Pontifícia Universidade Católica
do Rio de Janeiro

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Essays on Labor and Development Economics

Tese de Doutorado

Thesis presented to the Programa de Pós-graduação em Economia of PUC-Rio in partial fulfillment of the requirements for the degree of Doutor em Economia.

Advisor: Prof. Gustavo Gonzaga

Rio de Janeiro
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To Lelina Maria, *in memoriam*.

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Abstract

Castro, Pablo; Gonzaga, Gustavo (Advisor). **Essays on Labor and Development Economics**. Rio de Janeiro, 2025. 106p. Tese de doutorado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

This dissertation consists of three essays on Labor and Development Economics. In Chapter 1, I investigate how the mandatory extension of collective bargaining agreements (ultractivity) increased labor unions' bargaining power and affected firms' hiring and firing decisions. Using matched employer-employee data and information on collective bargaining agreements (CBAs), I exploit variation in the timing of when a firm becomes subject to an ultractive CBA. I find that ultractivity reduces hiring, increases separations among high-tenure workers, and decreases separations among low-tenure workers. To interpret these results, I develop a framework in which firms anticipate higher adjustment costs under stronger labor protections and account for the substitutability between workers. Chapter 2 investigates the long-term effects of slavery on present-day Black homicide and incarceration rates. Using soil suitability for slavery-intensive crops as an instrument, I show that areas with greater historical slave intensity exhibit persistently higher levels of violence and incarceration affecting Black individuals. In Chapter 3, I apply the methodology proposed by Borusyak, Dix-Carneiro, and Kovak (2023) to estimate the effects of droughts and labor market changes on out-migration, focusing on Brazil's semi-arid region. I adjust local shocks by comparing them to the average conditions in typical destinations, weighting destination shocks by the share of past migrants from each origin to those areas. This approach shows that local aridity shocks alone no longer significantly affect emigration in recent years. However, relative economic conditions across regions remain a strong predictor of migration flows.

Keywords

Labor Market; Collective Bargaining Agreements; Employment; Slavery; Racial Discrimination; Climate shock; Migration.

Resumo

Castro, Pablo; Gonzaga, Gustavo. **Ensaios em Economia do Trabalho e do Desenvolvimento**. Rio de Janeiro, 2025. 106p. Tese de Doutorado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Esta tese consiste em três ensaios em Economia do Trabalho e do Desenvolvimento. No Capítulo 1, investigo como a extensão obrigatória da validade dos acordos coletivos (ultratividade) aumentou o poder de barganha dos sindicatos e afetou as decisões das firmas sobre contratação e demissão. Utilizando dados emparelhados de empregadores e empregados, além de informações sobre acordos coletivos, exploro a variação no momento em que uma firma passa a estar sujeita a um acordo com ultratividade. Encontro que a ultratividade reduz contratações, aumenta demissões entre trabalhadores com maior tempo de casa e reduz demissões entre os de menor tempo. Para interpretar esses resultados, desenvolvo um modelo em que as firmas antecipam maiores custos de ajuste diante de proteções trabalhistas mais rígidas e consideram a substituibilidade entre trabalhadores. O Capítulo 2 investiga os efeitos de longo prazo da escravidão sobre as atuais taxas de homicídio e encarceramento da população negra. Utilizando a adequação do solo para culturas intensivas em trabalho escravo como variável instrumental, mostro que áreas com maior intensidade histórica de escravidão apresentam níveis persistentemente mais altos de violência e encarceramento que afetam desproporcionalmente a população negra. No Capítulo 3, aplico a metodologia proposta por Borusyak, Dix-Carneiro e Kovak (2023) para estimar os efeitos de secas e mudanças no mercado de trabalho sobre a emigração, com foco na região semiárida do Brasil. Ajusto os choques locais comparando-os à média das condições observadas nos destinos mais comuns, ponderando os choques nas regiões de destino pela proporção de migrantes que saíram de cada município de origem para esses locais. Essa abordagem mostra que os choques locais de aridez, por si só, não afetam significativamente a emigração nos anos mais recentes. No entanto, as condições econômicas relativas entre regiões continuam sendo um forte preditor dos fluxos migratórios.

Palavras-chave

Mercado de Trabalho; Acordos Coletivos; Emprego; Escravidão; Discriminação Racial; Choque climático; Migração.

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Introduction

This dissertation brings together three essays on Labor and Development Economics that explore how institutions, history, and shocks influence labor market and socioeconomic outcomes. While each chapter addresses a distinct question, all three aim to estimate causal effects using different econometric approaches and applied microeconomic tools.

The first chapter examines the impact of an increase in labor unions' bargaining power on firms' employment decisions. I exploit exogenous variation in the timing of when a firm becomes subject to an ultratividade collective bargaining agreement, a legal change that extended the validity of expired contracts. Using matched employer-employee data and a staggered difference-in-differences framework, I find that firms facing ultratividade CBAs reduce hiring and increase separations among high-tenure workers. The findings are consistent with a dynamic model in which firms anticipate rising adjustment costs under stronger labor protections and account for the substitutability between high- and low-tenure workers.

The second chapter explores the persistent effects of slavery on contemporary racial disparities in incarceration and homicides in Brazil. I build a municipality-level dataset combining 19th-century slavery data with modern crime and incarceration statistics disaggregated by race. Using an instrumental variables strategy based on agro-climatic conditions for soil suitability for slave-intensive crops, I show that regions with higher historical slavery reliance exhibit worse outcomes for Black populations today, measured by higher homicide rates and incarceration gaps. I provide suggestive evidence that these patterns are driven by both structural factors (e.g., persistent racial inequality in educational attainment) and cultural mechanisms, such as greater racial bias among teachers in areas with higher historical slave shares.

The third chapter studies internal migration responses to aridity shocks and labor market changes in Brazil's semi-arid region. I apply the bilateral migration framework proposed by Borusyak *et al.* (2022), which models migration as a function of both origin and destination conditions. Using recent census data, I show that estimates relying only on local shocks can be misleading, sometimes producing signs opposite to theoretical expectations. Once I adjust for destination-side

conditions using shocks weighted by past migration flows, the expected patterns emerge. Although local aridity shocks no longer significantly affect migration, likely due to improved climate resilience, relative local economic conditions still exert a strong effect on retaining population. I also find that structural labor market changes, such as income growth, are associated with significant migration responses.

Taken together, the chapters in this dissertation contribute to a broader understanding of how labor market institutions, historical legacies, and environmental and economic shocks shape labor and socioeconomic dynamics in developing countries. The results have implications for the design of labor regulation, the persistence of racial disparities, and the adaptive capacity of populations facing climate and economic transitions.

1
Labor Unions, Bargaining Power, and its Effects on Employment

Abstract. This paper studies how firms respond to an increase in labor union bargaining power. I begin with a simple dynamic model when firms face tenure-based adjustment costs and anticipate higher future liabilities. The model predicts that firms respond by adjusting the composition of their workforce. I test these predictions exploiting the 2012 introduction of mandatory ultractivity in Brazilian collective bargaining agreements, which extended the terms of expired contracts until a new one is signed. Using staggered treatment timing and a difference-in-differences design, I find that firms after exposure to an ultractivity CBA reduce hiring by 9%, with no change in overall separations. However, separations rise among high-tenure and production workers and fall among low-tenure employees. The findings support model's prediction and suggest that stronger union protections can lead to unintended firm behavior, with trade-offs between job security and employment opportunities.

Keywords: labor unions; collective bargaining agreements; employment; job turnover.

1.1 Introduction

How does an increase in labor union bargaining power affect firms' employment decisions? There is extensive literature examining the role of labor unions and collective bargaining in wage determination (Freeman & Kleiner, 1990; Farber *et al.*, 2021). However, while unions have been shown to increase wages and improve working conditions through enhanced amenities (Lagos, 2024), union actions also affect the expected labor costs for employers, potentially altering hiring and firing decisions and influencing worker turnover.

This paper addresses that question by studying a reform that strengthened labor unions in Brazil through the introduction of mandatory "ultractivity", a rule that extended the terms of expired collective bargaining agreements (CBAs) until a new one was signed. I estimate the impact of this institutional change on firms' hiring and separations behavior. Prior research has struggled to isolate these effects due to limitations in measuring union power. CBAs provide a clear and measurable channel through which to examine how enhanced bargaining power influences labor market outcomes.

To estimate the effects of increased union bargaining power, I exploit variation in the timing of existing CBAs, as in Biasi & Sarsons (2022). Specifically, I leverage differences in the timing of a new CBA is signed after the introduction of mandatory ultractivity. This approach allows me to isolate the effect of the consolidation of a stronger bargaining instrument on firm responses.

This study takes advantage of a setting of substantial presence of collective bargaining, Brazil. The Brazilian government systematically records all CBAs in the *Sistema Mediador*, with agreements negotiated at the national and regional levels, complemented by detailed microdata on the formal labor market. Within this setting, unions and employers negotiate various forms of compensation and workplace amenities, influencing turnover and expected labor costs.

To guide the empirical analysis, I develop a dynamic model in which firms face adjustment costs related to hiring and firing. These costs include tenure-dependent severance payments, which increase with job tenure due to stronger worker protections. Additionally, unions negotiate for higher non-wage benefits and impose greater penalties on dismissals, further raising the cost of terminating high-tenure employees. When labor unions gain greater bargaining power, firms anticipate these rising adjustment costs and potential litigation risks, as unions provide stronger legal support to workers in disputes, while also consider the degree of substitutability between high- and low-tenure workers.

As a result, firms can choose to dismiss more productive high-tenure employees before severance liabilities become too high, especially when these workers are easily replaced.

Consistent with these predictions, I find that firms exposed to ultractivity CBAs reduced net employment by decreasing hiring without a corresponding decrease in overall separations. Hiring fell by 8.9%, this reduction represents 9 fewer hires per year, or 9.5% of the pre-ultractivity baseline hiring average of 93.2 new hires. As the separations remained stable, the turnover rate increased by 1.8%. These results indicate that stronger union protections led firms to adjust labor costs primarily through hiring margins.

These aggregate findings on hiring and separations mask important heterogeneity across job types. While I find no substantial differences across firm-level characteristics, the composition of dismissals changes at the worker level: although there is no significant overall effect on separations, dismissals of high-tenure workers increase by 5.8%, whereas those of low-tenure workers decrease by 4.8%. I also find an increase of 2.1% and 4.4% on dismissals of clerical and production workers, respectively.

My findings are consistent with the model's predictions. The increase in dismissals of high-tenure workers aligns with the idea that firms anticipate future costs. The result on separations of clerical and production workers is also in line with the model. Using data on task-content of each occupation in Brazil (Gonzaga & Guanziroli, 2019), clerical and production roles are more concentrated in routine tasks, which require fewer specialized skills and are therefore easier to replace.

According to insider-outsider models, high-tenure workers (insiders) benefit from stronger job protections and bargaining power. These models assume that dismissal costs increase with job tenure and that unions prioritize the interests of incumbent workers, making it more costly for firms to dismiss them and increasing retention rates (Lindbeck & Snower, 2001). However, my findings show a different pattern in the Brazilian context. In this setting, labor laws link job tenure directly to higher severance liabilities, meaning that experienced workers can represent a significant financial burden for firms. To further explore this mechanism, I analyze changes in CBA clauses following the introduction of ultractivity.

The mechanism test reveals that after the introduction of ultractivity, CBAs included significantly more clauses related to non-wage compensation, such as allowances, and amenities that enhanced workplace conditions. Therefore, the increase in bargaining power of labor unions increased labor costs for all

employers. Given that entrants are less productive, these increases in labor costs lead to a decrease in hiring toward this group.

Related Literature. This paper contributes to the research on job protection and labor turnover. Existing literature shows ambiguous effects of employment protection legislation on job creation and destruction, depending on the balance between dismissal costs and incentives for worker retention (Blanchard & Landier, 2002; Cahuc & Postel-Vinay, 2002; Guell & Mora, 2010). However, this literature often overlooks how dismissal probabilities change with job tenure. This paper aligns with Cahuc *et al.* (2019) and Arnold & Bernstein (2021), who show that firms anticipate future firing costs and increase separations earlier as workers approach tenure thresholds where dismissal costs increase sharply. While Arnold & Bernstein (2021) focuses on the three-month probationary period in Brazil, my time frame is closer to Cahuc *et al.* (2019), analyzing institutional rules that become binding at around two years of tenure. In all three cases, the policy or institutional environment generates tenure-dependent job protection.

Moreover, both Cahuc *et al.* (2019) and Arnold & Bernstein (2021) document asymmetric effects across workers, suggesting that firms substitute between more and less productive or experienced employees in response to rising labor costs. Similarly, I examine substitution patterns between low- and high-tenure workers, focusing on how relative productivity affects firms' employment decisions under stronger union bargaining power.

This paper and Arnold & Bernstein (2021) share the Brazilian institutional context, contributing to the national literature on labor regulation and job turnover (Gonzaga, 2003; Carvalho *et al.*, 2018; Gerard & Gonzaga, 2021). While this literature focuses on regulatory changes, this paper explores the role of labor unions providing job protection.

Finally, this study contributes to another strand of literature by improving our understanding of union impacts in developing economies characterized by strong labor regulations and high unionization rates (Lagos, 2024). Research on bargaining, compensation, and employment stability (Biasi & Sarsons, 2022; Farber *et al.*, 2021; DiNardo & Lee, 2004; Samuel Dodini & Willén, 2023; Card & Cardoso, 2022) often focus on developed economies. This paper examines a setting with extensive formal labor regulations, and broad collective agreement coverage, as seen in countries like Brazil, Argentina, and Mexico.

The remainder of the paper is organized as follows. Section 1.2 discusses the institutional background, describing Brazil's labor structure and the implementation of mandatory ultractivity. The theoretical model with the conceptual

framework is presented in Section 1.3. Section 1.4 presents the data, sample construction, summary statistics, and the empirical strategy, followed by results and mechanisms in Section 1.5. Section 1.6 concludes. Additional materials are provided in the Appendix.

1.2 Institutional Background

1.2.1 Outlook

Labor Unions. Labor unions are organizations that represent workers in negotiations with employers. In Brazil, a labor union represents workers from a specific category, which can be defined by industry or occupation, within a particular geographic area. Unions typically operate within specific category-geographic units (hereafter referred to as "category") and follow a hierarchical structure. At the base of this hierarchy are labor unions, the most granular unit, directly representing workers within a specific category. A federation is a group of at least five labor unions within the same category. At a higher level, confederations comprise at least three federations and operate nationally, they are limited to a single category and may represent either workers or employers. Finally, *Central Sindical* is the highest level of union representation, providing general representation across multiple categories. (Oliveira & da Costa, 2023).

Negotiations typically occur between labor unions and employers or between employer and employee federations, while higher-level organizations provide guidelines that labor unions follow. For example, as shown in Sharma (2022), a directive from the *Central Sindical* CUT to increase female representation led to more female-friendly agreements negotiated by labor unions. This paper will focus on labor unions.

A key feature of Brazilian labor unions is *unicidade sindical* ("single-union representation rule")[1]. This rule grants a labor union the exclusive and perpetual right to represent workers within a specific category (Brazil, 1988, 1943). As I will detail in Section 1.4, my sample consists of firms that have engaged in negotiations with labor unions. This structure rules out the possibility of a

[1]This is somewhat similar to the "exclusive representation" principle in U.S. labor law. Under the National Labor Relations Act (NLRA); Section 9(a), if a union wins a majority vote in a workplace, it becomes the sole representative for all workers in the bargaining unit (Congress, 1935). However, unlike in Brazil, unions in the U.S. compete for representation, and workers can vote to replace their union.

firm avoiding negotiations after an increase in the union bargaining power or choosing to negotiate with a different union.

As of 2023, Brazil had 13,026 labor unions and 5,672 employer unions. Half of the labor unions operate at the municipal level, meaning they represent workers from a specific category within a single municipality (Oliveira & da Costa, 2023).

Collective Bargaining. Collective Bargaining Agreements (CBAs) are the primary instrument of negotiation between firms and labor unions. CBAs include various clauses that define rules, working conditions, amenities, and the rights and responsibilities of both firms and workers.

CBA coverage is universal, meaning that all worker within a specific category is represented by the labor unions, regardless of whether these workers are members or not [2]. That is why some researchers and labor leaders often say that every formal worker in Brazil is represented by a union.

There are two types of CBAs in Brazil. Firm-level agreements, known as *Acordo Coletivo de Trabalho*, are negotiated directly between a labor union and an individual firm. These are the most common form of CBA, accounting for over 76% of agreements signed between 2007 and 2022. In contrast, sector-level agreements, or *Convenção Coletiva de Trabalho*, are negotiated between a labor union and an employer association, and apply to multiple firms within a given sector. Although less frequent, sector-level agreements cover a substantially larger number of workers.

A typical CBA establishes key aspects of the employment relationship. It defines wages and compensation, including minimum wage floors, overtime pay, bonuses, and other forms of remuneration. It also regulates shift hours and work schedules, addressing working hours, flexible arrangements, and limits on overtime. Health and safety standards, specifying workplace conditions, the use of protective equipment, and occupational hazards prevention. CBAs also include provisions on job security and dismissal, such as severance pay and layoff procedures. Leave policies, covering vacation, maternity and paternity leave. In addition to these, CBAs outline non-wage benefits, such as meal vouchers, transportation allowances, and childcare support. Finally, they establish union rights and representation, including rules on dues, worker representation, and collective action. Figure 1.B.1 provides examples of CBAs signed in Brazil. CBAs cannot remain in force for more than two years.

[2] In Brazil, labor unions membership and contribution were mandatory until the 2017 Labor Reform.

Negotiation Process. Until 2017, before the Labor Reform, the negotiation process was always initiated by the labor union. Prior to a CBA's expiration, the labor union had the prerogative to lead negotiations [3].

The negotiation process typically begins with the *Assembleia Geral* (General Assembly), where union members discuss and approve their *pauta de reivindicações* (list of demands). This document outlines the workers' key demands, which almost always include expanding or securing new rights [4].

Due to single-union representation rule, labor unions do not compete to represent the same category of workers. As a result, firms usually negotiate with a small predefined set of labor unions [5]. Figure 1.1 illustrates the share of CBAs renewed each year. The majority of CBAs are renewed, and most are renegotiated within one month of the previous agreement's expiration.

