.019	0.003
6	69,458	42,430	4,203	0.008	0.006
7	22,825	5,877	12,420	0.006	0.007
8	4,528	2,711	209	0.002	0.019
9	1,608	1,608	0	0.000	-

This table shows estimated survival function for job stayers. Second column refers to the number of employees in the beginning of each year, third column refers to the number of wage change during the year. Fourth column refers to the number of censored cases. SD refers to standard deviation of estimation, S(t).

Table 9: Survival analysis - per region - 2008-2016

Region	Time	N.risk	N.event	N.censor	S(t)	SD
Norte	1	2,657,236	1,788,879	484,159	0.327	0.001
	2	384,198	222,666	50,005	0.137	0.002
	3	111,527	41,215	14,778	0.087	0.003
	4	55,534	17,737	4,040	0.059	0.004
	5	33,757	6,099	1,463	0.048	0.005
	6	26,195	25,054	496	0.002	0.029
	7	645	213	263	0.001	0.040
	8	169	124	6	0.0004	0.134
	9	39	39	0	0.000	-
Nordeste	1	6,664,881	4,402,957	1,504,733	0.339	0.001
	2	757,191	355,848	155,321	0.180	0.001
	3	246,022	111,127	33,439	0.099	0.002
	4	101,456	52,622	10,832	0.047	0.004
	5	38,002	20,620	2,828	0.022	0.007
	6	14,554	8,327	1,146	0.009	0.012
	7	5,081	1,838	1,919	0.006	0.016
	8	1,324	851	92	0.002	0.040
	9	381	381	0	0.000	-
Sudeste	1	27,503,635	21,856,278	4,224,822	0.205	0.0004
	2	1,422,535	738,440	328,838	0.099	0.001
	3	355,257	193,770	50,586	0.045	0.002
	4	110,901	54,492	12,096	0.023	0.004
	5	44,313	18,977	3,383	0.013	0.005
	6	21,953	6,230	1,840	0.009	0.007
	7	13,883	3,355	7,651	0.007	0.008
	8	2,877	1,732	94	0.003	0.024
	9	1,051	1,051	0	0.000	-
Sul	1	8,626,752	7,227,127	1,064,899	0.162	0.001
	2	334,726	183,128	80,321	0.073	0.002
	3	71,277	31,538	15,711	0.041	0.004
	4	24,028	10,674	3,507	0.023	0.007
	5	9,847	3,202	1,517	0.015	0.010
	6	5,128	1,660	655	0.010	0.014
	7	2,813	585	1,775	0.008	0.017
	8	453	342	11	0.002	0.084
	9	100	100	0	0.000	-
Centro Oeste	1	4,256,587	3,053,919	835,604	0.283	0.001
	2	367,064	174,962	82,495	0.148	0.002
	3	109,607	49,630	18,003	0.081	0.003
	4	41,974	21,575	8,186	0.039	0.006
	5	12,213	5,380	946	0.022	0.010
	6	5,887	3,165	496	0.010	0.017
	7	2,226	897	846	0.006	0.025
	8	483	202	9	0.004	0.046
	9	272	272	0	0.000	-

Table 10: Fitting exponential distribution - Brazil - 2008-2016

		Dependent variable:			
		$S(t)$			
		Coefficient	Std. Error	χ^2	DF
(1)	$Constant$	0.291^{***}	0.000157	-	-
(2)	$Constant$	0.442^{***}	0.000690	$313,837.3^{***}$	4
	$Nordeste$	0.016^{***}	0.000823		
	$Sudeste$	-0.188^{***}	0.000721		
	Sul	-0.245^{***}	0.000781		
	$Centro.Oeste$	-0.071^{***}	0.000882		
(3)	$Constant$	0.226^{***}	0.000197	$326,411.6^{***}$	4
	IG_2	0.122^{***}	0.000397		
	IG_3	0.160^{***}	0.000501		
	IG_4	-0.245^{***}	0.000781		
	IG_5	-0.071^{***}	0.000882		

*p<0.1; **p<0.05; ***p<0.01

Table 11: Survival analysis - per income group - 2008-2016

IG	Time	N.risk	N.event	N.censor	S(t)	SD
1	1	30,354,809	24,749,583	4,331,189	0.185	0.0004
	2	1,274,037	662,047	293,888	0.089	0.001
	3	318,102	152,800	62,447	0.046	0.002
	4	102,855	35,099	12,585	0.030	0.003
	5	55,171	21,252	2,693	0.019	0.005
	6	31,226	27,522	894	0.002	0.016
	7	2,810	1,373	300	0.001	0.024
	8	1,137	709	40	0.0004	0.045
	9	388	388	0	0.000	-
2	1	10,604,686	7,734,645	1,926,638	0.271	0.001
	2	943,403	502,658	175,076	0.126	0.001
	3	265,669	123,684	31,133	0.068	0.002
	4	110,852	74,113	9,485	0.022	0.005
	5	27,254	12,230	2,554	0.012	0.007
	6	12,470	7,383	1,052	0.005	0.013
	7	4,035	1,751	491	0.003	0.019
	8	1,793	1,021	59	0.001	0.033
	9	713	713	0	0.000	-
3	1	6,143,522	4,304,645	1,268,911	0.299	0.001
	2	569,966	298,279	119,544	0.143	0.002
	3	152,143	85,005	21,362	0.063	0.003
	4	45,776	19,553	6,868	0.036	0.005
	5	19,355	8,909	1,459	0.019	0.008
	6	8,987	5,803	507	0.007	0.017
	7	2,677	1,336	200	0.003	0.025
	8	1,141	619	84	0.002	0.041
	9	438	438	0	0.000	-
4	1	1,236,175	783,218	295,550	0.366	0.001
	2	157,407	67,725	31,122	0.209	0.002
	3	58,560	18,499	5,877	0.143	0.004
	4	34,184	10,154	4,262	0.100	0.005
	5	19,768	2,705	1,080	0.087	0.006
	6	15,983	1,555	1,642	0.078	0.006
	7	12,786	1,168	11,223	0.071	0.007
	8	395	329	8	0.012	0.113
	9	58	58	0	0.000	-
5	1	423,693	202,184	106,760	0.523	0.001
	2	114,749	40,741	48,110	0.337	0.003
	3	25,898	9,162	7,846	0.218	0.005
	4	8,890	2,135	3,353	0.166	0.008
	5	3,402	933	1,677	0.120	0.013
	6	792	167	108	0.095	0.023
	7	517	249	206	0.049	0.048
	8	62	33	18	0.023	0.144
	9	11	11	0	0.000	-

Source: RAIS

Table 12: Estimation results - POLS, FE, RE (1)

	Dependent variable:			
	Nominal wage change			
	(1)	(2)	(3)	(4)
	POLS	FE-i	FE-t	FE-tw
π_{-it}	0.538***	0.572***	0.509***	0.469***
	(0.003)	(0.003)	(0.006)	(0.006)
π_{it}	0.181***	0.145***	0.069***	0.050***
	(0.002)	(0.002)	(0.006)	(0.005)
$Contract.term_{it}$	−0.330***	−0.355***	−0.267***	−0.259***
	(0.003)	(0.002)	(0.005)	(0.005)
$Norte_i$	1.423***	2.040***	1.456***	2.184***
	(0.060)	(0.367)	(0.059)	(0.351)
$Nordeste_i$	1.625***	−0.057	1.660***	−0.216
	(0.058)	(0.441)	(0.056)	(0.421)
$Sudeste_i$	1.427***	4.673***	1.457***	4.766***
	(0.055)	(0.192)	(0.054)	(0.183)
Sul_i	1.723***	2.279***	1.754***	2.137***
	(0.056)	(0.300)	(0.055)	(0.286)
$Centro.Oeste_i$	1.217***	0.527***	1.249***	0.459**
	(0.059)	(0.190)	(0.057)	(0.181)
$Multi.Employers_{it}$	−0.609***	−0.822***	−0.117***	−0.130***
	(0.018)	(0.028)	(0.019)	(0.028)
$Multi.Unions_{it}$	−0.315***	−0.279***	−0.038	0.144***
	(0.030)	(0.055)	(0.030)	(0.053)
$Grad.wage.raise_{it}$	0.540***	0.734***	0.619***	0.806***
	(0.029)	(0.029)	(0.029)	(0.028)
$Lower.lim_{it}$	1.200***	0.227***	1.249***	0.388***
	(0.019)	(0.031)	(0.018)	(0.029)
$Upper.lim_{it}$	0.284***	0.409***	0.308***	0.463***
	(0.018)	(0.025)	(0.018)	(0.024)
May_{it}	0.194***	0.130***	0.186***	0.035
	(0.013)	(0.040)	(0.013)	(0.038)
$Constant$	4.386***			
	(0.061)			
Observations	170,255	170,255	170,255	170,255
R^2	0.222	0.383	0.079	0.090
Adjusted R^2	0.222	−0.036	0.079	−0.527
F Statistic	3,461.694***	4,493.106***	1,042.021***	714.060***