Finally, CBAs hold legal force, meaning that once negotiated, their terms become binding for both employers and workers within the covered category.

1.2.2 Policy Change

Mandatory Ultractivity. Ultractivity refers to the principle that the provisions of a Collective Bargaining Agreement (CBA) remain in effect even after the agreement expires, until a new agreement is negotiated. This ensures that all provisions of an expired CBA would remain valid until renegotiated. Figure 1.2 illustrates how ultractivity works. For example, consider a CBA that includes a meal voucher benefit:

- Without ultractivity, the benefit expires along with the CBA, and the employer is not required to continue providing it unless it is explicitly renegotiated.
- With ultractivity, the meal voucher remains in effect even after the CBA expires, ensuring workers continue receiving the benefit until a new agreement is signed.

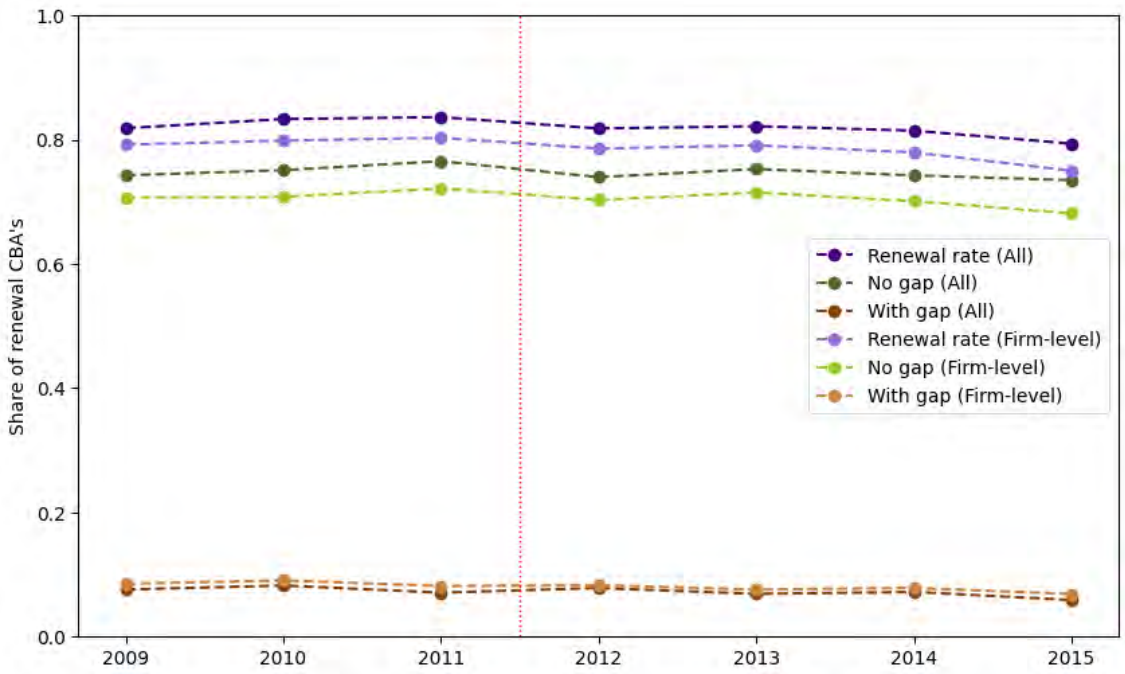
While some CBAs already included ultractivity as a negotiated feature, in September 2012, the *Tribunal Superior do Trabalho* (TST), Brazil's highest labor

[3] A federation could only negotiate in the absence of a labor union for that category within the territorial jurisdiction.

[4] After the 2017 Labor Reform, employers also acquired the right to introduce demands, as the reform prioritized negotiated agreements over statutory law.

[5] A firm may have: (i) one labor union if the union represents an industry-wide category; (ii) multiple labor unions if representation is based on specific occupations within the firm.

Figure 1.1: Renegotiation Share



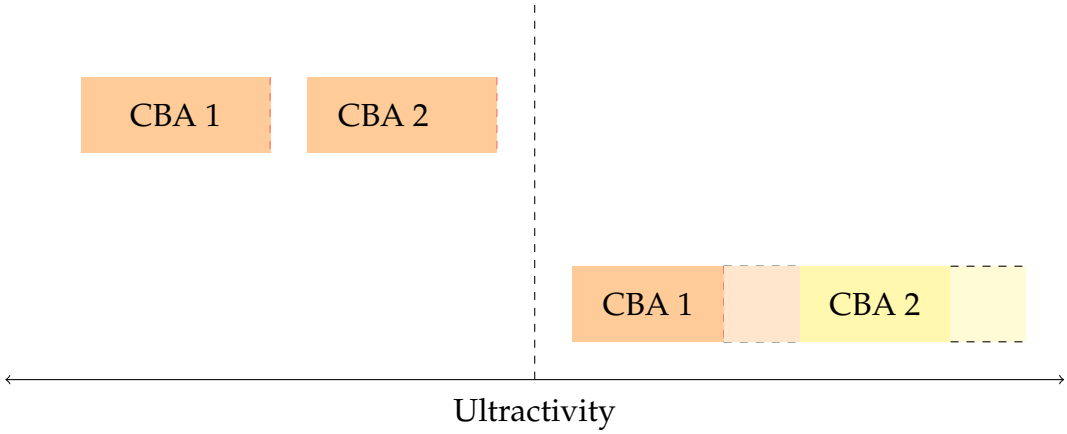
Note: This figure shows the proportion of collective bargaining agreements (CBAs) renewed within two years, distinguishing between all negotiations (*All*) and those conducted at the firm level (*Firm-level*). Solid lines represent the overall renewal rates, while lighter lines indicate firm-level rates. The vertical red line marks the introduction of mandatory ultractivity. The categories analyzed include: *Renewal rate* (CBAs renewed with the same union within two years), *No gap* (agreements signed without a break longer than one month), and *With gap* (agreements signed after a gap exceeding one month).

court, changed its interpretation of CBA expiration rules, imposing mandatory ultractivity on all CBAs (BRASIL. Tribunal Superior do Trabalho (TST), 2012). This change was implemented through a revision of *Súmula 277*, in which the TST interpretate worker benefits secured through CBAs as an acquired right. Figure 1.B.2 shows the original and revised versions of *Súmula 277*.

This decision strengthened unions' bargaining power, as it prevented employers from rolling back benefits after CBAs expire. Anecdotal evidence suggests that ultractivity benefited labor unions. Labor unions typically initiated demands during the negotiation process, while firms already had little leverage to reduce benefits even before mandatory ultractivity (Zylberstajn, 2021). With the new rule, the outside option for unions improved as they no longer risked losing previous agreements while pushing for additional benefits.

Additionally, employer associations strongly opposed ultractivity (see Figure 1.3), indicating that they perceived it as a significant shift in bargaining power toward unions. As I show in section 1.4.2, empirical evidence corroborate with

Figure 1.2: Ultractivity scheme



Note: This figure illustrates the concept of ultractivity in collective bargaining agreements (CBAs). The horizontal axis represents time, with the "Ultractivity" mark indicating the policy's imposition. To the right of this mark, ultractivity is in effect, ensuring that expired agreements remain valid until renegotiated. To the left, CBAs expire without automatic extension. The orange and yellow-shaded areas represent active CBAs, while the dashed red lines indicate their expiration dates. The light orange and light yellow regions denote ultractivity periods, during which the terms of an expired CBA continue to apply until a new agreement is reached.

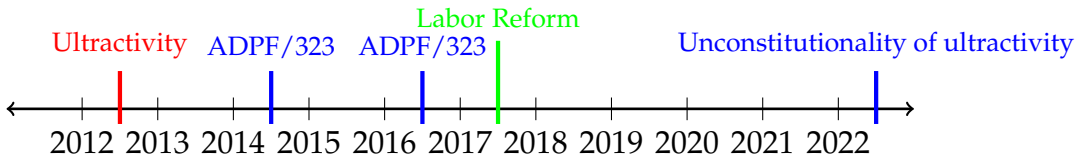
this shift in bargaining power, showing that number of clauses in CBAs increased after the introduction of ultractivity.

This institutional change provides a quasi-natural experiment to estimate the effects of increasing union bargaining power on firms. However, before conducting this analysis, it is essential to identify how firms were affected by this change.

Juridical Discussion. The amended of *Súmula 277* did not explicitly define which firms the mandatory ultractivity rule was applied to (see Figure 1.B.2). This ambiguity primarily affected the CBAs signed near the time of the legal transition, as it was unclear whether the rule applied retroactively or only to new agreements. In judicial decisions, multiple legal principles guide the interpretation and application of new rules (Delgado, 2020). In this case, two key principles are particularly relevant. The *Princípio da Norma Mais Favorável* (Rule of Lenity) states that in cases of ambiguity, courts should adopt the interpretation most favorable to workers, ensuring that employee rights are preserved. The *Princípio da Segurança Jurídica* (Rule of Law) requires courts to ensure stability and predictability in legal decisions, avoiding abrupt changes that could create uncertainty for firms and employees.

Despite the TST establishing mandatory ultractivity, it did not made any binding precedent or general guidance on which principle should take place

Figure 1.3: Relevant events timeline



- 2012: Amendment of *Súmula* 277 - mandatory **ultractivity** on Collective Bargaining Agreements (CBAs)
- 2014: ADPF 323/STF - Employer Association demanded unconstitutionality of ultractivity
- 2016: ADPF 323/STF - Brazil's Supreme Federal Court member suspended Súmula 277
- 2017: Labor Reform struck down ultractivity
- 2022: ADPF 323/STF: Supreme Court declared **ultractivity** unconstitutional

in applying the rule. As a result, labor courts have handled cases individually, leading to more than 7,000 appellate decisions on this issue, many of which are still under adjudication. Figure 1.B.3 shows examples of decisions' court.

Why does this matter? Understanding how courts interpreted and applied ultractivity is important because it directly influences the approach to analyzing its effects. If the predominant interpretation followed the Rule of Lenity, then mandatory ultractivity would have been applied universally to all CBAs, including both agreements that had not yet expired and subsequent agreements. Under this scenario, firms that did not anticipate the extension of their CBAs would form a natural treatment group, as shown in Figure 1.C.1a, where the extension of CBAs under ultractivity is represented by lighter shades.

On the other hand, if the Rule of Law prevailed, then previously negotiated agreements remained valid until their expiration under the legal framework in place at the time they were signed. Legal certainty ensures that only newly negotiated CBAs, those signed after the implementation of mandatory ultractivity, were subject to the new rule. This distinction implies that the timing of treatment varied across firms, as each company's first exposure to ultractivity depended on the expiration and renegotiation timeline of its existing agreement. This created heterogeneous treatment timing, which the empirical analysis must take into account. Figure 1.C.1b illustrates this setting, where subscripts g denote different groups exposed to treatment at different times.

To assess how courts actually applied the new rule, I analyzed TST rulings

between September 2012 and 2015 [6] using web scraping techniques on the court's official website. Specifically, I examined which of these two legal principles judges referenced in their decisions. The analysis revealed that most rulings favored the Principle of Rule of Law (four for each one whose refer to Rule of Lenity), ensuring that previously negotiated agreements remained in effect rather than retroactively applying ultractivity to all firms. This legal interpretation was formally reinforced in 2015, when the TST ruled to modulate the effects of *Súmula 277* (Carneiro, 2018), clarifying that the rule would not apply retroactively. However, even before this formal clarification, the majority of court decisions had already followed this reasoning.

Given this juridical context, our empirical approach will exploit variation in the timing of the first CBA signed after the policy change. This allows us to identify how firms were affected based on when they first encountered mandatory ultractivity. The details of this identification strategy are discussed in Section 1.4.3.

1.3 Conceptual Framework

In this section, I outline a conceptual framework to understand the effects of an increase of bargaining power of labor unions on firm's employment decision. We outline a simple model that frames the empirical results of this paper by formalizing the interaction between firms and labor unions in determining labor costs and employment decisions. In the spirit of Lockwood & Manning (1989) and Lindbeck & Snower (1987), we incorporate *adjustment costs* and dynamics on union decisions to reflect hiring and firing expenses.

We assume that firms optimally choose stocks of high-tenure workers (L_H), low-tenure workers (L_L), and new hires (L_E) in each period t, considering adjustment costs, including benefits negotiated with labor unions. In a Nash Bargaining framework, where union bargaining power (γ) influences outcomes, firms and unions jointly determine non-wage benefits $x(\gamma)$ and dismissal penalties $\phi(\gamma)$. These choices directly influences firms' labor decisions with $\frac{\partial x}{\partial \gamma} > 0, \quad \frac{\partial \phi}{\partial \gamma} > 0$.

[6] Period immediately followed the introduction of ultractivity and preceded the TST's decision to modulate the effects of *Súmula 277*.

1.3.1 Setup

This section presents the Nash Bargaining framework, which endogenizes how unions bargaining power shapes key contractual parameters (non-wage benefits and dismissal penalties) and the firm's intertemporal optimization problem.

1.3.1.1 Nash Bargaining Problem.

The labor union and the firm negotiate the trajectories of non-wage benefits x^t and dismissal penalties ϕ^t over time. By the Indifference Principle (Cahuc *et al.*, 2014), firm and labor unions negotiate over non-wage benefits and dismissal penalties[7]. The union's intertemporal utility function is given by:

$$V_S = \sum_{t=0}^{\infty} \delta^t \left[\gamma_H \left(v(w_H^t) - v(\overline{w}) \right) L_H^t + \gamma_L \left(v(w_L^t) - v(\overline{w}) \right) L_L^t + \theta x^t + \lambda_H \phi^t L_H^t + \lambda_L \phi^t L_L^t \right], \tag{1.1}$$

where $\delta \in (0,1)$ is the union's discount factor, capturing its patience in negotiations, $v(w)$ is a concave and crescent function representing the workers' valuation of wages. The parameters γ_H and γ_L reflect internal bargaining power, where high-tenure workers exert more influence than low-tenure workers. Additionally, $\lambda_H > \lambda_L$ indicates that high-tenure workers place greater value on dismissal protection ϕ^t, while θ represents the importance of non-wage benefits x^t to the union.

Bargaining Problem. The negotiation process determines the optimal paths $\{x^t, \phi^t\}_{t=0}^{\infty}$ by solving:

$$\max_{\{x^t, \phi^t\}} \Omega = \left(\sum_{t=0}^{\infty} \beta^t \pi^t \right)^{1-\gamma} \times \left(\sum_{t=0}^{\infty} \delta^t v_S^t \right)^{\gamma}, \tag{1.2}$$

where γ represents the union's bargaining power, π the firm's profit function and $\beta \in (0,1)$ the firm's discount factor.

First-Order Conditions (FOCs). For each period t, the first-order conditions are:

[7] Firms do not negotiate over wage because in the optimal contract $w = \bar{w} + x$ where $\bar{w}$ is the competitive wage.

$$(1-\gamma)\frac{\partial \pi^t/\partial x^t}{\sum \beta^t \pi^t} + \gamma \frac{\delta^t \left[\gamma_H v'(w_H^t) L_H^t + \gamma_L v'(w_L^t) L_L^t + \theta\right]}{\sum \delta^t v_S^t} = 0. \tag{1.3}$$

$$(1-\gamma)\frac{\partial \pi^t/\partial \phi^t}{\sum \beta^t \pi^t} + \gamma \frac{\delta^t (\lambda_H L_H^t + \lambda_L L_L^t)}{\sum \delta^t v_S^t} = 0. \tag{1.4}$$

Interpretation. Why do x and ϕ increase with γ? An increase in γ raises the weight of the union's utility v_S in bargaining, strengthening its influence over negotiations. As a result, the union prioritizes two key objectives. First, it pushes for higher non-wage benefits ($x^t \uparrow$), aiming for an immediate improvement in working conditions. Second, it seeks stronger dismissal protection ($\phi^t \uparrow$), reducing future dismissal risks, particularly for high-tenure workers, as their job security concerns dominate ($\lambda_H L_H^t$). A simplified closed-form solution is soluted in Appendix 1.A.

1.3.1.2 Firm Problem

The firm selects L_H, L_L, and L_E to maximize the present value of discounted profits:

$$\max_{L_H^t, L_L^t, L_E^t} \sum_{t=0}^{\infty} \beta^t \left[F(L_H^t, L_L^t, L_E^t) - C_H^t L_H^t - C_L^t L_L^t - C_E^t L_E^t - A(\Delta L_H^t, \Delta L_L^t, L_E^t, \phi^t(\gamma))\right] \tag{1.5}$$

where $\beta \in (0,1)$ is the firm's discount factor, $F(L_H^t, L_L^t, L_E^t)$ represents the firm's production function, with $\frac{\partial F}{\partial L_H} > \frac{\partial F}{\partial L_L} > \frac{\partial F}{\partial L_E}$, implying that high-tenure workers are the most productive. Labor costs are given by $C_H^t = w_H^t + x^t(\gamma)$, $C_L^t = w_L^t + x^t(\gamma)$, and $C_E^t = w_E^t + x^t(\gamma)$, where w_H, w_L, and w_E represent wages for high-tenure, low-tenure, and entrant workers, respectively, with $w_H \geq w_L \geq w_E$. The term x represents non-wage benefits negotiated by the union, which are common to all workers. Finally, $A(\Delta L_H^t, \Delta L_L^t, L_E^t, \phi^t(\gamma))$ captures adjustment costs, which include both fixed costs (covering administrative, legislative, and transition costs of hiring and firing) and variable costs[8]. Define $\Delta L_j^t = L_j^t - L_j^{t-1} \quad j = H, L$. Variable costs account for severance liabilities and litigation risks, measured by ϕ, both of which increase with worker tenure and union bargaining power.

[8]To guarantee a unique solution, we assume that the production function $F(\cdot)$ is concave and the adjustment costs $A(\cdot)$ are convex in ΔL_h and ΔL_L. Also, to avoid separation equilibria where firms choose only one type of worker, we require a finite substitution elasticity between worker types. For example, a CES production function: $F(L_H, L_L, L_E) = \left(\alpha_H L_H^\rho + \alpha_L L_L^\rho + \alpha_E L_E^\rho\right)^{\frac{1}{\rho}}, \quad \rho < 1$ where ρ represents the substitution elasticity, and quadratic adjustment costs are sufficient to ensure unique equilibrium with firms demanding all worker's types.