*p<0.1; **p<0.05; ***p<0.01

Table 13: Estimation results - POLS, FE, RE (2)

	Dependent variable:		
	Nominal wage change		
	(5)	(6)	(7)
	RE-i	RE-t	RE-tw
π_{-it}	0.556***	0.509***	0.482***
	(0.003)	(0.006)	(0.003)
π_{it}	0.162***	0.069***	0.054***
	(0.002)	(0.006)	(0.003)
$Contract.term_{it}$	−0.329***	−0.267***	−0.251***
	(0.002)	(0.005)	(0.003)
$Norte_i$	1.848***	1.456***	2.069***
	(0.076)	(0.059)	(0.053)
$Nordeste_i$	2.167***	1.660***	2.394***
	(0.072)	(0.056)	(0.049)
$Sudeste_i$	1.806***	1.457***	2.027***
	(0.067)	(0.054)	(0.045)
Sul_i	2.086***	1.754***	2.263***
	(0.069)	(0.055)	(0.047)
$Centro.Oeste_i$	1.556***	1.249***	1.706***
	(0.073)	(0.057)	(0.049)
$Multi.Employers_{it}$	−0.697***	−0.117***	−0.120***
	(0.020)	(0.019)	(0.014)
$Multi.Unions_{it}$	−0.283***	−0.039	0.069***
	(0.035)	(0.030)	(0.023)
$Grad.wage.raise_{it}$	0.684***	0.619***	0.792***
	(0.027)	(0.029)	(0.016)
$Lower.lim_{it}$	1.165***	1.249***	1.049***
	(0.023)	(0.018)	(0.014)
$Upper.lim_{it}$	0.365***	0.308***	0.425***
	(0.020)	(0.018)	(0.012)
May_{it}	0.223***	0.186***	0.197***
	(0.019)	(0.013)	(0.013)
$Constant$	3.958***	4.384***	3.992***
	(0.072)	(0.222)	(0.138)
Observations	170,255	170,255	170,255
R^2	0.384	0.079	0.201
Adjusted R^2	0.384	0.079	0.201
F Statistic	67,533.490***	14,608.510***	38,096.510***

*p<0.1; **p<0.05; ***p<0.01

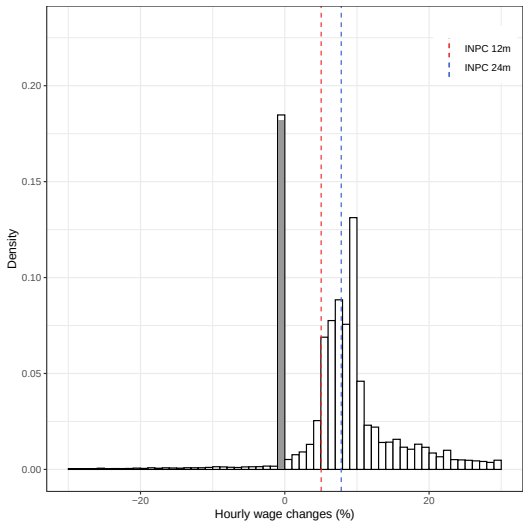
Table 14: Test results for econometric model selection

		Test type	Results	Statistics(DF)
(1)	POLS x FE-i	F	3.9802***	F(68,747;101,493)
(2)	POLS x FE-t	F	921.9***	F(10;170,230)
(3)	POLS x FE-tw	F	4.5148***	F(68,757;101,483)
(4)	POLS x RE-i	LM-BP	7,952.2***	$\chi^2(1)$
(5)	POLS x RE-t	LM-BP	3,205,055***	$\chi^2(1)$
(6)	POLS x RE-tw	LM-BP	3,213,007	$\chi^2(1)$
(6)	FE-i x RE-i	Hausman	2,480.2***	14
(7)	FE-t x RE-t	Hausman	5.6408	14
(8)	FE-tw x RE-tw	Hausman	1,152.4***	14

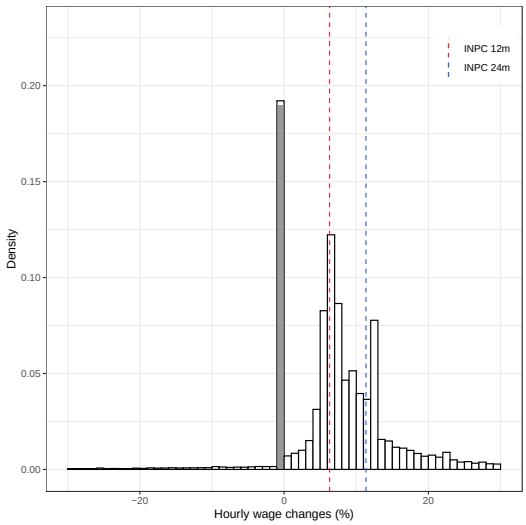
*p<0.1; **p<0.05; ***p<0.01

5.6 Figures

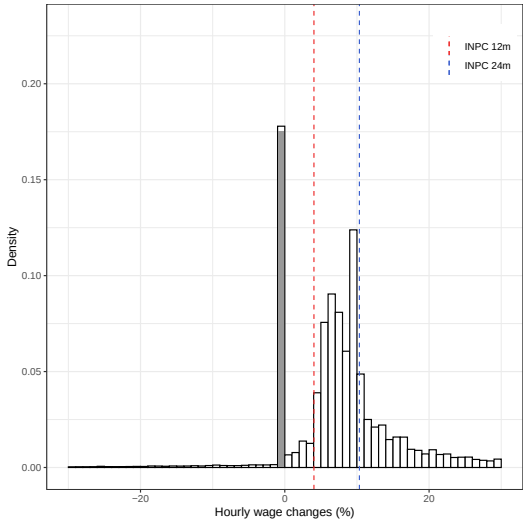
Figure 15: Histogram - Nominal wage changes (1)



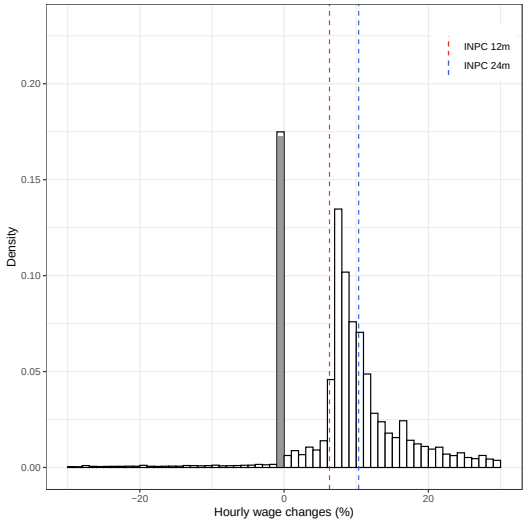
(a) 2007



(b) 2008

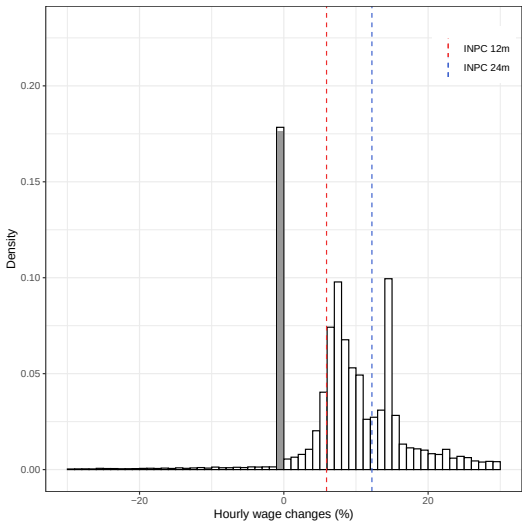


(c) 2009

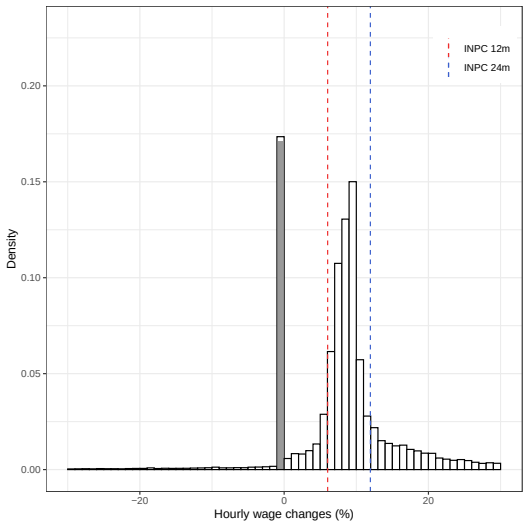


(d) 2010

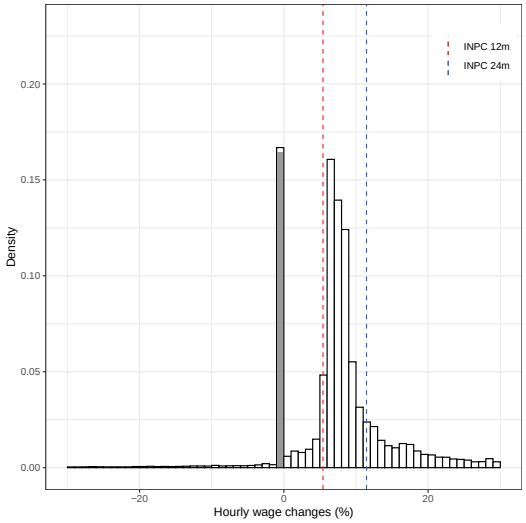
Figure 16: Histogram - Nominal wage changes (2)



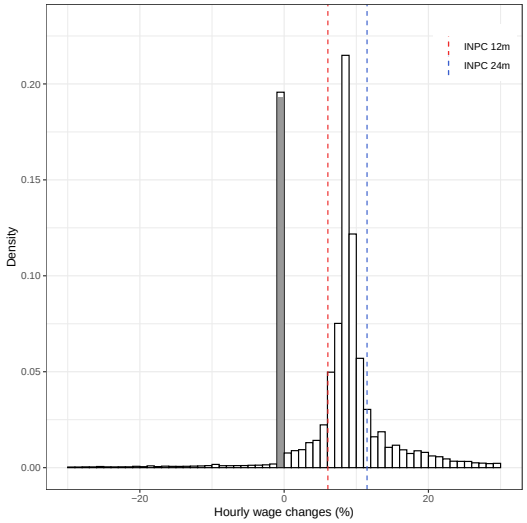
(a) 2011



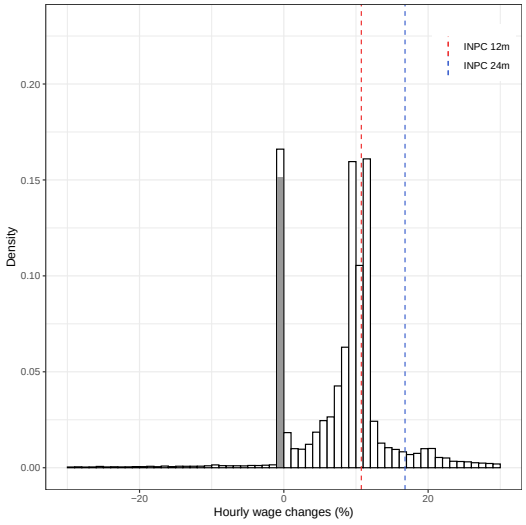
(b) 2012



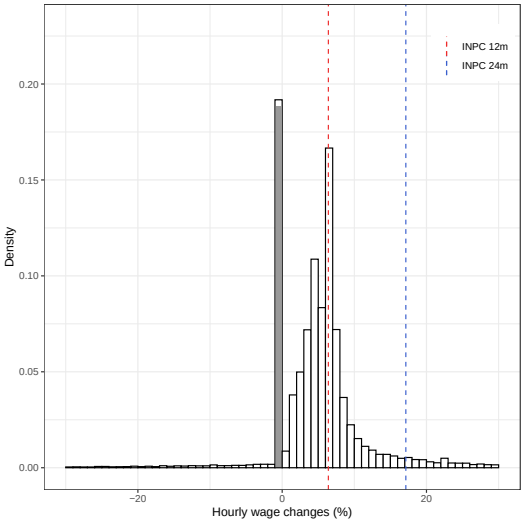
(c) 2013



(d) 2014



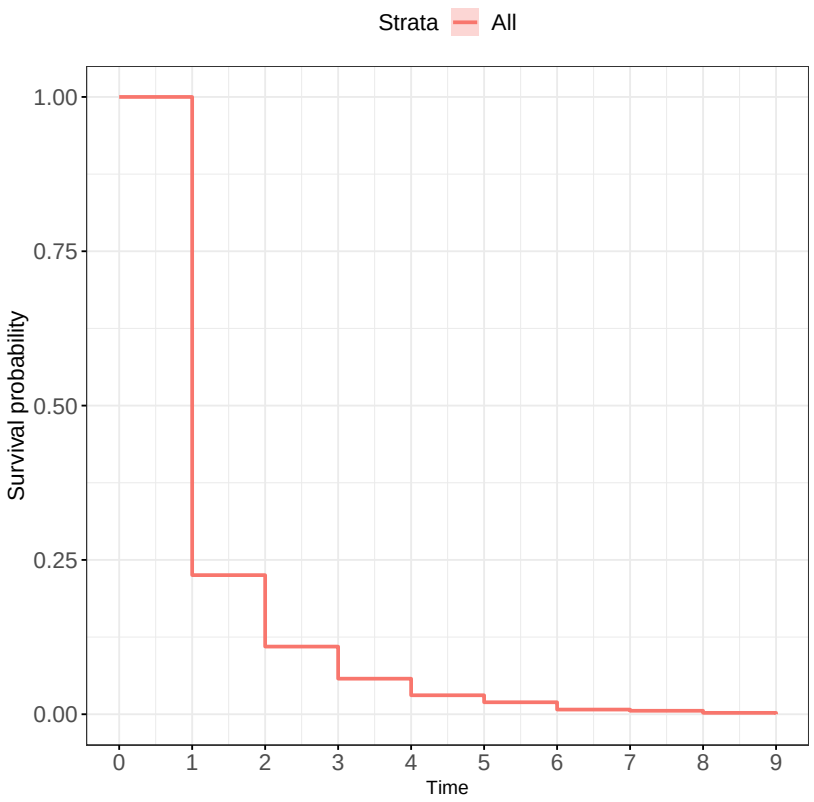
(e) 2015



(f) 2016

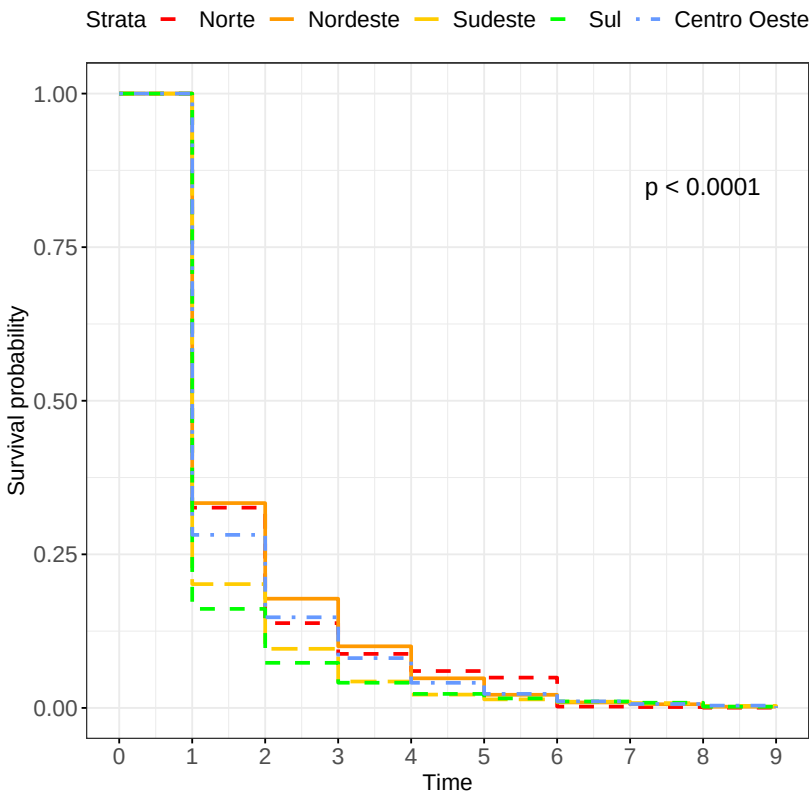
The chart shows the wage changes of job stayers for each year. All the variables are the same as in figure 2.
Source: RAIS

Figure 17: KM estimation for wage freeze



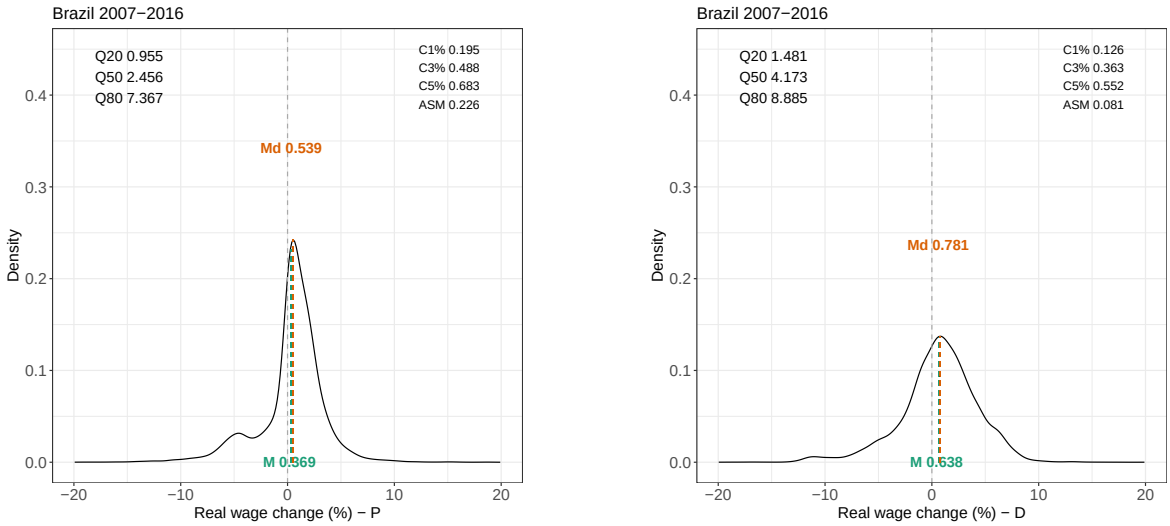
This chart shows estimation for job stayers' survival probability of wage freeze using KM estimator. Time is on x-axis and the survival probability is on y-axis.
Source: RAIS, original creation