First-Order Conditions: The firm chooses L_H^t, L_L^t, L_E^t to maximize profit. The first-order conditions (FOCs) are:

$$\frac{\partial F(\cdot)}{\partial L_j^t} = (w_j^t + x^t) + \frac{\partial A(L^t, \phi^t)}{\partial L_j^t} + \beta \frac{\partial A(L^{t+1}, \phi^{t+1})}{\partial L_j^t} \quad j = H, L \tag{1.6}$$

$$\frac{\partial F(\cdot)}{\partial L_E^t} = (w_E^t + x^t) + \frac{\partial A(L^t, \phi^t)}{\partial L_E^t} \tag{1.7}$$

From FOC (1.6), we obtain the firm's trade-off equation:

$$\underbrace{\frac{\partial F(\cdot)}{\partial L_j^t} - (w_j^t + x^t)}_{\text{Marginal benefit of retaining a } j\text{-tenure worker}} = \underbrace{\frac{\partial A(L^t, \phi^t)}{\partial L_j^t} + \beta \frac{\partial A(L^{t+1}, \phi^{t+1})}{\partial L_j^t}}_{\text{Marginal cost of retaining a } j\text{-tenure worker}} \quad j = H, L \tag{1.8}$$

Equation (1.8) shows that firms when deciding whether retain or not a high- or low-tenure workers it takes account for the future cost of dismiss them. Additionally, subtracting equation (1.6) for high-tenure from low-tenure show us that he marginal productivity gap between high- and low-tenure workers $\left(\frac{\partial F}{\partial L_H} - \frac{\partial F}{\partial L_L}\right)$ influences the firm's choice. If high-tenure workers contribute significantly more to output than their low-tenure counterparts, the firm may find it beneficial to retain them despite their higher costs.

1.3.2
Comparative Statistics

This section examines how optimal labor choices adjust in response to an increase in unions' bargaining power. To derive comparative statics and analyze how the optimal levels of L_H^*, L_L^*, and L_E^* respond to an increase in labor unions' bargaining power ($\uparrow \gamma$), I take the total derivative of the first-order conditions with respect to γ, yielding the following system of equations. For clarity, I omit the time index (t) and denote next-period values with a prime ($'$).

$$\frac{\partial^2 F}{\partial L_H^2}\frac{dL_H^*}{d\gamma} + \sum_{j \neq H} \frac{\partial^2 F}{\partial L_H \partial L_j}\frac{dL_j^*}{d\gamma} = \frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_H \partial \gamma} + \frac{\partial^2 A}{\partial L_H \partial \phi}\frac{d\phi}{d\gamma} + \beta\left(\frac{\partial^2 A'}{\partial L_H \partial \gamma} + \frac{\partial^2 A'}{\partial L_H \partial \phi'}\frac{d\phi'}{d\gamma}\right) \tag{1.9}$$

$$\frac{\partial^2 F}{\partial L_L^2}\frac{dL_L^*}{d\gamma} + \sum_{j \neq L} \frac{\partial^2 F}{\partial L_L \partial L_j}\frac{dL_j^*}{d\gamma} = \frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_L \partial \gamma} + \frac{\partial^2 A}{\partial L_L \partial \phi}\frac{d\phi}{d\gamma} + \beta\left(\frac{\partial^2 A'}{\partial L_L \partial \gamma} + \frac{\partial^2 A'}{\partial L_L \partial \phi'}\frac{d\phi'}{d\gamma}\right) \tag{1.10}$$

$$\frac{\partial^2 F}{\partial L_E^2}\frac{dL_E^*}{d\gamma} + \sum_{j\neq E}\frac{\partial^2 F}{\partial L_E \partial L_j}\frac{dL_j^*}{d\gamma} = \frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_E \partial \gamma} + \frac{\partial^2 A}{\partial L_E \partial \phi}\frac{d\phi}{d\gamma}. \tag{1.11}$$

Workers with tenure. First, let us analyze the right-hand side of Equations (1.9) and (1.10). Consider:

$$\eta_i = \frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_i \partial \gamma} + \frac{\partial^2 A}{\partial L_i \partial \phi}\frac{d\phi}{d\gamma} + \beta\left(\frac{\partial^2 A'}{\partial L_i \partial \gamma} + \frac{\partial^2 A'}{\partial L_i \partial \phi'}\frac{d\phi'}{d\gamma}\right) \quad i = H, L \tag{1.12}$$

We know by assumption that $\frac{dx}{d\gamma} > 0$ and $\frac{d\phi}{d\gamma} > 0$. The term $\frac{\partial^2 A}{\partial L_i \partial \gamma}$ captures the impact of changes in γ on marginal adjustment cost of L_i. While an increase in γ raises overall adjustment costs for L_i, we do not make any priori assumption about its affect on marginal adjustment costs. To proceed, let's assume that $\frac{\partial^2 A}{\partial L_i \partial \gamma} \geq 0$, i.e. an increase in γ does not reduce the marginal adjustment cost of L_i. Additionally, we assume that ϕ (which itself increases with γ) amplifies adjustment costs rather than reducing them, therefore $\frac{\partial^2 A}{\partial L_i \partial \phi} \geq 0$, ensuring that higher dismissal penalties further increase adjustment costs. Under these conditions $\eta_i \geq 0$. Therefore, analyzing the comparative statistics equation:

$$\frac{\partial^2 F}{\partial L_i^2}\frac{dL_i^*}{d\gamma} + \sum_{j\neq i}\frac{\partial^2 F}{\partial L_i \partial L_j}\frac{dL_j^*}{d\gamma} = \eta_i \geq 0 \quad i = H, L \tag{1.13}$$

Rearranging, the key equation governing the relationship between labor union bargaining power and the optimal labor decisions for tenured workers is:

$$\frac{dL_i^*}{d\gamma} = \frac{\eta_i - \sum_{j\neq i}\frac{\partial^2 F}{\partial L_i \partial L_j}\frac{dL_j^*}{d\gamma}}{\frac{\partial^2 F}{\partial L_i^2}} \quad i = H, L \tag{1.14}$$

To analyze the firm's dynamics between high- and low-tenure workers, consider that high-tenure (L_H) and low-tenure workers (L_L) are substitutes, implying $\frac{\partial^2 F}{\partial L_i \partial L_j} < 0$ para $i, j = H, L$. The production function is concave by assumption ($\frac{\partial^2 F}{\partial L_i^2} < 0$), and the term $\eta_i \geq 0$ captures the effect of adjustment costs and their sensitivity to union bargaining power. Therefore, the impact of γ on labor decisions depends on the difference between η_i and $\sum_{j\neq i}\frac{\partial^2 F}{\partial L_i \partial L_j}\frac{dL_j^*}{d\gamma}$, with the sign of $\frac{dL_i^*}{d\gamma}$ being the opposite of the numerator due to $\frac{\partial^2 F}{\partial L_i^2} < 0$. The analysis will focus on the effect of γ on L_H^* ($i = H$), with the effect on L_L^* following analogously.

$$\frac{dL_H^*}{d\gamma} = \frac{\eta_H - \sum_{j\neq H}\frac{\partial^2 F}{\partial L_H \partial L_j}\frac{dL_j^*}{d\gamma}}{\frac{\partial^2 F}{\partial L_H^2}} \tag{1.15}$$

- *High- and low-tenure workers are substitutes and L_L^* increases with γ:* in this case where $\frac{dL_L^*}{d\gamma} > 0$ and due to the substitution effect between high- and low-tenure workers, the term $\sum_{j \neq H} \frac{\partial^2 F}{\partial L_H \partial L_j} \frac{dL_j^*}{d\gamma}$ is negative. Since $\eta_H \geq 0$, the effect of adjustment costs will always dominate in this scenario. As a result, the numerator remains positive regardless of the magnitude of η_H. Consequently, $\frac{dL_H^*}{d\gamma} < 0$, implying that firms will reduce their demand for high-tenure workers.
- *High- and low-tenure workers are substitutes and L_L^* decreases with γ:* however, if $\frac{dL_L^*}{d\gamma} < 0$, the effect of increasing labor unions' bargaining power on L_H^* will depend on the magnitude of η_H:
  - *Large η_H:* with η_H sufficiently large, it dominates the numerator, making it positive, which implies that $\frac{dL_H^*}{d\gamma} < 0$. Consequently, an increase in union bargaining power reduces the employment of both high- and low- tenure workers.
  - *Small η_H:* when η_H is not sufficiently large and L_L^* decreases with γ, the response of L_H^* depends on the interaction with other labor inputs. If the substitution effect does not outweigh adjustment costs, the term $\sum_{j \neq H} \frac{\partial^2 F}{\partial L_H \partial L_j} \frac{dL_j^*}{d\gamma}$ remains small, ensuring that η_H dominates and $\frac{dL_H^*}{d\gamma}$ remains negative but with a smaller magnitude. On the other hand, if substitution effects between worker types are too strong and L_L^* decreases with γ, then the term $\sum_{j \neq H} \frac{\partial^2 F}{\partial L_H \partial L_j} \frac{dL_j^*}{d\gamma}$ becomes positive. If this term is larger than η_H, then $\frac{dL_H^*}{d\gamma} > 0$.

A large η_H is possible when adjustment costs increase substantially with γ, particularly if $\frac{\partial^2 A}{\partial L_H \partial \gamma}$ or $\frac{\partial^2 A}{\partial L_H \partial \phi}$ are large. When firms have a high discount factor β, the present value of future adjustment costs increases, intensifying the incentive to reduce L_H^*.

To summarize, we observe a dynamic effect where changes in L_H^* depend on L_L^* and vice versa. In all cases, an increase in union bargaining power leads firms to either reduce employment of both high- and low-tenure workers or substitute one group for the other. In the case of substitution, firms evaluate adjustment costs η_H and η_L. Under standard substitutability conditions between L_H and L_L, we typically have $\eta_H > \eta_L$ implying that $\frac{dL_H^*}{d\gamma} < \frac{dL_L^*}{d\gamma}$. However, if L_H and L_L are highly substitutable, this condition does not necessarily hold.

Entrants. Rearranging Equation (1.11) we have:

$$\frac{dL_E^*}{d\gamma} = \frac{\frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_E \partial \gamma} + \frac{\partial^2 A}{\partial L_E \partial \phi}\frac{d\phi}{d\gamma} - \sum_{j \neq E} \frac{\partial^2 F}{\partial L_E \partial L_j}\frac{dL_j^*}{d\gamma}}{\frac{\partial^2 F}{\partial L_E^2}} \tag{1.16}$$

Due to the concavity of $F(\cdot)$, the sign of $\frac{dL_E^*}{d\gamma}$ will be the opposite of the numerator. Therefore, if an increase in union bargaining power raises non-wage benefits or marginal adjustment costs, such as training or hiring costs, more than the interactive productivity between new entrants and incumbent workers, or if new entrants and incumbent workers are substitutes ($\sum_{j \neq E} \frac{\partial^2 F}{\partial L_E \partial L_j} < 0$), then $\frac{dL_E^*}{d\gamma} < 0$, leading firms to hire fewer workers. Conversely, if new entrants are highly complementary to tenured workers, then $\frac{dL_E^*}{d\gamma} > 0$, increasing new hiring.

To conclude this analysis, I made assumptions about other types of workers to understand how labor demand in one group changes when union bargaining power increases. However, as shown in Appendix 1.A, I can avoid those assumptions by solving a matrix system that isolates the derivative of labor demand with respect to γ. The next section presents the data and empirical strategy used to estimate the main results.

1.4 Data and Sample Construction

This study relies on two primary data sources: *Relação Annual de Informações Sociais* (RAIS) and *Sistema Mediador*. Below, I describe these datasets, the data construction process, and key descriptive statistics.

RAIS. A comprehensive administrative dataset containing matched employer-employee records. RAIS covers the universe of formal labor contracts in Brazil. Employers are required to submit annual information about all formal workers to the federal government. Firms are uniquely identified through their CNPJ (*Cadastro Nacional da Pessoa Jurídica*), enabling over-time tracking and match with other datasets.

The dataset includes key variables such as hiring and separation counts, wages, and establishment characteristics (e.g. municipality and industry). Using the worker-level data, I constructed firm-level variables, including workers characteristics (e.g., tenure, education level). The analysis focuses on data from 2009 to 2016, a period that captures the policy changes discussed in previous sections. Post-2016 data were excluded due to uncertainties regarding policy implementation and effectiveness.

Sistema Mediador. Dataset that contains all registered collective bargaining agreements (CBAs) negotiated between firms and labor unions in Brazil. These agreements include detailed information about negotiated clauses, such as wage floors, maternity leave, and work shifts. Each CBA identifies the negotiating counterparts through their unique CNPJ, enabling matching with RAIS.

The clauses in the CBAs were pre-classified into categories by Lagos (2024), who provided the data, allowing for detailed analysis of the contractual terms. Key variables include the start and expiration dates of agreements, geographic coverage, and classifications of negotiated clauses.

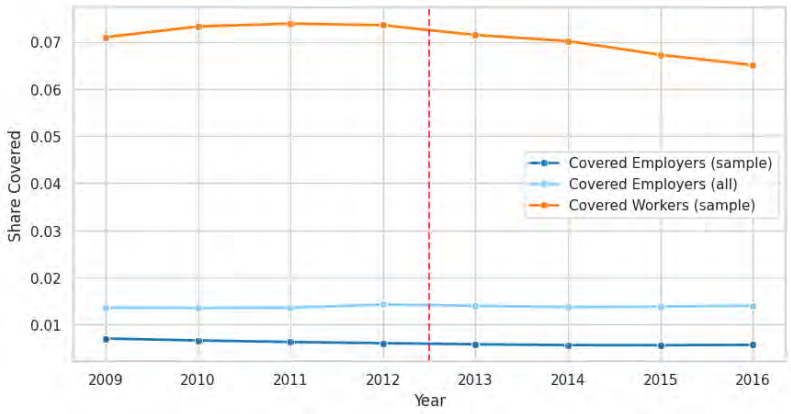
Other data sources. Information on judicial decisions comes from the TST jurisprudence database, which includes all rulings by Brazil's highest labor court. These rulings establish precedents that guide lower courts decisions. This information allows interpretation of the prevailing legal direction, whether Rule of Law or Rule of Lenity, on disputes regarding the validity of collective bargaining agreements (see 1.2.2). I also use a task-based classification proposed by Reijnders & de Vries (2017) mapped with the Brazilian occupational classification, along with data on the proportion of tasks performed in each occupation from Gonzaga & Guanziroli (2019).

1.4.1 Sample Construction

The main sample comprises approximately 20,423 establishments covering from 2009 to 2016. As shown in Figure 1.4, the final sample covers about 6% of workers and less than 1% of establishments. The sample was constructed to ensure that it includes establishments actively engaged in firm-level negotiations, whose bargaining behavior remained unchanged following the introduction of ultractivity. Additionally, I ensured that the analysis focuses on negotiations between establishments and labor unions, rather than higher-level agreements involving employer associations negotiating on behalf of multiple firms. As shown in Section 1.2.1, sector-level agreements cover the majority of workers. The sample construction process involved the following steps:

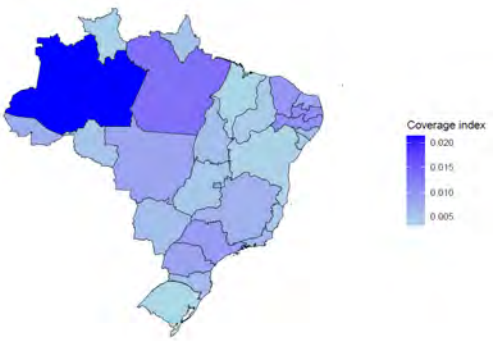
Figure 1.4: Final Sample Coverage

(a) Over time

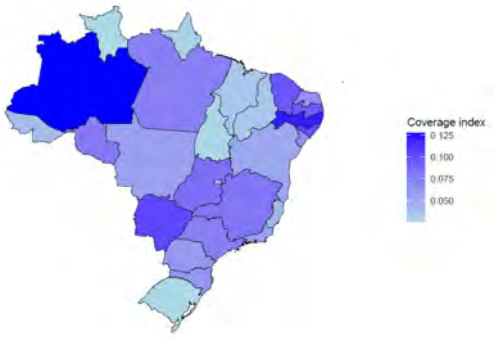


Note: This graph shows the percentage of the total number of firms and active workers in Brazil covered by the final sample of this paper over time. It was constructed by dividing the total number of employers and active workers in each year in the final sample by the total number of employers and active workers reported in RAIS.

(b) Regional distribution - Firms



(c) Regional Distribution - Workers



Note: The maps above show the regional distribution of how much the final sample represents the total number of firms and active workers in Brazil. They were constructed by dividing the average number of firms and workers in the final sample between 2009 and 2016 by the average total number of firms and workers in the country.

1. Selection of establishments: Using RAIS dataset, I selected establishments active from 2006 to 2016. These firms were then merged with CBA dataset using the unique identifier CNPJ.

2. Inclusion criteria: Only establishments with at least one CBA before and after imposition of ultractivity were included. I kept only establishment-level CBAs and dropped sector-level agreements.

3. Balanced Panel Construction: I included only establishments present in all years, resulting in a balanced panel of establishment-year observations for firms engaged in negotiations with labor unions.

To analyze worker heterogeneity, I aggregated vinculo-level data from RAIS to the establishment level. This process utilized detailed worker data on wages, hiring, and separations, segmented by education level, occupation, and tenure. This resulting in a dataset that includes a baseline panel of establishment-level information on wages, workforce flows, and amenity clauses.

1.4.2 Descriptive Statistics

In this section, I present general descriptive statistics on collective bargaining agreements for the universe of firm-level CBAs, along with firm characteristics and labor market outcomes for the final sample.

Table 1.1 summarizes key statistics of firm-level CBAs between 2009 and 2016, including the number of contracts, contract size, contract length, and other relevant aspects. The results indicate an increase in the average number of new CBAs per month and the number of clauses (contract size) by CBA after the introduction of ultractivity. This results suggest that agreements became more detailed or included additional provisions, aligning with the hypothesis that the introduction of ultractivity increased the bargaining power of labor unions. The number of firms negotiating a CBA also increased from 1.3 to 1.7 on average per month, indicating that labor unions became more active in securing firm-level CBAs after the policy change.