Figure 18: KM estimation for wage freeze per region



This chart shows estimation for job stayers' survival probability of wage freeze using KM estimator per region. Time is on x-axis and the survival probability is on y-axis. The number in the upper right refers to the log-rank test result.
Source: RAIS, original creation

Figure 19: Real wage rigidity - Brazil - all years



This figure shows estimated real wage distribution using kernel density estimation. Figure on the left uses past inflation rate to calculate real wage. Figure on the right uses inflation rate during the contract term to calculate real wage. On x-axis we have percentage real wage changes and on y-axis we have estimated density. Q20, Q50 and Q80 on the upper left refer to interquantile distances. C1%, C3% and C5% refer to concentration around 0, considering 0.5% 1.5% and 2.5% of margins for each side. ASM is the measure for asymmetry.
Source: Salariometro, RAIS, original creation

Figure 20: Real wage rigidity - region (1)

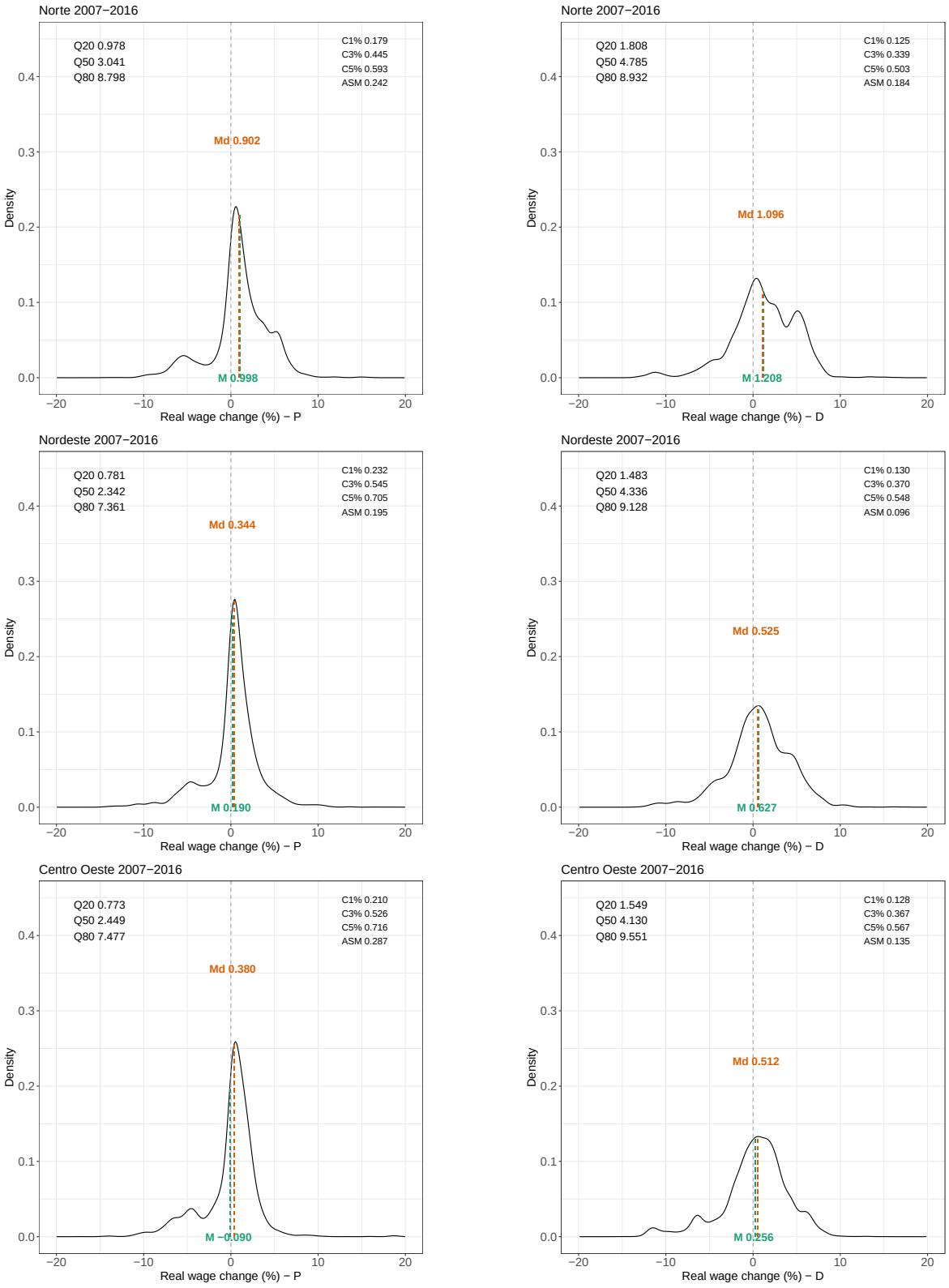
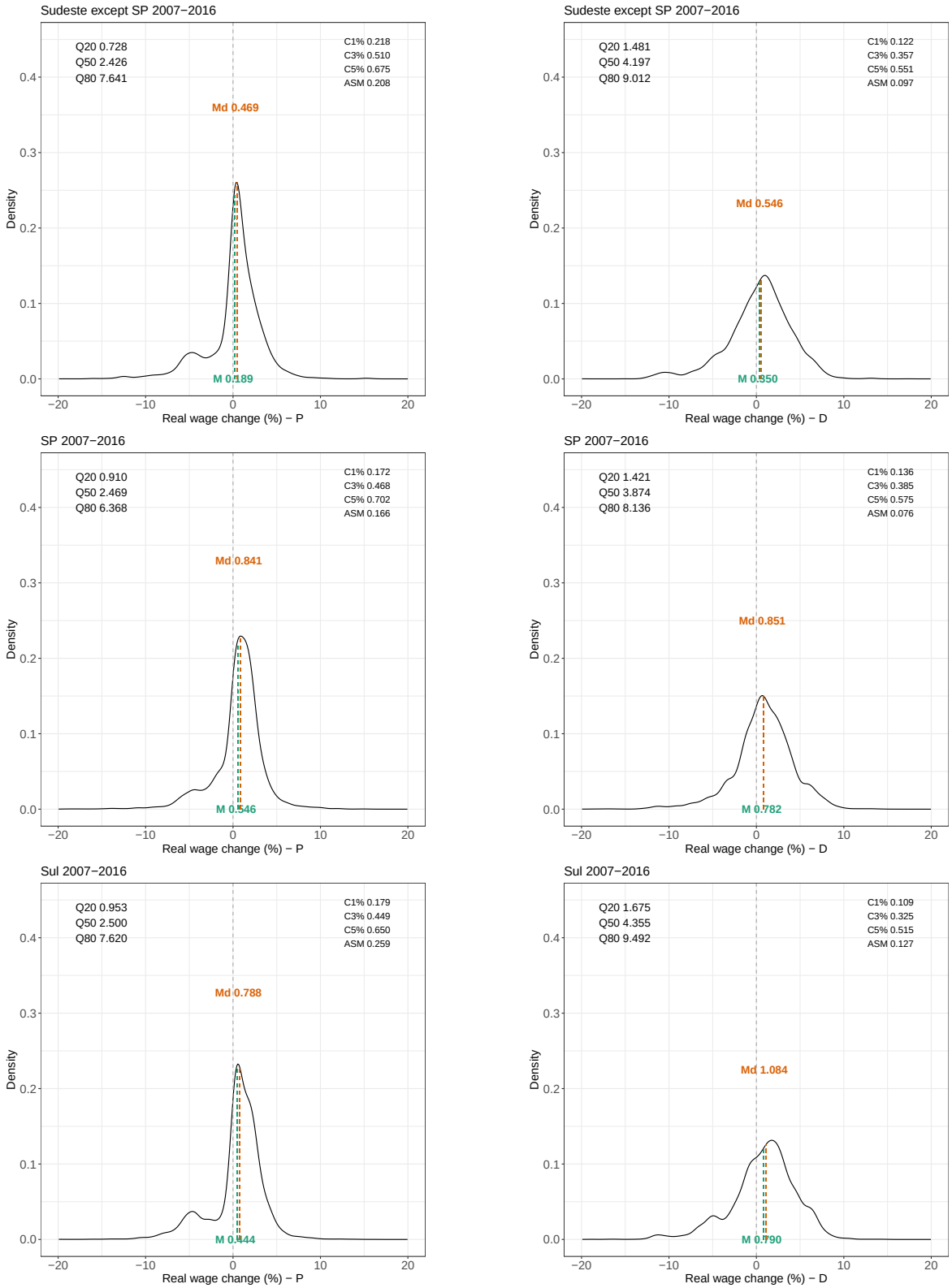


Figure 21: Real wage rigidity - region (2)



This figure shows estimated real wage distribution using kernel density estimation for each region. All the variables are the same as in figure 21.
Source: Salariometro, RAIS, original creation

6 Conclusions

This study investigates the existence and the extent of wage rigidities for job stayers in Brazil. Divided in 4 questions related to wage rigidities, RAIS, Brazilian administrative records on each employer's staff, reported by firms, and Salariometro, the database on collective bargaining agreement, are explored. The first discussion is on the extent of nominal wage rigidity, estimated using the observation of wage freeze and wage cut. Three different approaches are used to assess the nominal wage rigidity. As the NWR measures have different assumptions, it produces disparate results. However, the shares of employees experiencing wage freeze and wage cut are quite stable over the examined years.

The second question is on the stickiness of nominal wage. Using KM estimation method, survival function for the job stayers is estimated. Two main findings are reported. First, about 73% of job stayers have wage changed after two years; however, the persistence of wage freeze is also high. Second, about 6% of job stayers are expected to experience wage freeze for 4 consecutive years. Besides, about 15% of job stayers of the previous year are expected to quit or change jobs by the end of the year. Segregated by regions and income groups, the same analysis is repeated to verify the existence of heterogeneity across these variables. Norte and Nordeste are the regions with the stickiest nominal wages, while employees in Sul experience the least wage staggering. Also, income level is positively associated to the extent of wage stickiness. All these results are corroborated by the survival regression, significant at 1%. Also, using the relationship between Geometric distribution and Exponential distribution, Calvo probability is estimated.

The third question is about the benchmark used by unions and employers for wage adjustment. Panel models are estimated to identify which inflation rate is more relevant to wage adjustment during collective bargaining. Pooled OLS model, 3 Fixed Effect models and 3 Random Effect models are estimated here to find the benchmark used by negotiators. Model selection tests show that the Random Time Effect model is considered to best describe, although it explains very little of the association. The main finding here is that negotiators use past inflation rate as benchmark for wage adjustment, suggesting that both parties concern much on recovering loss of real wage.

Finally, the last part of this study is about the real wage rigidity. Here, two types of inflation rate are used to discount from the nominal wage change: past inflation and the inflation during the contract term. In the first case, it helps to evaluate the extent of resistance to recover part of real wage that was lost due to inflation in the past. The second type measures how much workers are resistant to real wage cut during the current period. Results from kernel density estimation show that employees are very reluctant to not retaking the lost part of their real wages, whereas, they are quite flexible to current real wage cut - real wage cut caused by the inflation rate during the contract period. About 13% of workers of all the studied years had 0 current real wage change, and about 20% of workers recovered all the lost real wage.

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A Tables

Table 15: Criteria applied to divide income groups - RAIS

Group	Wages measured in minimum wage
1	$1 < x \leq 2$
2	$2 < x \leq 4$
3	$4 < x \leq 10$
4	$10 < x \leq 20$
5	$x > 20$

Table 16: National minimum wage evolution 2007-2017

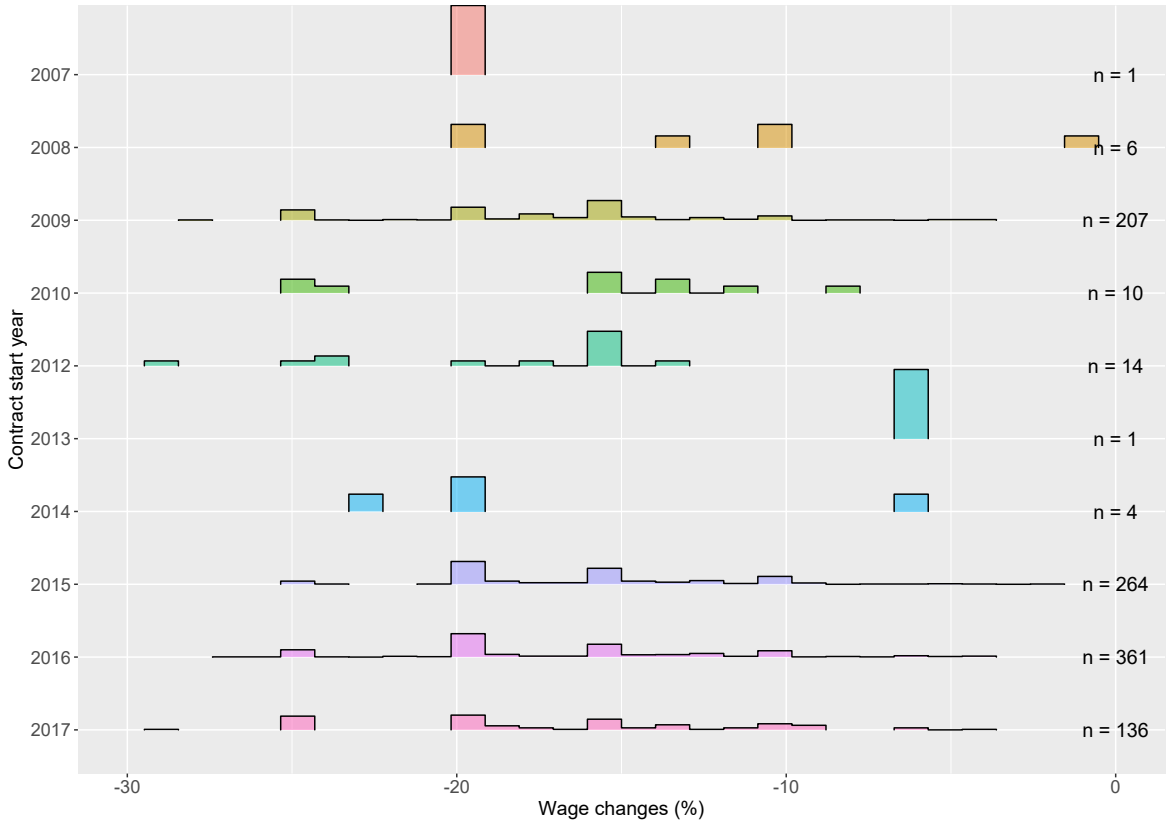
Year	Minimum wage (R$)	MW change
2007	380.00	-
2008	415.00	8.43%
2009	465.00	10.75&
2010[15]	510.00	8.82%
2011[16]	545.00	6.42%
2012	622.00	12.38%
2013	678.00	8.26%
2014	724.00	6.35%
2015	788.00	8.12%
2016	880.00	10.45%
2017	937.00	6.08%

Table 17: Bandwidth - P/v

	BR	N	NE	SE\SP	SP	S	CO
2008	.58 / .58	.58 / .58	.58 / .42	.58 / .58	.58 / .58	.54 / .58	.58 / .58
2009	.58 / .58	.46 / .57	.58 / .46	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2010	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2011	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2012	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2013	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2014	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2015	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2016	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58
2017	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58	.58 / .58