Interestingly, the data suggests that the policy did not affect the length of agreements, as there were no significant changes in negotiation time or contract duration. This suggests that while ultractivity influenced the volume and content of CBAs, it did not alter the overall bargaining process. These descriptive statistics provide initial evidence that the key features of CBAs expanded after the policy change, without modifying the fundamental structure of negotiations. As discussed in the previous section, this is relevant for sample selection, as I rely on firms engaged in firm-level agreements before and after ultractivity. This suggests that firms did not alter their behavior by avoiding or postponing negotiations in response to the policy change.

Table 1.1: Descriptive Statistics before and after ultractivity (September 2012) - CBAs

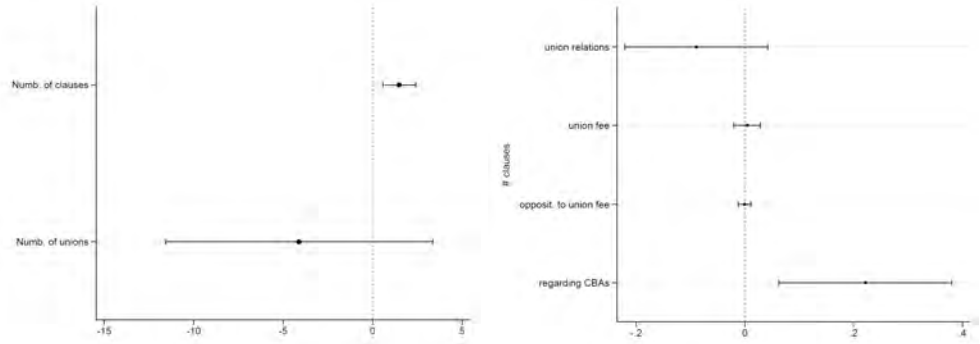
Variable	**Mean Before**	**Mean After**	**P-Value**
Average number of CBAs signed per month	4,559	6,583	—
Average number of clauses per CBA	19.91	20.52	0.0000
Average number of unique firms per month	1,299	1,695	—
Average contract duration (days)	397.59	397.61	0.9707

Note: This table compares variables before and after the policy change in September 2012, including a t-test to assess statistically significant differences. The p-value indicates whether the difference between periods is significant. The average number of clauses per CBA increased significantly ($p\text{-}value < 0.05$), while average contract duration remained virtually unchanged ($p\text{-}value = 0.97$). Statistics for negotiation time could not be calculated due to missing data.

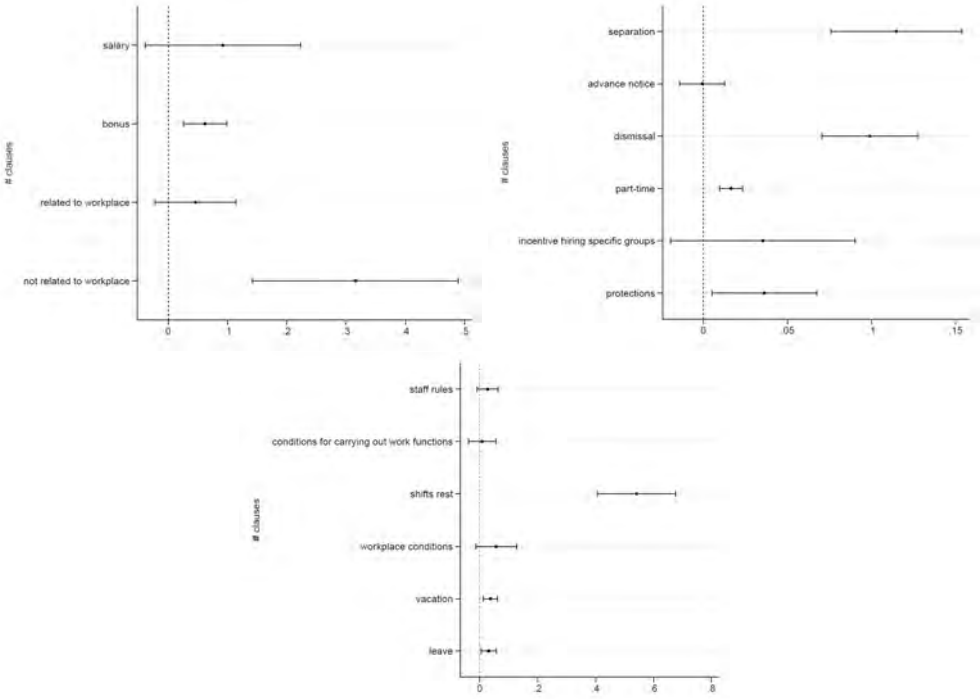
Figure 1.5 compares the behavior of several types of firm-level clauses before and after ultractivity using a simple model that includes employer-union pair fixed effects. Panel 1.5a shows that after ultractivity, the number of clauses increased without a corresponding increase in the number of labor unions. Panel 1.5b explores different types of CBAs, showing that the increase in clauses was primarily driven by those related to employer payments. As discussed in Section 1.3 and 1.5.3, this resulted in a higher expected cost per worker for employers and an increase in the perceived risk of liability processes from workers more protected by unions.

Figure 1.5: Effect on the number of clauses after ultractivity.

(a) Increase in number of clauses without altering CBA negotiation process



(b) Increase in clauses that raised expected worker costs for employers



Note: Model specification: $y_i = \alpha + \beta\,(AfterTreated)_i + \gamma_j + \varepsilon_i$, where y_i are the outcomes and $AfterTreated_i$ is a dummy that indicates periods after treatment time.

A potential concern is whether firms changed their negotiation behavior with labor unions following the imposition of ultractivity on CBAs. As shown in Figure 1.1, the pattern of CBA renewals did not change after the introduction of ultractivity. Since the sample includes only firms with at least one CBA before and one after the policy change, my sample restriction ensures that most firms are captured within the renewed agreements represented in this figure.

Finally, Table 1.2 presents summary statistics for the main sample constructed in Section 1.4.1. Since we do not have a natural control group, I report

the means of the variables during the baseline period, a period before treatment. In the next section, I outline the empirical strategy before presenting the results.

Table 1.2: Descriptive Statistics - Final Sample

Variable	**Mean**	**Std. Dev.**
Firm size (active contracts)	233.48	866.66
Hiring	93.21	399.38
Separations	88.02	376.61
Average wage	1,700.87	1,650.73
Share of male workers	0.63	0.29
Tenure (months)	44.65	34.50
Up to 24 years-old	0.19	0.16
25-35 years-old	0.39	0.17
36-50 years-old	0.30	0.16
50 years and older	0.12	0.14

Note: This table presents descriptive statistics on firm outcomes for the final sample. The mean and standard deviation are calculated for the baseline period, defined as one year before treatment.

1.4.3 Empirical Strategy

Starting from the premise that the policy change introducing mandatory ultractivity increased union bargaining power, I examine how firms responded to this shift. Even though I leverage the same exogenous variation as Lagos (2024), my approach differ in key aspects. Lagos analyzes how firms reacted to the increase in unions' bargaining power during the negotiation process, defining as treated firms those that had a CBA signed before September 2012 but expiring afterward. In contrast, my analysis focuses on the effect of ultractivity itself, rather than on the negotiation period, but on the direct impact of an active ultractivity CBA on firm outcomes.

As discussed in Section 1.2.2, most court decisions pointed to the Rule of Law principle. Therefore, my identification strategy relies on variation in the timing at which firms were definitively subject to an ultractivity CBA. This approach also rules out possible concerns about delays in judicial rulings, since court decisions can take a long time, and what matters is how firms adapted to the new rule in real time. By focusing on the moment when a firm faces an ultractivity CBA in effect, I ensure that the treatment definition captures the consolidation

shift in bargaining power, rather than a possible legal uncertainty.

Thus, I define the treatment event as the first CBA signed after the implementation of mandatory ultractivity in September 2012. I exploit variation in treatment timing, based on the premise that negotiations tend to occur continuously, always initiated by unions. Additionally, I assume that the difference between a firm's last CBA expiration date and September 2012 is exogenous, given that the policy change was abrupt and externally imposed, as showed by Lagos (2024).

1.4.3.1 Identification

To estimate the effect of mandatory ultractivity CBAs on firm outcomes, I adopt a difference-in-differences (DiD) estimator with staggered adoption, following the framework of Callaway & Sant'Anna (2021). A key challenge in this setting is the lack of a natural control group, as all firms eventually experience an ultractivity CBA at different points in time. To address this, I define firms that have not yet encountered an ultractivity CBA as the control group at each point in time.

This estimator accounts for treatment effect heterogeneity across firms, allowing for differences in when each firm first faces an active ultractivity CBA. Instead of assuming a homogeneous treatment effect, this approach compares firms treated at different times while leveraging variation in treatment timing to construct valid counterfactuals.

Following Sun & Abraham (2021) and Roth *et al.* (2022), I estimate group-time average treatment effects ($\text{ATT}_{g,t}$), where firms treated in a given period are compared to firms that have not yet been treated. The estimator follows the general structure:

$$ATT_{g,t} = E[Y_{g,t}(1) - Y_{g,t}(0) \mid G = g] \tag{1.17}$$

where $Y_{g,t}(1)$ represents the outcome for firms treated in period g at time t, and $Y_{g,t}(0)$ represents the counterfactual outcome if they had not yet been treated. Given that treatment is irreversible, once a firm signs an ultractivity CBA, it remains in the treated group.

I define the treatment variable as a discrete indicator that takes the value of one when a firm first encounters an active ultractivity CBA after their obligation The especification follows:

$$Y_{jt} = \sum_{\tau \neq -1} \beta_\tau \, Treat_j \cdot I(t - Treat = \tau) + \alpha X_{jt} + \theta_j + \theta_t + \epsilon_{jt} \tag{1.18}$$

where $Y_{j,t}$ denotes firm-level outcomes (e.g., hiring or separations), $Treat_j \cdot I(t - Treat = \tau)$ is an event-time indicator equal to one if firm j is τ periods away from experiencing its first CBA under ultractivity at time t, $X_{j,t}$ is a vector of time-varying firm-level controls, including firm size and fixed effects for the educational composition of the workforce. I include firm fixed effects θ_j and time fixed effects θ_t, to account for unobserved heterogeneity and time trends. $\epsilon_{j,t}$ is an idiosyncratic error term. Standard errors are clustered at the firm level.

Finally, I conduct robustness checks, including pre-trend tests and alternative specifications. The details of these tests are discussed in Appendix 1.D.

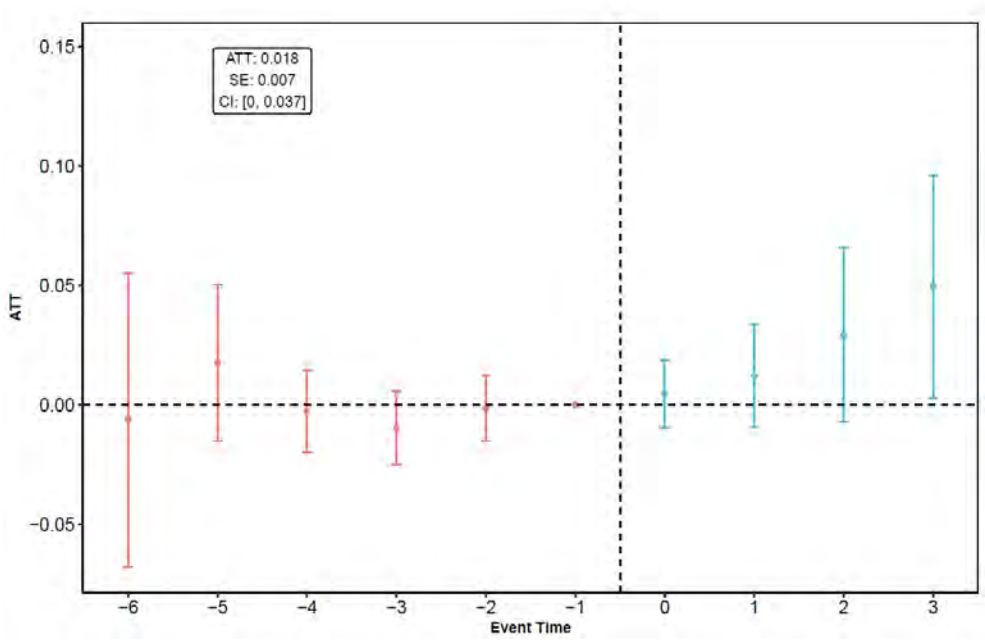
1.5 Results

In this section, I present the effects of the increase in the bargaining power of labor unions, consolidated by the imposition of ultractivity on CBAs, on the labor market outcomes. The sample is restricted to firms engaged in firm-level negotiations with unions. Therefore, these results reflect the impact on firms that were not represented by an employer association but instead negotiated directly with labor unions. All outcomes are measured on an annual basis.

1.5.1 General Results

Figure 1.6 presents the estimated dynamic effects of treatment on firm turnover. The aggregate effect, shown in the upper left box, shows a marginally significant increase in turnover. Specifically, firms subject to a new CBA under ultractivity experienced an average increase in turnover rate of approximately 0.018 log points (or 1.8%). Turnover rate is defined as the sum of hires and separations divided by the total number of active contracts at the firm-year level. In the following, I explore the components driving this increase.

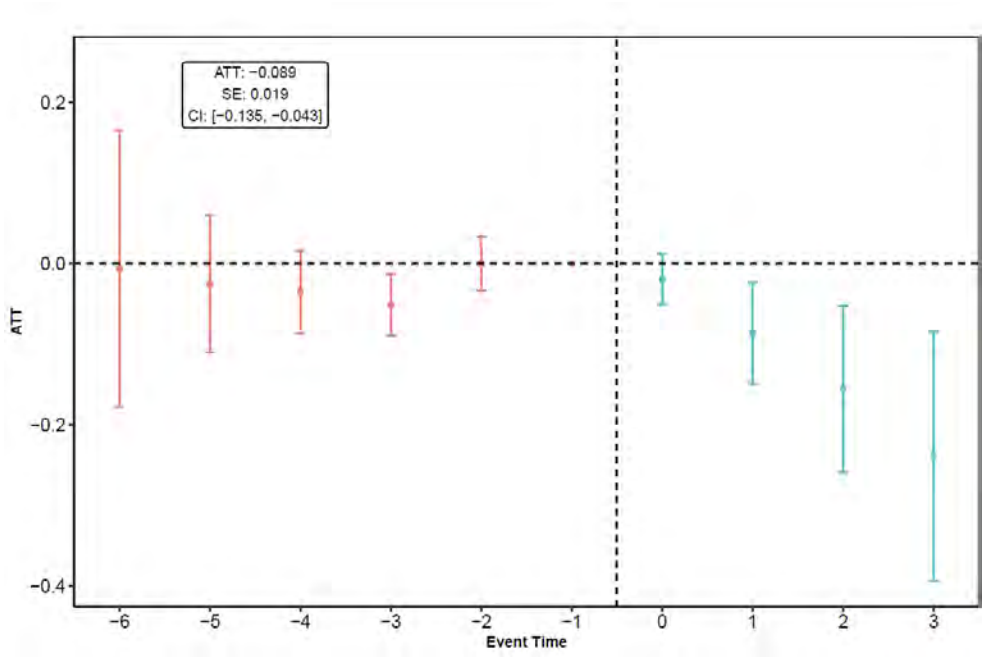
Figure 1.6: Effects on Turnover (ihs)



Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on Turnover, using the inverse hyperbolic sine (IHS) transformation. Each dot represents the estimated average treatment effect on the treated (ATT) for a given event time, with 95% confidence intervals shown. The shaded box in the upper left corner reports the average post-treatment ATT, its standard error (SE), and the corresponding confidence interval. Turnover was calculated by the sum of hiring and separations divided by the total of active contracts by year per firm.

Figure 1.7 displays the effect of ultractivity on hiring. Pre-treatment, the estimated coefficients are statistically equal to zero, supporting the assumption of parallel trends. Post-treatment, treated firms exhibit a significant decline in hiring. The estimated average treatment effect on the treated (ATT) is –0.089 log points, corresponding to an 8.9% reduction relative to the control group (firms not treated yet). Given a baseline mean of 93 new hires per year (Table 1.2), this result implies that, on average, treated firms hired approximately 8 to 9 fewer workers annually after facing its first ultractive CBA. This decline is consistent with the model's prediction: increased bargaining power raises adjustment costs, reducing hiring.

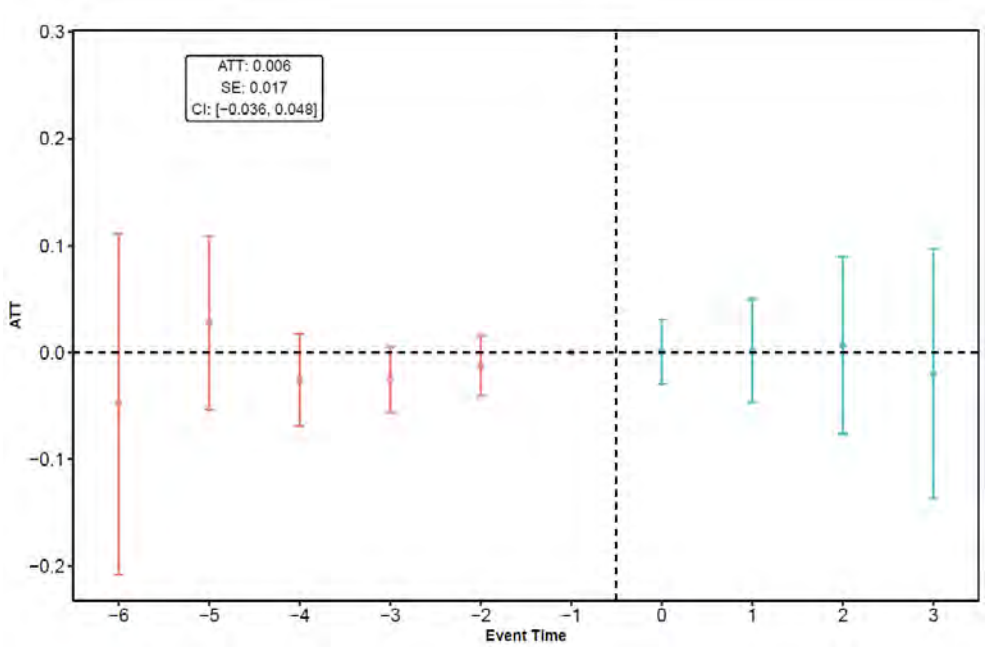
Figure 1.7: Effects on Hiring (ihs)



Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on Hiring, using the inverse hyperbolic sine (IHS) transformation. The vertical line at $t = 0$ marks the CBA renewal date. Each point reflects the estimated average treatment effect on the treated (ATT) at a given event time. Confidence intervals at the 95% level are shown.