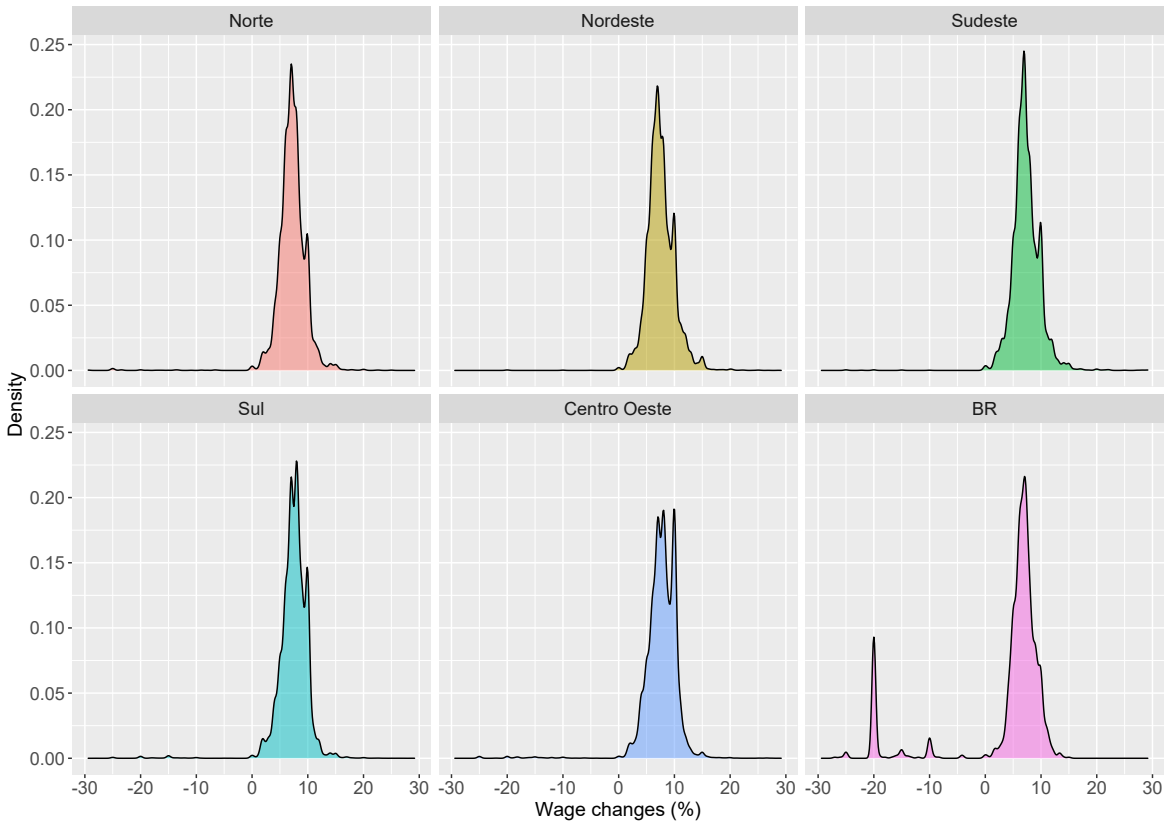
B Figures

Figure 22: Histogram of wage cut contracts



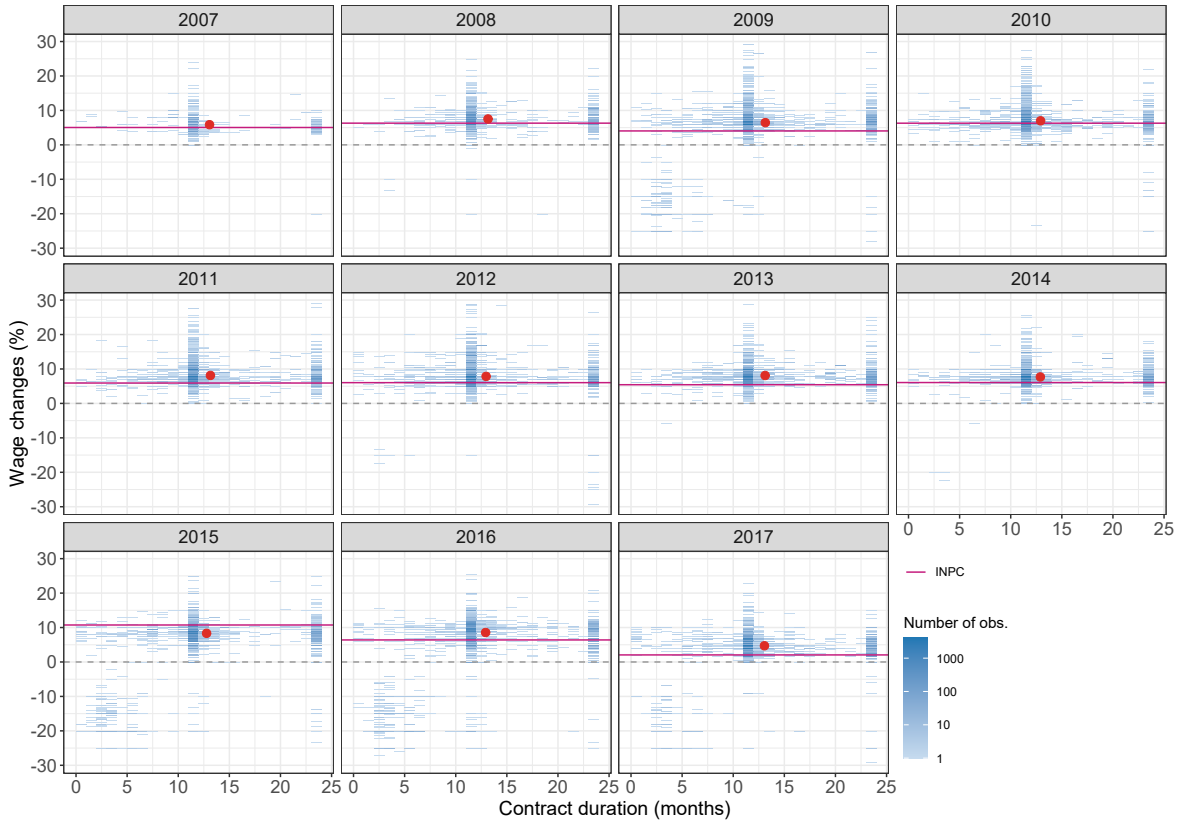
The histogram of wage cut contracts shows wage changes in percentage on x-axis and the density on y-axis. The bin size is 1% and ”n” is the number of observations for each year.
Source: Salariometro

Figure 23: Estimated distribution for wage changes per Regiao - 2007-2017



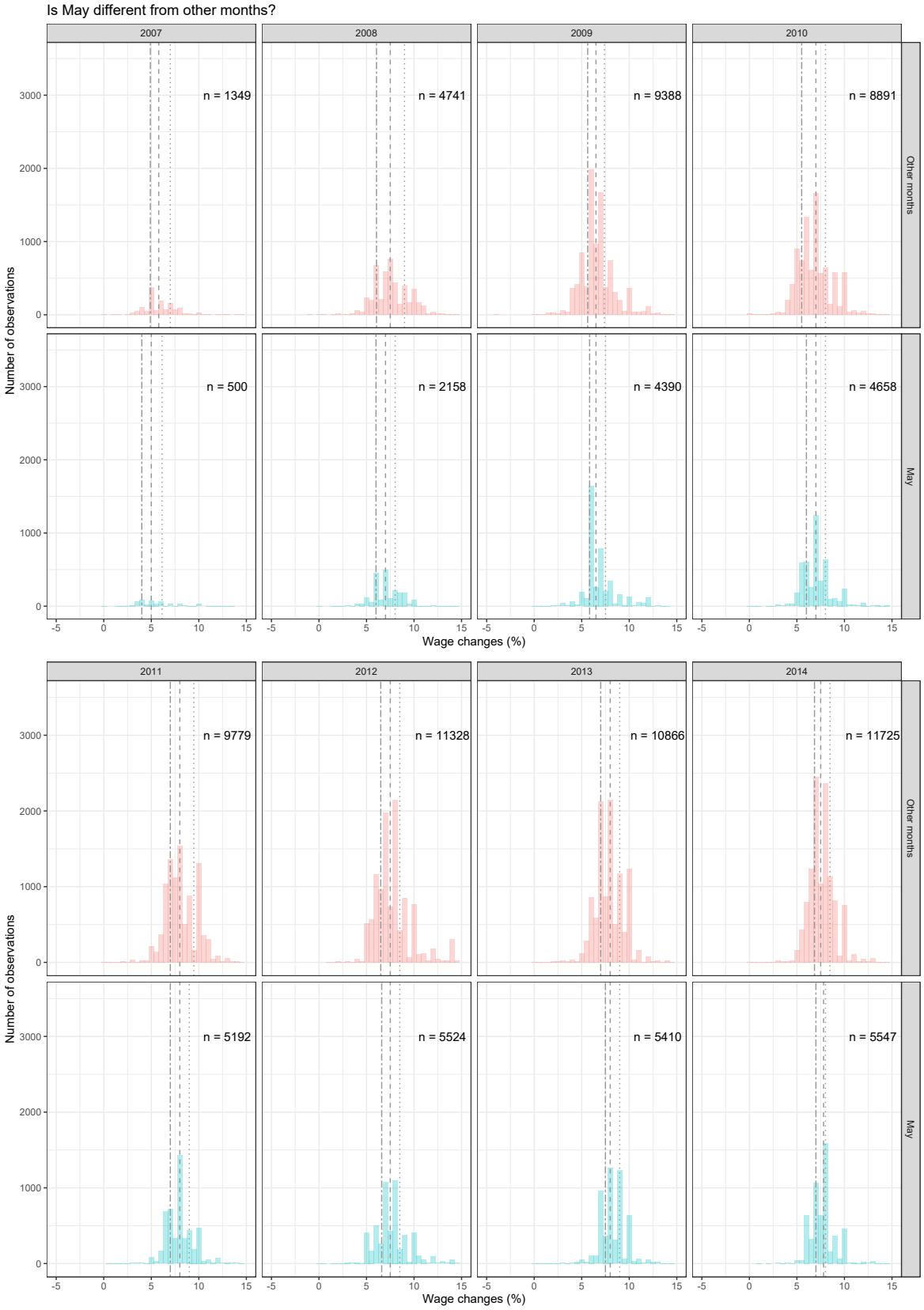
This chart shows how wage changes via CBA are distributed, clustered by regions. The joint bandwidth used is 0.35. On x-axis we have percentage wage changes. We have estimated density of wage changes for each region on y-axis.
Source:Salariometro, original creation

Figure 24: Wage changes and contract duration



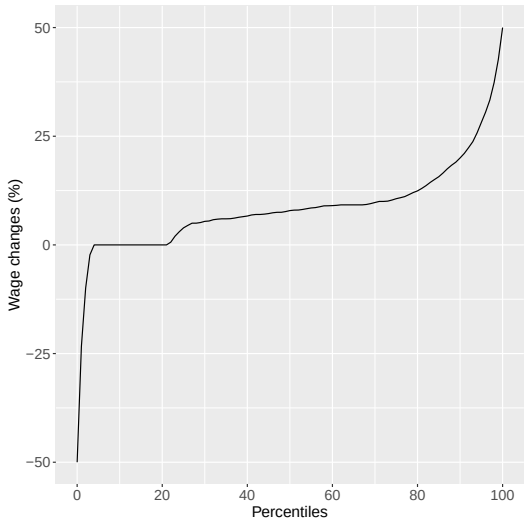
This heatmap shows contract duration on x-axis and percentage wage changes on y-axis. Each bin represents the presence of contracts with matching features; the darker is it, the greater is the number of observations with these characteristics. Red vertical line represents average inflation rate, 5.42%, for the period of 2007-2017. Red dot is the average contract - its x-coordinate represents average duration and y-coordinate represents average wage changes.
Source: Salariometro

Figure 25: Comparison between May and other months per year

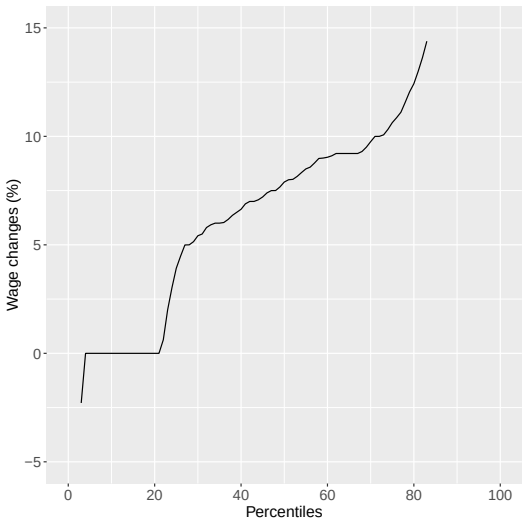


This panel shows histograms of number of contracts that come into force in May and in other months for each year. All the variables are the same as in figure 10.
Source: Salariometro

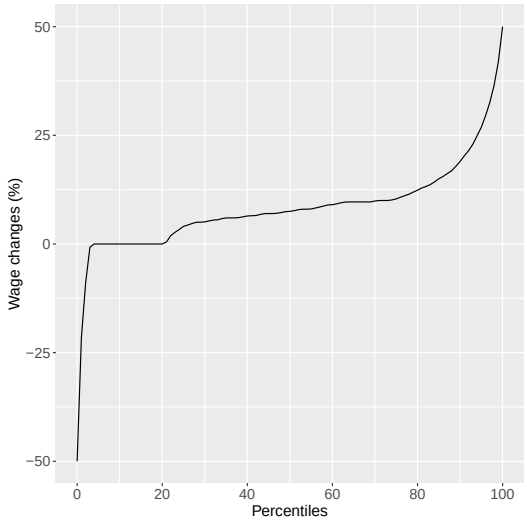
Figure 26: Nominal wage changes in ascending order