In contrast, Figure 1.8 shows no statistically significant effect on separations. The point estimates remain close to zero throughout the post-treatment period, suggesting that firms did not respond to increased union bargaining power by increasing dismissals, on average, in the short run. Rather, the observed adjustment appears to operate primarily through reductions in hiring. However, in the next section we show that there are differences in dismissal paths by worker's job tenure.

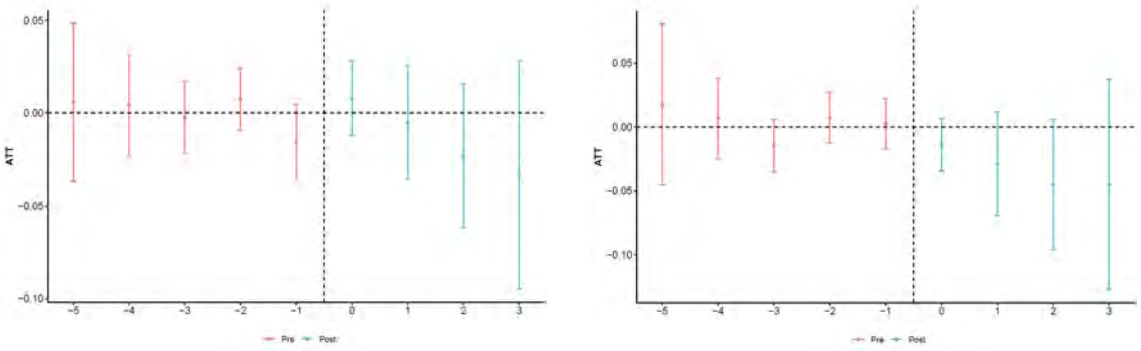
Figure 1.8: Effects on Layoffs (ihs)



Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on Separations, using the inverse hyperbolic sine (IHS) transformation. Each dot represents the estimated average treatment effect on the treated (ATT) for a given event time, with 95% confidence intervals shown. The shaded box in the upper left corner reports the average post-treatment ATT, its standard error (SE), and the corresponding confidence interval.

Figure 1.9 presents the effects on wages. I separate wages for new entrants and incumbents to examine whether the policy had any impact on either group. The estimates show no significant effects in either case. The next section explores heterogeneity in the main results.

Figure 1.9: Effects on Wages (log)



(a) New entrants (b) Incumbents

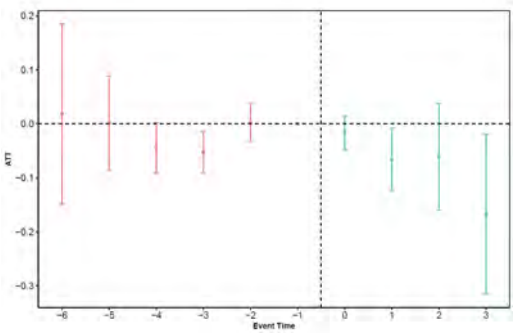
Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on log wages. Panel (a) shows effects for new entrants, and panel (b) for incumbent workers. Each point represents the estimated average treatment effect on the treated (ATT) at each event time, with 95% confidence intervals.

1.5.2 Heterogeneity

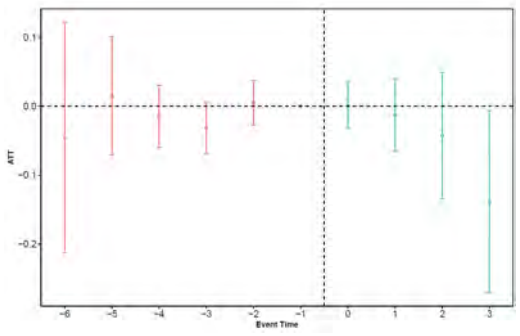
This section investigates heterogeneity in treatment effects across worker and firm types. As discussed in the conceptual framework (Section 1.3), changes in firm's composition are likely to vary by job tenure when union bargaining power increases non-wage benefits and adjustment costs. I begin by exploring heterogeneity across workers.

Worker-Level Heterogeneity. While the overall effect on separations is not statistically significant, Figure 1.10 shows heterogeneity across workers with different tenure levels. After the introduction of ultractivity, separations decreased among low-tenure workers but increased among high-tenure employees. Table 1.3 shows that both the magnitude and the statistical significance of the treatment effect increase with tenure.

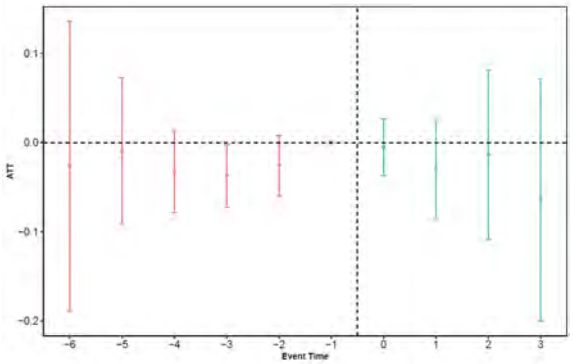
Figure 1.10: Effects on Separations by Tenure Group (ihs)



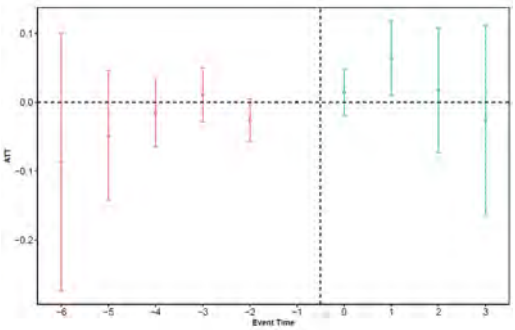
(a) Tenure up to 3 months



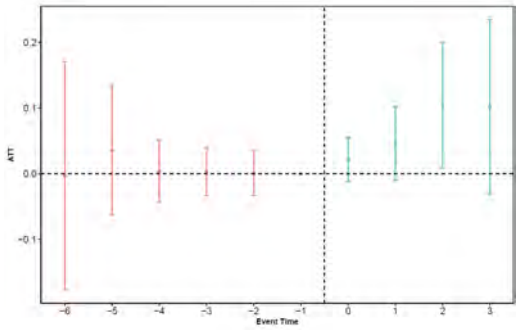
(b) Tenure 3–6 months



(c) Tenure 6–12 months



(d) Tenure 12–24 months



(e) Tenure 24 months or more

Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on Separations, using the inverse hyperbolic sine (IHS) transformation. Each panel reports results separately for different tenure groups, as indicated in the titles. Each dot represents the estimated average treatment effect on the treated (ATT) for a given event time, with 95% confidence intervals shown.

This result suggests that firms responded to increased union bargaining power by dismissing older, more protected employees, while retaining newer hires. This finding is in line with the model's predictions in Section 1.3 where high- and low-tenure workers are substitutes and dismissal costs increase with

tenure, especially under anticipatory behavior by firms in avoiding of future liabilities.

Table 1.3: Effect of Treatment on Separations by Tenure Group (IHS)

Tenure Group	**ATT**	**SE**
Up to 3 months	-0.0478***	(0.0187)
3 to 6 months	-0.0179	(0.0190)
6 to 12 months	-0.0116	(0.0194)
12 to 24 months	0.0308	(0.0191)
24 months or more	0.0592***	(0.0186)

Notes: This table reports the average treatment effect on separations (inverse hyperbolic sine transformation), by tenure group. Standard errors in parentheses. $^{*}p < 0.1$, $^{***}p < 0.01$.

To further examine this mechanism, I investigate whether separations vary by occupations that differ in substitutability. I adopt the occupational classification proposed by Reijnders & de Vries (2017) and used by Acemoglu & Autor (2011), which classifies occupations into three wage-based categories: (i) high-wage level: managerial and professional jobs; (ii) middle-wage level: clerical (supportive activities) and production (craft and machine operators); and (iii) low-wage level: sales and services.

Table 1.4 presents the estimated effects on hiring and separations by occupational group. As expected, I find no significant effects on separations for high-wage workers, who are more difficult to replace due to their specialized human capital. In contrast, separations increase significantly in clerical and production occupations. Hiring declines across most occupational categories. Appendix 1.D provides evidence supporting the parallel trends assumption for each occupation group included in the analysis.

To explore substitutability among workers, I use the task-content data constructed by Gonzaga & Guanziroli (2019), based on the classification of Spitz-Oener (2006). Table 1.5 reports the average proportion of tasks by occupation. Clerical and production occupations are involved with more routine tasks, which are less specialized and thus easier to substitute.

These findings are consistent with the model's predictions. I find that layoffs increased among workers in occupations characterized by lower specialization and higher substitutability: clerical and production jobs. These occupations fall within the middle-wage tier, meaning they are costly enough for firms to care about rising adjustment costs, while still replaceable enough for firms to dismiss them. Importantly, if substitutability alone were driving the results, we would

Table 1.4: Effect of Treatment on Hiring and Separations by Occupation (IHS)

Occupation	**Hiring**	**Separations**
Managerial	-0.001	0.001
	(0.001)	(0.001)
Professional	-0.038***	0.011
	(0.015)	(0.015)
Clerical	-0.047***	0.021***
	(0.016)	(0.015)
Production	-0.038***	0.044***
	(0.019)	(0.016)
Sale	-0.014***	-0.008
	(0.008)	(0.010)
Services	-0.020***	0.003
	(0.015)	(0.014)
Farming	-0.006	-0.005
	(0.008)	(0.007)

Notes: This table reports the average treatment effect on hiring and separations (IHS transformation) by occupation group. Standard errors are reported in parentheses below each coefficient. $^{*}p < 0.1$, $^{***}p < 0.01$.

Table 1.5: Task Composition by Occupational Group

	Tasks				
Occupational	**Non-Routine**		**Routine**		**Non-Routine**
Group	**Analytic**	**Interactive**	**Cognitive**	**Manual**	**Manual**
Managerial	0.365	0.561	0.074	0.000	0.000
Professional	0.336	0.312	0.291	0.057	0.004
Clerical	0.091	0.221	0.545	0.138	0.005
Production	0.083	0.051	0.306	0.521	0.039
Sale	0.055	0.354	0.437	0.142	0.013

Note: Each value represents the average share of a given task type across all CBO-4 occupations classified within each occupational group. Task proportions are based on a content analysis of CBO occupation descriptions, following the methodology of Gonzaga and Guanziroli (2019). The mapping between CBO-2002 and ISCO-88 groups is based on the classification provided by Reijnders and de Vries.

Table 1.6: Heterogeneous Effects by Firm Size (# Active Contracts)

	ATT	**SE**	**95% Conf. Interval**		Quantile
Panel A: Separations					
Below median	0.0197	0.0265	-0.0323	0.0717	42
Above median	0.0232	0.0252	-0.0262	0.0726	42
Above percentile 75	0.0210	0.0339	-0.0454	0.0874	143
Above percentile 90	-0.0564	0.0550	-0.1642	0.0515	452
Panel B: Hiring					
Below median	-0.0865***	0.0302	-0.1456	-0.0273	42
Above median	-0.0758***	0.0278	-0.1302	-0.0214	42
Above percentile 75	-0.0739*	0.0383	-0.1489	0.0011	143
Above percentile 90	-0.0994*	0.0527	-0.2028	0.0040	452

Note: This table reports heterogeneous treatment effects by firm size, measured by the number of active contracts. Quantiles are defined from the distribution of firm size in the baseline period. Results are shown for hiring and separations without due cause. Standard errors are clustered at the firm level. $^{*}p < 0.1$, $^{***}p < 0.01$.

expect similar effects for less-specialization workers in sales and services. The absence of significant effects in that group reinforces the role of adjustment costs, specifically, firms anticipate future dismissal-related liabilities. As predicted by the model, it is the interaction between substitution potential and adjustment costs that shapes firm responses.

These results contrast with the static insider–outsider framework of Lindbeck & Snower (1988), which assumes that firms differentiate between insiders (established employees with strong bargaining positions) and outsiders (new hires or temporary workers). This model predicts the insiders secure job protections through union power, making them less likely to be dismissed. While the insider–outsider theory predicts higher retention of tenured workers under stronger union regimes (Lindbeck & Snower, 2001), it does not account for forward-looking behavior by the firms. By adding anticipation into a dynamic framework, the model developed in Section 1.3 better captures firms' incentives to reduce exposure to future liabilities, offering a more complete explanation of the empirical patterns.

Firm-Level Heterogeneity. Table 1.6 shows that hiring decreases across all firm size groups, while separations remain statistically indistinguishable from zero. The magnitude of the effect on hiring is slightly larger among smaller firms, although statistically similar across the distribution. In contrast, separations do not display a clear pattern by size.

Table 1.7: Heterogeneous Effects by Time Since Last Negotiation

	ATT	**SE**	**95% Conf. Interval**	
Panel A: Separations (no due cause)				
1 year	-0.0310	0.0190	-0.0683	0.0063
2 years	-0.0200	0.0281	-0.0751	0.0351
3+ years	0.0521*	0.0289	-0.0006	0.1049
Panel B: Hiring				
1 year	-0.0454***	0.0183	-0.0812	-0.0095
2 years	0.0094	0.0270	-0.0435	0.0622
3+ years	-0.0488*	0.0286	-0.1048	0.0072

Note: This table reports heterogeneous effects by the time elapsed since the firm's last negotiation (start date of the last collective bargaining agreement). Categories are defined as the number of years since the previous agreement before treatment. Results are shown for hiring and separations without due cause. Standard errors are clustered at the firm level. $^{*}p < 0.1$, $^{***}p < 0.01$.

Table 1.7 explores heterogeneity by time since last negotiation (start date of the last CBA signed before treated). Firms that had negotiated one year prior show a drop in hiring and decline in separations. Those with more time since their last agreement show no significant effect in hiring but a moderate rise in separations. Overall, heterogeneity at the firm level appears limited, with most of the variation concentrated in worker characteristics, as explored in the previous subsection.

1.5.3 Mechanisms

Table 1.8 presents the estimated effect of treatment on the share of specific clause types in collective bargaining agreements (CBAs). The outcomes measure the proportion of clauses in each category relative to the total number of clauses. Because firms do not negotiate a new agreement every year, I impute zero for years without a new CBA and estimate the average treatment effect. The results show that following the first CBA under ultractivity, agreements become denser and more concentrated on provisions that raise labor costs. The largest effects are found in clauses related to salary (4.9 percentage points), allowances and bonuses (4.6 p.p.), and shift and rest rules (14 p.p.).

As shown in Sections 1.3, stronger union bargaining power raises expected labor and adjustment costs. The increase in separations among more experienced and production workers illustrates one of the underlying mechanisms: firms anticipate the cost of future dismissals. A second mechanism, more difficult

Table 1.8: Average Treatment Effect on the Share of Specific Contract Clauses

Clause Type	**ATT**	**SE**
Salary	0.049^{***}	(0.002)
Bonus	0.007^{***}	(0.000)
Shift Premium	0.016^{***}	(0.001)
Allowances	0.046^{***}	(0.002)
Separation Rules	0.010^{***}	(0.001)
Part-time Work Rules	0.001^{***}	(0.000)
Specific Groups Rules	0.009^{***}	(0.000)
Staff Rules	0.007^{***}	(0.001)
Task Assignments	0.007^{***}	(0.001)
Protections	0.008^{***}	(0.000)
Rest Between Shifts	0.140^{***}	(0.004)
Workplace Conditions	0.010^{***}	(0.001)
Vacations	0.004^{***}	(0.000)
Leave Rules	0.002^{***}	(0.000)

Notes: Outcomes represent the share of clauses of a given type over the total number of clauses in collective agreements. Years without observed agreements are coded as zero. Standard errors in parentheses. $^{*}p < 0.1$, $^{***}p < 0.01$.

to quantify, involves changes in the legal environment. As workers feel more protected by union legal support, the perceived risk of labor litigation increases. This legal risk amplifies the implicit cost of retention for firms. While it would be ideal to test whether labor lawsuits increased after ultractivity, such analysis is limited by the decentralized nature of Brazil's labor courts, where workers file cases locally and court data is not centrally consolidated.

1.5.4 Robustness checks

Finally, I conduct several robustness checks to validate the main results in this section.

Alternative outcome measure: Figure 1.D.1 replicates the main event study using the share of hires and separations over the total of active contracts, rather than the inverse hyperbolic sine (ihs) transformation. The results remain consistent with the baseline specification. In fact, we observe a positive overall effect on separations, reinforcing the the results presented at the worker-level heterogeneity.

Other estimators: To reinforce the main results obtained using the Callaway & Sant'Anna (2021) method, I estimate treatment effects with two alternative approaches. Figures 1.D.2 and 1.D.3 show the results. First, following Sun & Abraham (2021), I use the last treated group, which serves as the control group for all cohorts in the main specification, as the control group. Then, using the same sample, I estimate a canonical two-way fixed effects (TWFE) model. Both approaches yield results that are consistent with the main estimates.

1.6 Concluding Remarks

This paper investigates how an exogenous increase in union bargaining power, caused by the introduction of mandatory ultractivity in collective bargaining agreements, affects firms' employment decisions. Using variation in the timing of when firms first face an ultractivity CBA and applying a dynamic difference-in-differences framework, I find that treated firms reduce hiring significantly, by around 9%, while total separations remain unchanged on average. However, this average hides important differences across worker types: separations increase among high-tenure and production workers, and decrease among low-tenure workers.

These results are consistent with a mechanism where stronger union bargaining power increases expected labor costs through more generous non-wage benefits and higher anticipated severance liabilities. As these costs grow with tenure, firms respond by acting early, laying off workers who could become too expensive to dismiss later. This behavior is in line with the model developed in the paper, where adjustment costs and worker tenure jointly influence employment decisions. The model predicts that firms will anticipate rising dismissal costs and reduce their exposure by dismissing workers with higher expected liabilities, especially those in less specialized or more substitutable roles.

The analysis also faces important limitations. The collective bargaining agreement (CBA) database does not report the specific occupation or worker's profile covered by each agreement, limiting the ability to identify exactly which group of workers are most affected by negotiated clauses. Additionally, the decentralized nature of Brazil's labor courts makes it difficult to observe changes in the volume or nature of labor disputes ("*processos trabalhistas*") across treated firms.

The findings of the study have potential implications for labor policy in contexts with widespread collective bargaining. Although ultractivity can increase

worker protections and improve institutional stability in negotiations, it may also create unintended incentives for firms to avoid future liabilities by reducing hiring and substituting away from experienced workers. This trade-off are important to consider when designing labor institutions in environments where unions play a central role in wage and benefit setting.

Appendices

1.A
Conceptual Framework

1.A.1
A simplified closed-form solution for the Bargaining Problem Example

To derive a closed-form solution, we simplify the model by considering the bargaining problem in Equation (1.2) as static. Applying the logarithm and taking the first-order conditions, we obtain:

$$\frac{\partial \ln \Omega}{\partial x} = (1-\gamma)\frac{\partial \pi / \partial x}{\pi} + \gamma \frac{\partial v_S / \partial x}{v_S} = 0. \tag{.19}$$

Given the partial derivatives:

$$\frac{\partial v_S}{\partial x} = \left[\gamma_H v'(w_H) L_H + \gamma_L v'(w_L) L_L + \theta\right], \quad \frac{\partial \pi}{\partial x} = -(L_H + L_L + L_E). \tag{.20}$$

This results in:

$$\frac{\left[\gamma_H v'(w_H^t) L_H^t + \gamma_L v'(w_L^t) L_L^t + \theta\right]}{v_S} = \frac{(1-\gamma)}{\gamma} \frac{(L_H + L_L + L_E)}{\pi}. \tag{.21}$$

Similarly, for ϕ:

$$\frac{\partial \ln \Omega}{\partial \phi} = (1-\gamma)\frac{\partial \pi / \partial \phi}{\pi} + \gamma \frac{\partial v_S / \partial \phi}{v_S} = 0. \tag{.22}$$

With the derivatives:

$$\frac{\partial v_S}{\partial \phi} = \lambda_H L_H + \lambda_L L_L, \quad \frac{\partial \pi}{\partial \phi} = -(w_H |\Delta L_H| + w_L |\Delta L_L|). \tag{.23}$$

Thus, we obtain:

$$\frac{\lambda_H L_H + \lambda_L L_L}{v_S} = \frac{(1-\gamma)}{\gamma} \frac{(w_H |\Delta L_H| + w_L |\Delta L_L|)}{\pi}. \tag{.24}$$

As the union's bargaining power increases ($\gamma \to 1$), the term $\frac{(1-\gamma)}{\gamma} \to 0$. For the first-order conditions to hold ($\partial v_S / \partial \phi = \frac{\left[\gamma_H v'(w_H^t) L_H^t + \gamma_L v'(w_L^t) L_L^t + \theta\right]}{v_S} \to 0$ and

$\partial v_S/\partial x = \frac{\lambda_H L_H + \lambda_L L_L}{v_S} \to 0$), the denominators v_S must diverge to infinity.

However, since v_S is bounded by the concave function $v(\cdot)$ (diminishing marginal utility of wages and benefits), the only way to maximize v_S while satisfying the FOCs is to increase x and ϕ ($\partial v_S/\partial \phi \to 0$ and $\partial v_S/\partial x \to 0$ then ϕ and x are maximized).

1.A.2
Comparative Statistics in Matrix Form

From equation 1.16 define $\eta_E = \frac{dx}{d\gamma} + \frac{\partial^2 A}{\partial L_E \partial \gamma} + \frac{\partial^2 A}{\partial L_E \partial \phi}\frac{d\phi}{d\gamma}$. Using equations 1.14 and 1.16 we obtain the matrix form for the optimal labor demand as:

$$\begin{bmatrix} \frac{dL_H^*}{d\gamma} \\ \frac{dL_L^*}{d\gamma} \\ \frac{dL_E^*}{d\gamma} \end{bmatrix} = \begin{bmatrix} 0 & -\frac{\frac{\partial^2 F}{\partial L_H \partial L_L}}{\frac{\partial^2 F}{\partial L_H^2}} & -\frac{\frac{\partial^2 F}{\partial L_H \partial L_E}}{\frac{\partial^2 F}{\partial L_H^2}} \\ -\frac{\frac{\partial^2 F}{\partial L_L \partial L_H}}{\frac{\partial^2 F}{\partial L_L^2}} & 0 & -\frac{\frac{\partial^2 F}{\partial L_L \partial L_E}}{\frac{\partial^2 F}{\partial L_L^2}} \\ -\frac{\frac{\partial^2 F}{\partial L_E \partial L_H}}{\frac{\partial^2 F}{\partial L_E^2}} & -\frac{\frac{\partial^2 F}{\partial L_E \partial L_L}}{\frac{\partial^2 F}{\partial L_E^2}} & 0 \end{bmatrix} \cdot \begin{bmatrix} \frac{dL_H^*}{d\gamma} \\ \frac{dL_L^*}{d\gamma} \\ \frac{dL_E}{d\gamma} \end{bmatrix} + \begin{bmatrix} \frac{\eta_H}{\frac{\partial^2 F}{\partial L_H^2}} \\ \frac{\eta_L}{\frac{\partial^2 F}{\partial L_L^2}} \\ \frac{\eta_E}{\frac{\partial^2 F}{\partial L_E^2}} \end{bmatrix} \tag{.25}$$

Define:

$$\mathbf{q} = \begin{bmatrix} \frac{dL_H^*}{d\gamma} \\ \frac{dL_L^*}{d\gamma} \\ \frac{dL_E^*}{d\gamma} \end{bmatrix}, \quad \boldsymbol{\eta} = \begin{bmatrix} \frac{\eta_H}{\frac{\partial^2 F}{\partial L_H^2}} \\ \frac{\eta_L}{\frac{\partial^2 F}{\partial L_L^2}} \\ \frac{\eta_E}{\frac{\partial^2 F}{\partial L_E^2}} \end{bmatrix}$$

$$\mathbf{A} = \begin{bmatrix} 0 & -\frac{\frac{\partial^2 F}{\partial L_H \partial L_L}}{\frac{\partial^2 F}{\partial L_H^2}} & -\frac{\frac{\partial^2 F}{\partial L_H \partial L_E}}{\frac{\partial^2 F}{\partial L_H^2}} \\ -\frac{\frac{\partial^2 F}{\partial L_L \partial L_H}}{\frac{\partial^2 F}{\partial L_L^2}} & 0 & -\frac{\frac{\partial^2 F}{\partial L_L \partial L_E}}{\frac{\partial^2 F}{\partial L_L^2}} \\ -\frac{\frac{\partial^2 F}{\partial L_E \partial L_H}}{\frac{\partial^2 F}{\partial L_E^2}} & -\frac{\frac{\partial^2 F}{\partial L_E \partial L_L}}{\frac{\partial^2 F}{\partial L_E^2}} & 0 \end{bmatrix}$$

The system can be written as:

$$\mathbf{q} = \mathbf{A} \cdot \mathbf{q} + \boldsymbol{\eta}$$

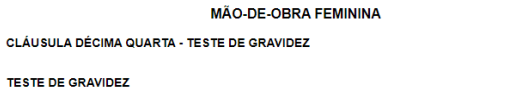
Therefore, we can isolate $\mathbf{q}'$ and obtain:

$$\mathbf{q} - \mathbf{A} \cdot \mathbf{q} = \eta \quad \Rightarrow \quad (\mathbf{I} - \mathbf{A}) \cdot \mathbf{q} = \eta \quad \Rightarrow \quad \mathbf{q} = (\mathbf{I} - \mathbf{A})^{-1}\eta$$

a closed-form solution for the variation in labor demand resulting from an increase in bargaining power without requiring any other assumptions about the behavior of other types of labor demand.

1.B
Documents

Figure 1.B.1: Collective Bargaining Agreement (CBA) - examples



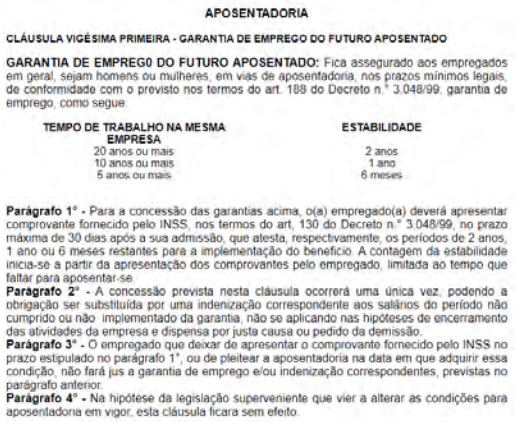
MÃO-DE-OBRA FEMININA

CLÁUSULA DÉCIMA QUARTA - TESTE DE GRAVIDEZ

TESTE DE GRAVIDEZ

A empresa não exige teste de gravidez às mulheres trabalhadoras por ocasião da admissão.

Pregnancy Test Clause: Companies cannot require pregnancy tests during hiring process.



APOSENTADORIA

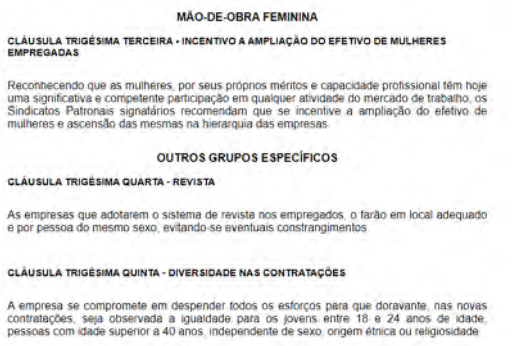
CLÁUSULA VIGÉSIMA PRIMEIRA - GARANTIA DE EMPREGO DO FUTURO APOSENTADO

GARANTIA DE EMPREGO DO FUTURO APOSENTADO: Fica assegurado aos empregados em geral, sejam homens ou mulheres, em vias de aposentadoria, nos prazos mínimos legais, de conformidade com o previsto nos termos do art. 188 do Decreto n.º 3.048/99, garantia de emprego, como segue:

TEMPO DE TRABALHO NA MESMA EMPRESA	ESTABILIDADE
20 anos ou mais	2 anos
10 anos ou mais	1 ano
5 anos ou mais	6 meses

Parágrafo 1º - Para a concessão das garantias acima, o(a) empregado(a) deverá apresentar comprovante fornecido pelo INSS, nos termos do art. 130 do Decreto n.º 3.048/99, no prazo máximo de 30 dias após a sua admissão, que atesta, respectivamente, os períodos de 2 anos, 1 ano ou 6 meses restantes para a implementação do benefício. A contagem da estabilidade inicia-se a partir da apresentação dos comprovantes pelo empregado, limitada ao tempo que faltar para aposentar-se.
Parágrafo 2º - A concessão prevista nesta cláusula ocorrerá uma única vez, podendo a obrigação ser substituída por uma indenização correspondente aos salários do período não cumprido ou não implementado da garantia, não se aplicando nas hipóteses de encerramento das atividades da empresa e dispensa por justa causa ou pedido da demissão.
Parágrafo 3º - O empregado que deixar de apresentar o comprovante fornecido pelo INSS no prazo estipulado no parágrafo 1º, ou de pleitear a aposentadoria na data em que adquirir essa condição, não fará jus a garantia de emprego e/ou indenização correspondentes, previstas no parágrafo anterior.
Parágrafo 4º - Na hipótese da legislação superveniente que vier a alterar as condições para aposentadoria em vigor, esta cláusula ficara sem efeito.

Retirement Job Security: Employees close to retirement receive employment protection.



MÃO-DE-OBRA FEMININA

CLÁUSULA TRIGÉSIMA TERCEIRA - INCENTIVO A AMPLIAÇÃO DO EFETIVO DE MULHERES EMPREGADAS

Reconhecendo que as mulheres, por seus próprios méritos e capacidade profissional têm hoje uma significativa e competente participação em qualquer atividade do mercado de trabalho, os Sindicatos Patronais signatários recomendam que se incentive a ampliação do efetivo de mulheres e ascensão das mesmas na hierarquia das empresas.

OUTROS GRUPOS ESPECÍFICOS

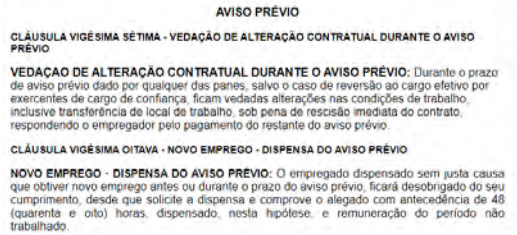
CLÁUSULA TRIGÉSIMA QUARTA - REVISTA

As empresas que adotarem o sistema de revista nos empregados, o farão em local adequado e por pessoa do mesmo sexo, evitando-se eventuais constrangimentos.

CLÁUSULA TRIGÉSIMA QUINTA - DIVERSIDADE NAS CONTRATAÇÕES

A empresa se compromete em despender todos os esforços para que doravante, nas novas contratações, seja observada a igualdade para os jovens, entre 18 e 24 anos de idade, pessoas com idade superior a 40 anos, independente de sexo, origem étnica ou religiosidade.

Female Workforce Incentive: Employers should promote gender diversity and female career growth.



AVISO PRÉVIO

CLÁUSULA VIGÉSIMA SÉTIMA - VEDAÇÃO DE ALTERAÇÃO CONTRATUAL DURANTE O AVISO PRÉVIO

VEDAÇAO DE ALTERAÇÃO CONTRATUAL DURANTE O AVISO PRÉVIO: Durante o prazo de aviso prévio dado por qualquer das panes, salvo o caso de reversão ao cargo efetivo por exercentes de cargo de confiança, ficam vedadas alterações nas condições de trabalho, inclusive transferência de local de trabalho, sob pena de rescisão imediata do contrato, respondendo o empregador pelo pagamento do restante do aviso prévio.

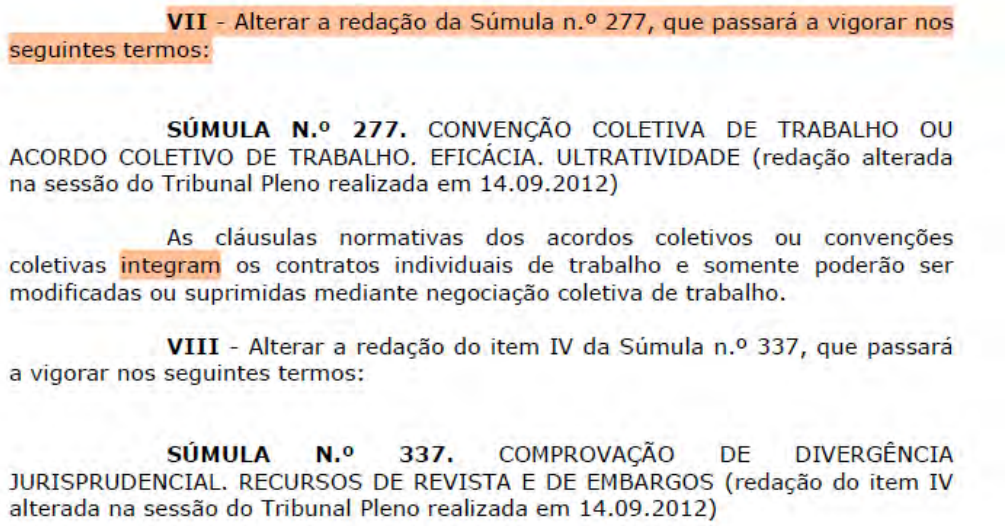
CLÁUSULA VIGÉSIMA OITAVA - NOVO EMPREGO - DISPENSA DO AVISO PRÉVIO

NOVO EMPREGO - DISPENSA DO AVISO PRÉVIO: O empregado dispensado sem justa causa que obtiver novo emprego antes ou durante o prazo do aviso prévio, ficará desobrigado do seu cumprimento, desde que solicite a dispensa e comprove o alegado com antecedência de 48 (quarenta e oito) horas, dispensado, nesta hipótese, e remuneração do período não trabalhado.

Advance Notice Rules: Restrictions on employment contract changes and notice period exemptions.

Figure 1.B.2: Original and Revised text - *Sumula 277*

- **Original text:** "As condições de trabalho alcançadas por força de sentença normativa vigoram no prazo assinado, *não integrando*, de forma definitiva, os contratos."
- **Revised text:**



VII - Alterar a redação da Súmula n.º 277, que passará a vigorar nos seguintes termos:

SÚMULA N.º 277. CONVENÇÃO COLETIVA DE TRABALHO OU ACORDO COLETIVO DE TRABALHO. EFICÁCIA. ULTRATIVIDADE (redação alterada na sessão do Tribunal Pleno realizada em 14.09.2012)

As cláusulas normativas dos acordos coletivos ou convenções coletivas integram os contratos individuais de trabalho e somente poderão ser modificadas ou suprimidas mediante negociação coletiva de trabalho.