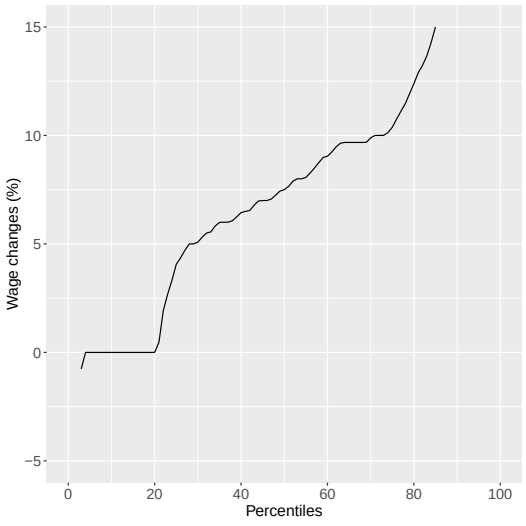
(a) RAIS 2007-2008



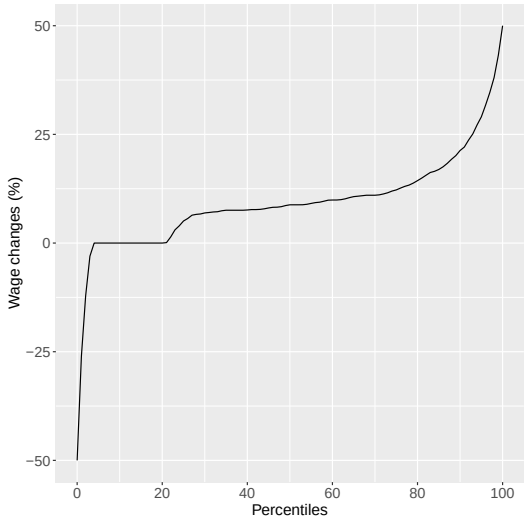
(b) Zoom in on NWC between -5% and 15%



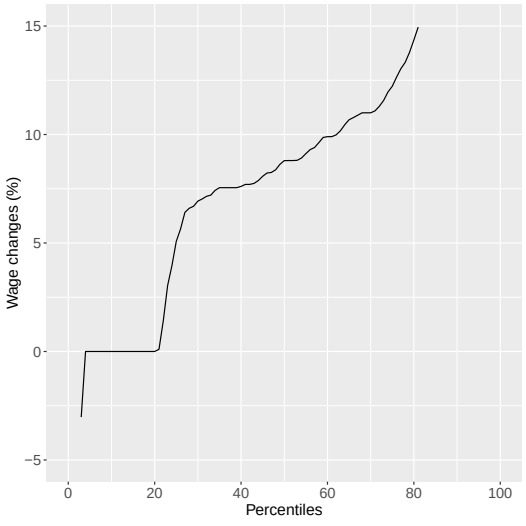
(c) RAIS 2009-2010



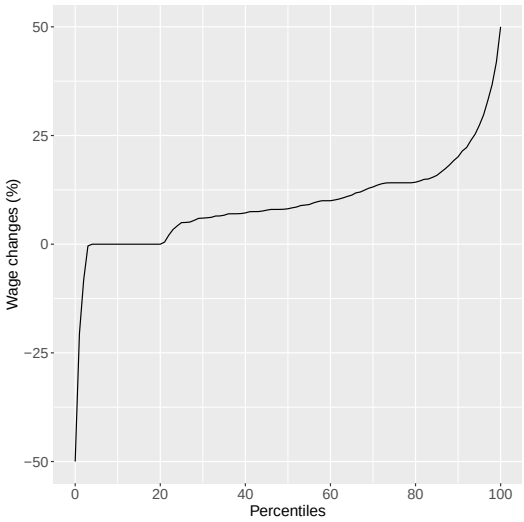
(d) Zoom in on NWC between -5% and 15%



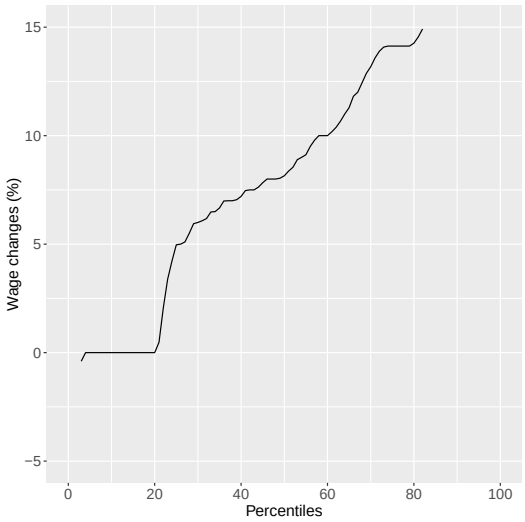
(e) RAIS 2010-2011



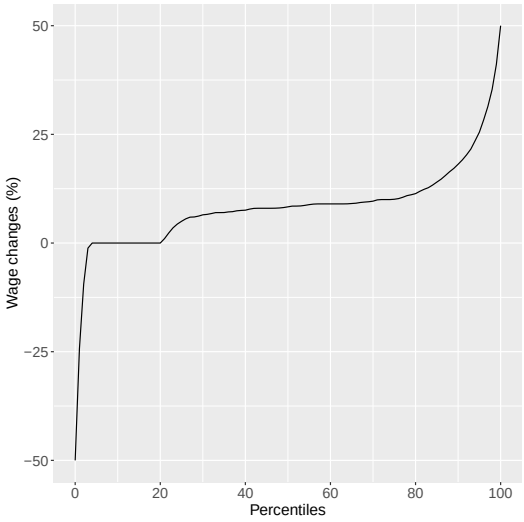
(f) Zoom in on NWC between -5% and 15%



(a) RAIS 2011-2012



(b) Zoom in on NWC between -5% and 15%



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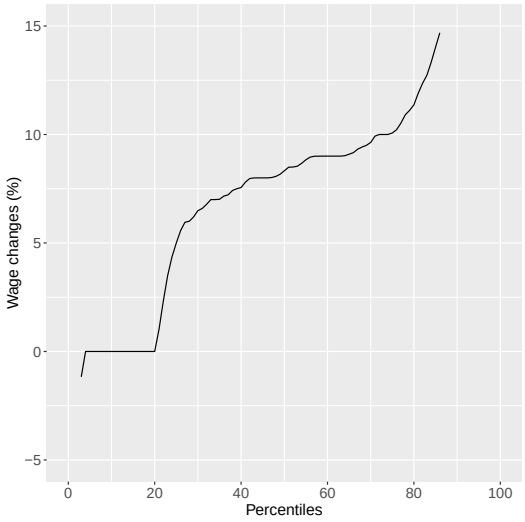
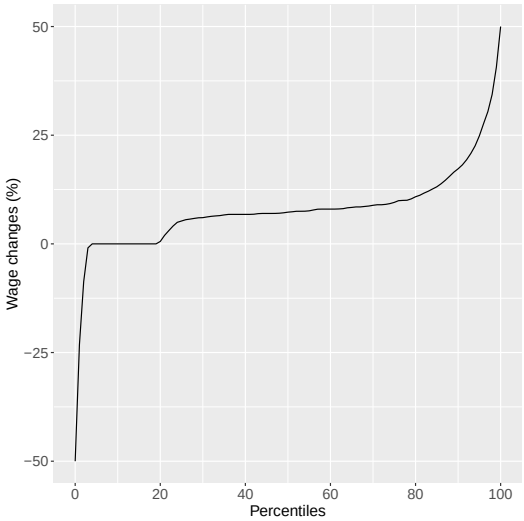
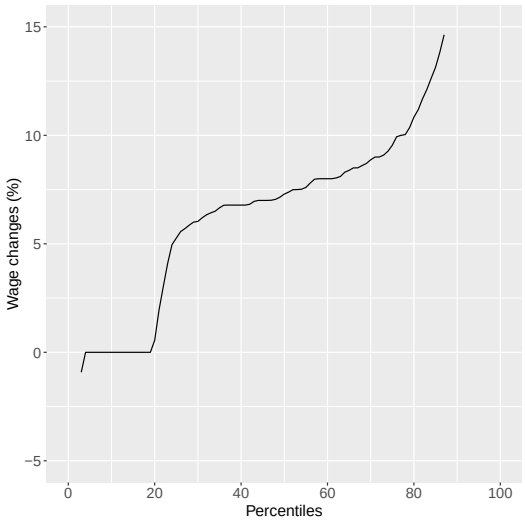


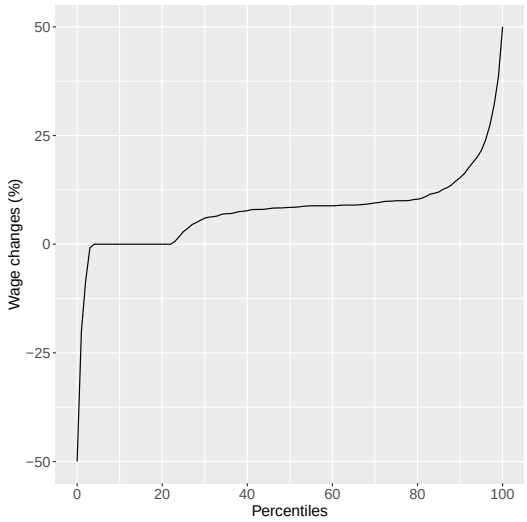
(d) Zoom in on NWC between -5% and 15%



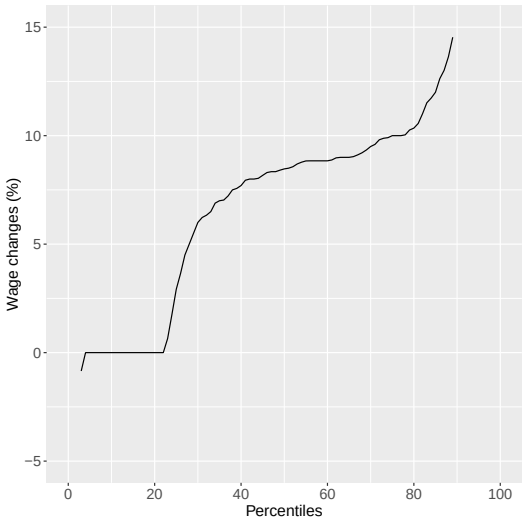
(e) RAIS 2013-2014



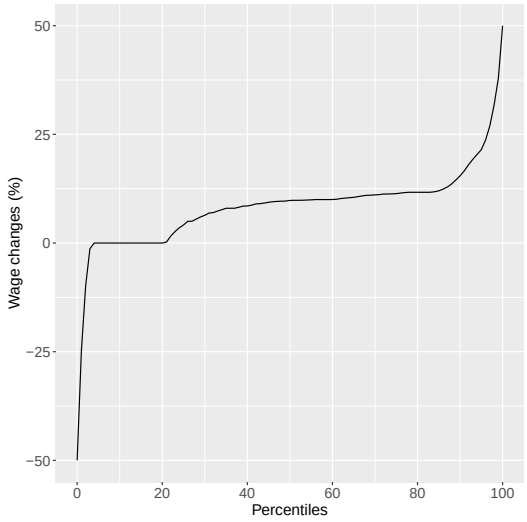
(f) Zoom in on NWC between -5% and 15%



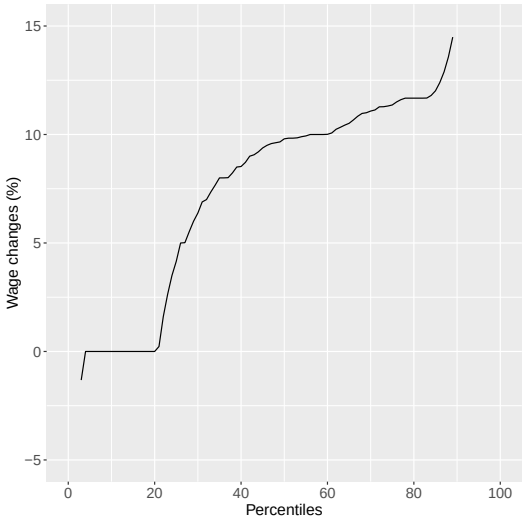
(a) RAIS 2014-2015



(b) Zoom in on NWC between -5% and 15%



(c) RAIS 2015-2016



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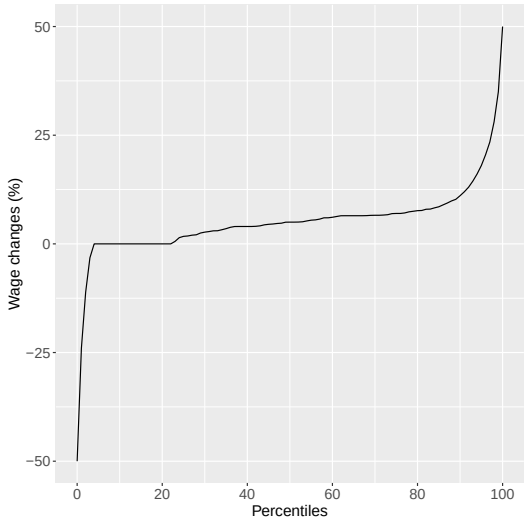
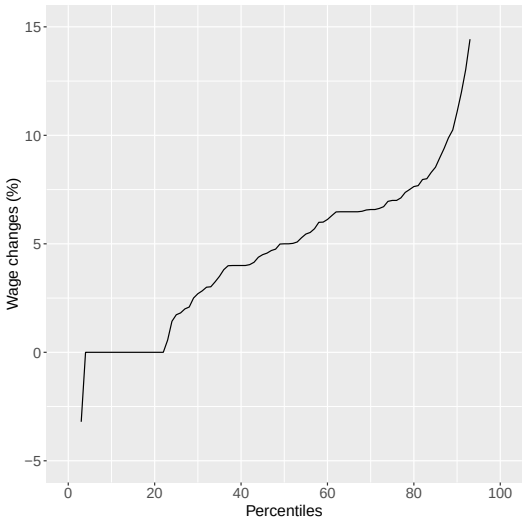


(e) RAIS 2016-2017



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