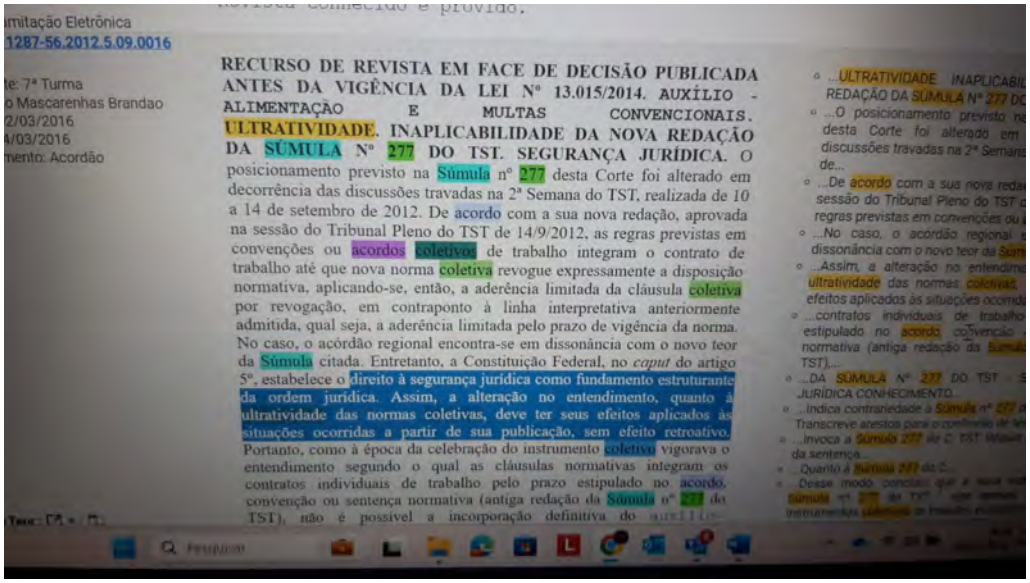
VIII - Alterar a redação do item IV da Súmula n.º 337, que passará a vigorar nos seguintes termos:

SÚMULA N.º 337. COMPROVAÇÃO DE DIVERGÊNCIA JURISPRUDENCIAL. RECURSOS DE REVISTA E DE EMBARGOS (redação do item IV alterada na sessão do Tribunal Pleno realizada em 14.09.2012)

Note: Translation of highlighted segments in the image:
VII - Amend the wording of Súmula No. 277, which shall henceforth read as follows:
SÚMULA NO. 277. COLLECTIVE CONVENTION OR AGREEMENT (*sector- or firm-level agreements*). EFFECTIVENESS. ULTRACTIVITY. (wording amended in the Plenary Session held on 09/14/2012)

The normative clauses of collective labor agreements or conventions **become part of** individual employment contracts and may only be modified or eliminated through collective bargaining.

Figure 1.B.3: Example of an decision court



imitação Eletrônica
1287-56.2012.5.09.0016
te: 7ª Turma
o Mascarenhas Brandao
2/03/2016
4/03/2016
mento: Acordão

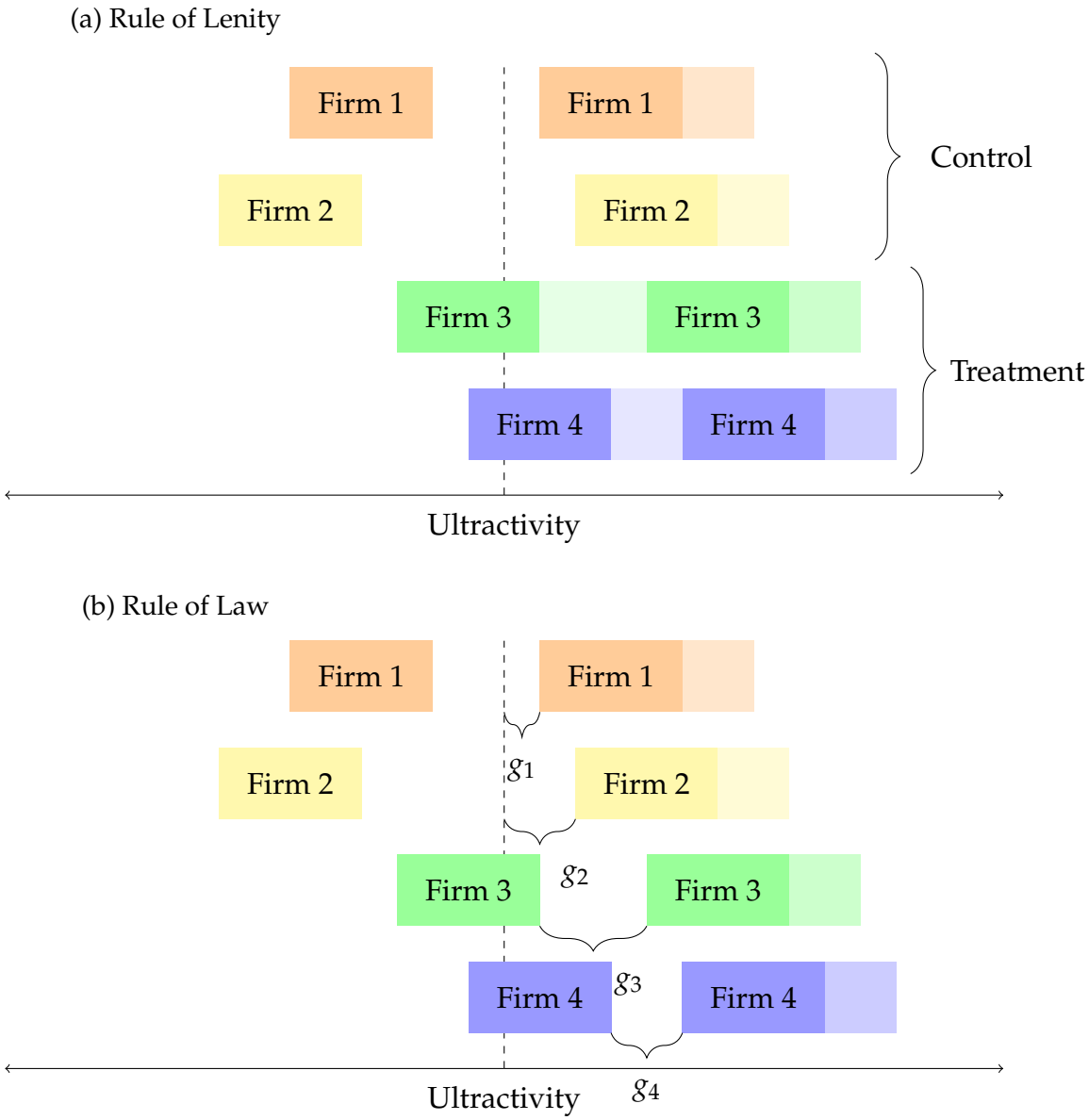
RECURSO DE REVISTA EM FACE DE DECISÃO PUBLICADA ANTES DA VIGÊNCIA DA LEI Nº 13.015/2014. AUXÍLIO - ALIMENTAÇÃO E MULTAS CONVENCIONAIS. ULTRATIVIDADE. INAPLICABILIDADE DA NOVA REDAÇÃO DA SÚMULA Nº 277 DO TST. SEGURANÇA JURÍDICA. O posicionamento previsto na Súmula nº 277 desta Corte foi alterado em decorrência das discussões travadas na 2ª Semana do TST, realizada de 10 a 14 de setembro de 2012. De acordo com a sua nova redação, aprovada na sessão do Tribunal Pleno do TST de 14/9/2012, as regras previstas em convenções ou acordos coletivos de trabalho integram o contrato de trabalho até que nova norma coletiva revogue expressamente a disposição normativa, aplicando-se, então, a aderência limitada da cláusula coletiva por revogação, em contraponto à linha interpretativa anteriormente admitida, qual seja, a aderência limitada pelo prazo de vigência da norma. No caso, o acórdão regional encontra-se em dissonância com o novo teor da Súmula citada. Entretanto, a Constituição Federal, no *caput* do artigo 5º, estabelece o direito à segurança jurídica como fundamento estruturante da ordem jurídica. Assim, a alteração no entendimento, quanto à ultratividade das normas coletivas, deve ter seus efeitos aplicados às situações ocorridas a partir de sua publicação, sem efeito retroativo. Portanto, como à época da celebração do instrumento coletivo vigorava o entendimento segundo o qual as cláusulas normativas integram os contratos individuais de trabalho pelo prazo estipulado no acordo, convenção ou sentença normativa (antiga redação da Súmula nº 277 do TST), não é possível a incorporação definitiva do

...ULTRATIVIDADE. INAPLICABIL
REDAÇÃO DA SÚMULA Nº 277 DO
...O posicionamento previsto na
desta Corte foi alterado em
discussões travadas na 2ª Semana
de...
...De acordo com a sua nova reda
sessão do Tribunal Pleno do TST
regras previstas em convenções ou
...No caso, o acordão regional
dissonância com o novo teor da Súm
...Assim, a alteração no entendim
ultratividade das normas coletivas,
efeitos aplicados às situações ocorrid
...contratos individuais de trabalho
estipulado no acordo, convenção
normativa (antiga redação da Súmula
TST)...
...DA SÚMULA Nº 277 DO TST
JURÍDICA CONHECIMENTO...
...Indica contrariedade à Súmula nº 277
Transcreve arestos para o confronto de te
...Invoca a Súmula 277 do C. TST. Mesmo
da sentença...
...Quanto à Súmula 277 do C.
...Desse modo, concluo que a nova re
Súmula nº 277 do TST" com ressalva
interpretativa adotada no trecho transcrito

Note: This decision from the 7th Panel of the TST (Brazilian Superior Labor Court) addresses the inapplicability of the revised wording of Súmula No. 277 to cases prior to its publication on September 14, 2012. The ruling argues that, although the new version of Súmula 277 granted ultratividade to collective norms (making them automatically part of employment contracts until renegotiated), applying this retroactively would violate the constitutional principle of legal certainty. Therefore, the court establishes that such changes should only apply to situations occurring after the publication date.

1.C
Juridical Discussion

Figure 1.C.1: Juridical Discussion



Note: This figure illustrates the judicial debate over the application of mandatory ultractivity following the amendment of *Súmula 277*. The horizontal axis represents time, with the dashed vertical line indicating the moment when ultractivity was introduced. Each colored rectangle represents a CBA signed by a firm, and its expiration is marked by the end of the rectangle.

The key legal question was whether ultractivity should be applied retroactively to all existing CBAs or only to agreements negotiated after the policy change. Two competing legal principles guided judicial decisions: the *Princípio da Norma Mais Favorável* (Rule of Lenity) and the *Princípio da Segurança Jurídica* (Rule of Law).

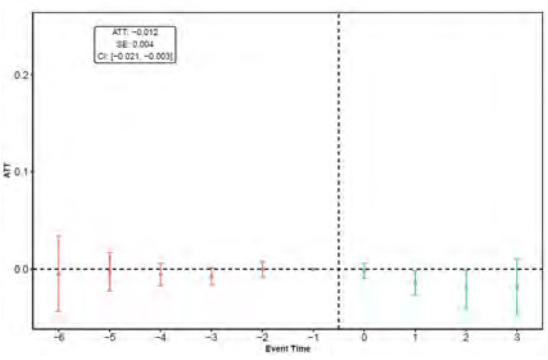
Panel (a) represents the *Rule of Lenity* interpretation, which dictated that ultractivity should apply broadly to all CBAs, including those that had not yet expired at the time of the policy change. Under this view, previously signed agreements were automatically extended. The light-colored extensions illustrate how CBAs continued beyond their original expiration dates due to ultractivity. This interpretation implies that firms were uniformly treated by the policy.

Panel (b) illustrates the *Rule of Law* interpretation, which held that CBAs signed before the amendment remained governed by the previous legal framework until their expiration. In this case, mandatory ultractivity was only enforced for CBAs negotiated after the policy change, ensuring legal certainty. This created staggered treatment timing, as firms first encountered ultractivity upon renegotiating their agreements.

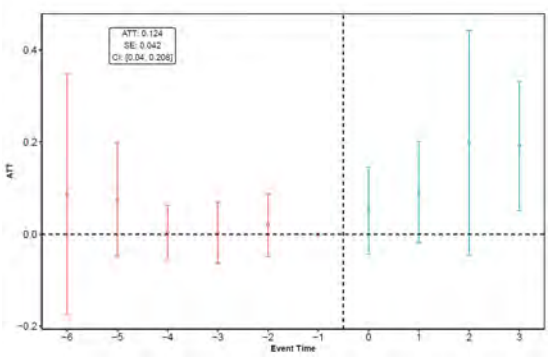
1.D
Robustness checks

Figure 1.D.1: Robustness – Effects on Hiring and Separations (share of contracts)

(a) Share of Hirings

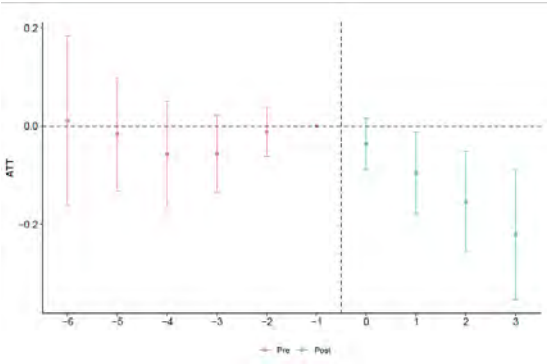


(b) Share of Separations

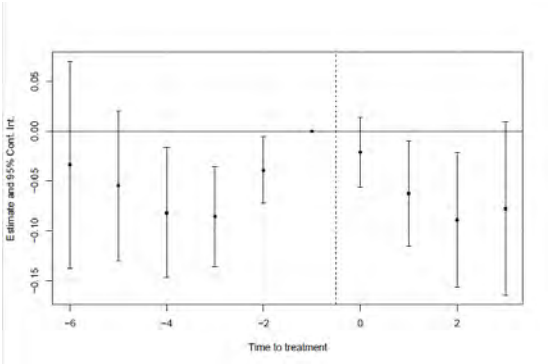


Note: This figure displays event-study estimates of the effect of CBA renewals under ultractivity on the share of Hiring and Separations over the total number of active contracts. Each dot represents the estimated average treatment effect on the treated (ATT) at a given event time, with 95% confidence intervals shown. The shaded box in the upper left corner of each panel reports the average post-treatment ATT, its standard error (SE), and the corresponding confidence interval.

Figure 1.D.2: Robustness - Effects of Treatment on Hiring (alternative estimators)



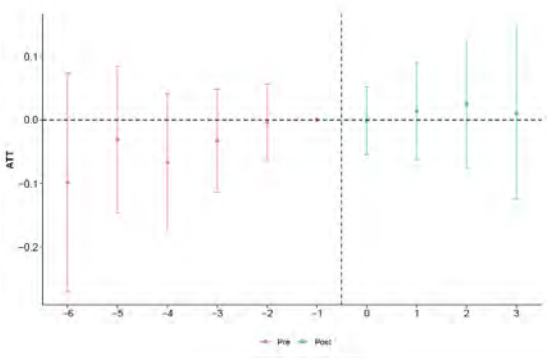
(a) Sun and Abraham estimator (last treated as never treated)



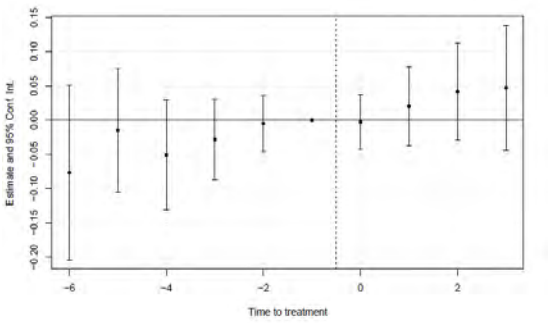
(b) Canonical TWFE estimator

Notes: Panel (a) reports estimates using the Sun and Abraham (2021) method, which treats the last treated group as never treated. Panel (b) presents results from a standard two-way fixed effects (TWFE) specification using the same sample.

Figure 1.D.3: Robustness - Effects of Treatment on Separations (alternative estimators)



(a) Sun and Abraham estimator (last treated as never treated)



(b) Canonical TWFE estimator

Notes: Panel (a) reports estimates using the Sun and Abraham (2021) method, which treats the last treated group as never treated. Panel (b) presents results from a standard two-way fixed effects (TWFE) specification using the same sample.

2
Slavery, Black Homicides and Incarceration in Brazil

Abstract. This paper estimates the long-term effects of slavery on racial disparities in incarceration and homicide rates in Brazil. Today, Afro-Brazilians face the highest rates of homicide victimization and represent a disproportionate share of the prison population. Historically, Brazil retained a substantial legacy marked by an extensive dependence on enslaved labor. To quantify the impact of slavery, we combine historical census data from 1872 with contemporary socioeconomic indicators. To address the endogeneity of slavery's geographic distribution, we use an Instrumental Variable (IV) strategy, exploiting satellite-based measures of the potential coffee yield, a crop historically dependent on enslaved labor. We find that one percentage point increase in the share of enslaved individuals in 1872 leads to an increase of 0.5 percentage point in Black incarceration and homicide rates today. We explore three channels: structural, institutional, and cultural; and find that slavery is associated with persistent racial inequality in education, and mixed signals on racial bias.

Keywords: slavery; incarceration; homicide; racial violence; long-term effect.

2.1 Introduction

Brazil holds a deep historical legacy of extensive use of slave labor. The country received more enslaved Africans than any other country and was the last country in the Western Hemisphere to abolish slavery. Slavery played a fundamental role in the economy for nearly four centuries. Enslaved labor sustained key sectors during colonial and post-colonial periods, such as sugar, coffee, and mining, and left marks on Brazil's social, cultural, and economic structures.

More than 130 years after abolition of slavery, Brazil consistently reports some of the highest homicide rates in the world. However, these violent deaths do not affect citizens uniformly: Afro-Brazilians account for 71% of the homicide victims and represent 79.1% of those killed in police interventions (FBSP, 2020). This racial group also comprises the majority of Brazil's incarcerated population. Although Black and Mixed-race individuals comprise 55.4% of the Brazilian population, they represent 63.6% of incarcerated people Infopen (2017).

This paper investigates the historical roots of racial disparities in homicide victimization and incarceration by estimating the long-term effects of slavery on these outcomes. To do so, we compile data from several distinct sources. Our measure of slavery intensity comes from Brazil's first national census, conducted in 1872, which reports the share of enslaved individuals in each municipality. We link this historical data to contemporary datasets that provide information on our main outcomes: the incarceration and homicide rates of Afro-Brazilians. To control for confounding historical factors, we also incorporate additional 19th-century data that may influence present-day violence and incarceration.

A key identification challenge is that the historical intensity of slavery may be endogenous to long-run municipal characteristics. Areas with higher historical slave intensity may have had unobservable characteristics, such as extractive institutions, entrenched elite power, or economic structures, that continue to shape contemporary outcomes. Moreover, the measurement of slave intensity in 1872 may be subject to error due to limitations in historical records. These concerns imply that OLS estimates may be biased and fail to capture the long-term causal impact of slavery. To address these issues, we employ an instrumental variable (IV) strategy using satellite-based data from the FAO-GAEZ project that uses agro-climatic suitability for coffee cultivation as an instrument for the share of enslaved people in 1872. This approach isolates variation in slave intensity driven by exogenous geographic factors, helping to recover the causal effect of slavery on current racial disparities.

We find that slavery has persistent effects on racial violence and incarceration in Brazil. A one percentage point increase in the share of enslaved individuals in 1872 leads to a 0.5 percentage point increase in the Black homicide rate and a 0.5 percentage point increase in the Black incarceration rate today. Although our primary analysis focuses on Afro-Brazilians as a broader racial category, the results are driven specifically by the Black subgroup. The instrumental variable estimates align with the OLS results, even after accounting for potential threats to the exclusion restriction, such as historical access to the railroad network.

Given these findings, we next explore the mechanisms that may drive the long-run effects of slavery on racial disparities in incarceration and homicide. We begin by testing a structural mechanism: are Afro-Brazilians more likely to engage in criminal activity or be victims of violence because of persistent racial disparities in socioeconomic conditions? Afro-Brazilians typically earn lower incomes, have lower levels of education, and are disproportionately represented among those living in poverty or facing unemployment. While advocates of the so-called *Democracia Racial* (Racial Democracy) argue that these socioeconomic disadvantages explain racial gaps in incarceration and homicide, it is important to consider that these disparities may themselves be a legacy of slavery (Laudares & Caicedo, 2023).

To test this, we estimate the effect of historical slavery intensity on present-day socioeconomic indicators, including the Gini index, Human Development Index (IDHm), and GDP per capita. We also regress slavery intensity on measures of racial inequality in income, poverty, and schooling. We find that municipalities with higher historical reliance on slave labor present larger racial disparities in educational attainment. This evidence is consistent with the idea that slavery contributed to enduring socioeconomic inequalities. At the same time, we find a positive coefficient for GDP per capita, similar to the results reported in Laudares & Caicedo (2023), suggesting that slavery was more concentrated in areas that were historically wealthier.

A second potential mechanism is institutional: the legacy of slavery may still influence local institutions that continue to reproduce racially biased outcomes. In the early 20th century, official government documents reflected explicit racial bias, portraying Afro-descendants as inferior and promoting a national agenda of "whitening" the population. This ideology was codified in laws that criminalized behaviors common among formerly enslaved individuals and their descendants, such as vagrancy or practicing Afro-Brazilian religions (Batista, n.d.; Flauzina, 2008). To test whether such institutional legacies persist, we examine two outcomes: the rate of homicide due to police intervention and municipal engagement

with racial equity policies (e.g., the existence of racial equity councils or legislation promoting racial equality). However, we do not find conclusive evidence confirming this mechanism.

Finally, we test the cultural transmission hypothesis. As theorized by Bisin & Verdier (2017), cultural beliefs and institutional arrangements may interact to perpetuate practices and beliefs across generations. To examine whether anti-Black bias persists in areas with greater historical slavery intensity, we use data from the 2009 ENEM socioeconomic survey, which included questions about racial attitudes. Against our initial hypothesis, we find that municipalities with higher historical slave populations report lower levels of self-declared racism. To address potential measurement bias in self-reports, especially given the social desirability bias about racism, we use data from Equidade.Info, a nationally representative survey that includes Implicit Association Test (IAT) scores for public school teachers and principals. Although data limitations prevent us from conducting formal regressions, descriptive evidence shows that municipalities with the higher historical slavery intensity also have the higher frequency of implicit anti-Black bias among educators.

Despite empirical challenges, particularly those related to data quality and the difficulty of identifying long-run effects, we find that slavery contributes to current racial disparities in incarceration and homicide rates among Black Brazilians. The mechanisms we explore are not mutually exclusive, but our analysis suggests stronger evidence for the structural channel rather than the institutional one.

Related Literature. This project contributes to three strands of the literature. First, we present new evidence on the effects of slavery on crime and violence. A well-established literature investigates the long-term effects of slavery and forced labor on economic development (Nunn, 2008; Nunn & Wantchekon, 2011). Most of this literature focuses on estimating effects on racial income and educational inequality levels (Dell, 2010; Laudares & Caicedo, 2023). In contrast, our paper sheds light on another dimension of economic development: we show that slavery has persistent effects on Black homicides and incarceration. Other works such as Buonanno & Vargas (2019) examine slavery and violence but use slavery as an instrument for inequality, while we estimate the direct effect.

Second, our findings provide new insights into the long-term effects of slavery in developing countries. A growing body of literature focuses on understanding how slavery and American segregation laws impact today's outcomes (Althoff & Reichardt, 2022; Rubio, 2022), contexts where explicit racial discrimina-

tion was legally codified. Our paper explores a setting where racial discrimination persisted not through formal segregation laws but through structural racism embedded in institutions and implicit individual actions.

Finally, the paper contributes to the literature on racial disparities in the judicial system (Anwar *et al.*, 2012; Alesina & La Ferrara, 2014; Cerqueira & Coelho, 2017), allowing for a more comprehensive understanding of the historical roots of these disparities.

2.2 Historical Context

Slavery in Brazil. Brazil was the largest recipient of enslaved Africans in the world, receiving 4.9 million of the 12 million individuals that were taken from Africa during the transatlantic slave trade (Eltis & Richardson, 2010). Between the 16th and 19th centuries, enslaved labor played a central role in the Brazilian economy across multiple periods and regions.

During the sugarcane cycle in the 16th century, slavery was concentrated in the Northeast of the country. In the late 17th century, the discovery of gold in the state of Minas Gerais led to a shift toward mining. In the North, rubber and cotton production also relied on enslaved labor. By the 19th century, coffee had become Brazil's dominant export, with slave labor concentrated in the Vale do Paraíba (in São Paulo state), Rio de Janeiro, and southern Minas Gerais (Klein & Luna, 2009).

Beyond agriculture and extractive activities, slavery was also widespread in urban areas. Enslaved individuals worked in domestic service, construction, artisan trades, and served in the military during the Paraguayan War (1864-1870)[1]. Slavery in Brazil between the 16th and 19th centuries permeated all sectors of society and spanned the entire national territory. Figure 2.A.1 illustrates the share of enslaved individuals in each municipality in 1872.

Post-abolition. Slavery was officially abolished in Brazil in 1888, one year before the end of the Empire. However, abolition did not represent the end of racial inequality. There was no compensation policy or land redistribution, and the transition to free labor replaced formerly enslaved workers with European immigrants, particularly in the coffee sector. The abolition was a strategic response to growing international pressure to end slavery. To avoid resistance from landown-

[1] Conrad (1975) estimated that 20,000 slaves joined the war, without account for runway slaves.

ers, the recently established republican government destroyed all official records of enslaved individuals, making it impossible to trace ancestry or secure reparations. At the turn of the 20th century, official government documents reflected a clear preference for whiteness, frequently describing the Black population in negative terms and showing enthusiasm about increases in the white population share (see Appendix 2.A.2).

Several historians and sociologists argue that the current high homicide rates among Black Brazilians are a legacy of slavery and its associated systems of oppression (Batista, n.d.; Flauzina, 2008). In the post-abolition period, the Brazilian state created laws that disproportionately targeted the freedoms of the Black population. For instance, the criminal code classified the practice of *capoeira*, a traditional Afro-Brazilian martial art, criminal offense. Another tool of racial control was the "vagrancy" law, which criminalized individuals without a employment, who could not prove subsistence-level consumption, or had attitudes seemed as immoral, such as sex work professionals, the practice of Afro-Brazilian religions, or participation in *rodas de samba* (Flauzina, 2008; Teixeira *et al.*, 2016). Teixeira *et al.* (2016) further argues that imprisonment on the basis of vagrancy remained widespread well into the first half of the 20th century, suggesting a long-run effect of these discriminatory laws.

Racial Classification in Brazil. Brazil experienced a deep process of racial mixing, which has shaped social structure and national identity over time. Miscegenation became a central characteristic of Brazilian society, marked by the historical coexistence of Indigenous, African, and European populations (Ribeiro, 2015). Reflecting this complex racial composition, IBGE classifies Afro-descendants into two categories: *pretos* (Black) and *pardos* (Mixed-race). In this paper, we follow this classification and refer to them jointly as Afro-Brazilians. Sociologists highlight the importance of analyzing both groups together in studies of racial inequality, as they share similar demographic characteristics (Gonzalez, Lélia and Hasenbalg, Carlos, 2022; Silva & Hasenbalg, 1992; Hasenbalg, 1999).

2.3 Data

This section describes the data sources used to estimate the long-term effects of slavery. Because our data span different time periods and municipal boundaries in Brazil have changed over time, we adopt the *Área Mínima Comparável* (Minimum Comparable Area - AMC) provided by the *Instituto Brasileiro de Ge-*

ografia e Estatística (IBGE) as our unit of analysis. AMCs harmonize historical municipal borders to ensure comparability between 1872 and 2010. In 1872, Brazil had 641 municipalities, which correspond to 451 AMCs. For simplicity, we refer to these as "municipalities" throughout the paper. We draw from six main data sources, detailed below.

1872 Imperial Census. The 1872 Brazilian Census, organized by the Imperial *Diretoria Geral de Estatística*, provides data on total population and the number of enslaved individuals, allowing us to calculate the share of enslaved people in each municipality. We also extract information on literacy rates, migrant population, and labor force by occupation. Using shapefiles and population data, we compute historical population density. Additionally, we incorporate historical data from Américo (2024) on the distance from each municipality to the nearest railroad line.

2010 Demographic Census. We use several indicators from the 2010 Demographic Census, provided by IBGE, to capture socioeconomic conditions and racial disparities. We also use complementary data from IBGE, including GDP per capita, the Municipal Human Development Index (IDHm), and the *MUNIC* survey, which reports municipal policies related to racial equity.

Homicide Data. We obtain data on homicides from the (*DataSUS*) system. For each municipality, we compute the average number of homicides between 2010 and 2018. We also identify deaths caused by police intervention.

Incarceration Data. Incarceration data come from the *Levantamento Nacional de Informações Penitenciárias* (Infopen), which provides information at the prison level, including the racial composition of the incarcerated population. We aggregate this data to the municipal level and restrict the sample to prisons that report prisoners' race.

Soil Suitability. To construct our instrumental variable, we use data from the FAO-GAEZ project on crop-specific soil suitability. This dataset reports potential agricultural yields under varying technological conditions at the pixel level. We aggregate pixel-level data to the municipal level using low-input technology and the earliest available period (1961–1990). We argue that the measure under low-input conditions is more persistent over time.

Self-reported Discrimination and Implicit Racial Bias. To explore cultural mechanisms, we draw on two data sources. First, we use responses to the 2008 socioeconomic questionnaire of the *Exame Nacional do Ensino Médio* (ENEM), which included questions related to racial attitudes. We construct municipal-level measures of self-reported racism and awareness of racist behaviors. Second, we use data from Equidade.Info, a nationally representative survey that includes Implicit Association Test (IAT) scores for public school teachers and principals.

Finally, we match historical and current municipalities. To link historical and modern municipal names, we use a map provided by IBGE and construct a name-similarity algorithm that allows us to match records across periods. Table 2.1 presents descriptive statistics for our sample.

Table 2.1: Descriptive Statistics

	Mean	SD	Min	Max	N
Panel A: 1872 Census					
Population	189,004	300,084	11,542	4,527,043	474
Slave population	27,980	49,263	162	595,963	474
Share slaves	0.14	0.10	0.01	0.57	474
Panel B: 2010 Census					
Share of Afro-Brazilian	0.56	0.21	0.09	0.92	474
Panel C: DataSus/Infopen					
Afro-Brazilian Homicide rate	0.70	0.27	0.00	1.00	474
Afro-Brazilian incarceration rate	0.65	0.18	0.00	1.00	238
Afro-Brazilian police violence rate	0.70	0.37	0.00	1.00	474
Panel D: Coffee suitability data					
Potential production (coffee) - tons/ha	348.41	134.87	0.00	678.37	N

2.4 Baseline OLS

2.4.1 Empirical Strategy

We estimate the persistent effect of slavery on Black incarceration and homicides by running the following regression:

$$Y_m^{current} = \alpha + \beta \cdot \text{ShareSlaves}_m^{1872} + \gamma \cdot \text{ShareBlack}_m^{2010} + \mathbb{X}_m\theta + \varepsilon_m \qquad (2.1)$$

where $Y_m^{current}$ denotes the mean value of the share of homicide in which victims are Black (the ratio of black homicides over total homicides) or the share of Black incarceration (Total black prison population over the total incarcerated

population) for each municipality m. $\text{ShareSlaves}_m^{1872}$ stands for the share of the enslaved population in a given municipality in 1872. $\text{ShareBlack}_m^{2010}$ represents the share of the black population in a municipality in 2010. $\mathbb{X}_m$ are a set of historical controls such as demographic density, share of literate population, share of agriculture workers.

The identifying variation in equation 2.1 comes from differences in the historical intensity of slavery across municipalities that today have similar shares of Black residents. Several mechanisms can generate this variation, including post-abolition migration flows, differential fertility and mortality rates, or local economic dynamics shaping the racial composition over time. Each of these channels has distinct implications for how slavery's legacy persists. For instance, regions with historically high slave intensity may have experienced stronger barriers to human capital accumulation, limiting upward mobility over generations. Alternatively, selective migration could have altered demographic trajectories. As such, β should not be interpreted as the direct effect of slave presence in 1872, but rather as the cumulative effect of slavery's historical footprint conditional on today's demographics. I explore potential mechanisms and assess robustness to alternative specifications in Section 2.6.

2.4.2 Baseline OLS results

This section presents OLS estimates of the relationship between the historical share of enslaved people and current incarceration and homicide rates. In all tables, Panel A reports the estimates for Afro-Brazilians (i.e., the combined Black and Mixed-race populations), while Panels B and C show the results separately for each group. Table 2.2 reports OLS estimates for incarceration rates. Column (1) shows a negative association between the slave share and the incarceration rate of Afro-Brazilians. However, this result is not robust to the inclusion of controls. Once the 2010 racial share is added in column (2), the coefficient becomes small and statistically insignificant. This remains the case in column (3), which adds historical controls for population density and literacy in 1872.

In Panel B, the estimated effect of slave share on incarceration rates of Black individuals is positive and statistically significant after controlling for both the 2010 Black share and historical demographic characteristics, while no significant effect is found for Mixed-race individuals (Panel C). After accounting for initial conditions, municipalities with higher historical slave shares tend to have higher incarceration rates of Black individuals today. Since we do not

observe incarceration in all Brazilian municipalities, we have a low number of observations in Table 2.2.

Table 2.2: Effect of Slave Share on Incarceration Rates

	(1)	(2)	(3)
Panel A: Afro-Brazilians			
Slave share (1872)	-0.354***	0.015	-0.004
	(0.134)	(0.100)	(0.100)
Afro-Brazilian share (2010)		0.639***	0.632***
		(0.043)	(0.044)
R-squared	0.029	0.496	0.502
Adj. R-squared	0.025	0.492	0.493
F-statistic	7.04	115.78	58.66
Panel B: Black only			
Slave share (1872)	0.285***	0.088	0.205**
	(0.065)	(0.073)	(0.090)
Black share (2010)		1.121***	0.746***
		(0.231)	(0.260)
R-squared	0.075	0.255	0.401
Adj. R-squared	0.071	0.249	0.339
F-statistic	19.43	23.82	8.73
Panel C: Mixed-race only			
Slave share (1872)	-0.640***	-0.189*	-0.071
	(0.124)	(0.107)	(0.153)
Mixed-race share (2010)		0.598***	0.608***
		(0.053)	(0.085)
R-squared	0.101	0.465	0.576
Adj. R-squared	0.097	0.461	0.532
F-statistic	26.55	91.04	15.07
Observations	238	238	237
1872 controls	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.3 presents OLS estimates for the relationship between slave share and homicide rates. In Panel A, all specifications show a negative and statistically significant coefficient for the Afro-Brazilian homicide rate. The inclusion of racial composition and historical controls does not alter the direction or magnitude of the estimate. By contrast, Panel B shows a positive and significant association between slave share and homicide rates for Black individuals in all specifications. These findings suggest that the historical legacy of slavery is associated with higher levels of violence against the Black population today.

The estimates for Mixed-race individuals move in the opposite direction. However, this does not imply that higher levels of slavery are associated with lower incarceration or homicide rates for Mixed-race populations. This result captures a composition effect since we are using the population share as the out-

Table 2.3: Effect of Slave Share on Homicide Rates

	(1)	(2)	(3)
Panel A: Afro-Brazilians			
Slave share (1872)	-0.732***	-0.204***	-0.236***
	(0.118)	(0.048)	(0.048)
Afro-Brazilian share (2010)		1.174***	1.166***
		(0.023)	(0.023)
R-squared	0.075	0.856	0.861
Adj. R-squared	0.073	0.855	0.860
F-statistic	38.12	1397.68	726.98
Panel B: Black only			
Slave share (1872)	0.360***	0.230***	0.131***
	(0.038)	(0.031)	(0.047)
Black share (2010)		0.874***	0.827***
		(0.065)	(0.104)
R-squared	0.222	0.539	0.665
Adj. R-squared	0.221	0.537	0.648
F-statistic	91.01	183.71	24.54
Panel C: Mixed-race only			
Slave share (1872)	-1.091***	-0.314***	-0.175**
	(0.099)	(0.053)	(0.069)
Mixed-race share (2010)		1.302***	0.811***
		(0.028)	(0.068)
R-squared	0.155	0.839	0.919
Adj. R-squared	0.151	0.837	0.905
F-statistic	121.50	1377.72	43.00
Observations	475	475	474
1872 controls	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

come. Another possible interpretation is that they reflect historically distinct patterns of racial structure across municipalities. Municipalities with a higher share of mixed-race in 2010, for instance, may experienced more intense miscegenation in the past, leading to different trajectories of racial categorization over time. Under this interpretation, the historical legacy of slavery may be more linked to contexts with more racial segregation. Alternatively, these results may reflect selective migration effects or regional variation in how racial identities are socially constructed.

Finally, we do not include state fixed effects or contemporary socioeconomic controls in the main specifications, as these variables absorb key dimensions of historical variation that are central to the identification strategy. State fixed effects remove between-region variation, while contemporary variables, such as poverty or income inequality, may be part of the causal channel from slavery to present-day racial disparities.

2.5 IV Design

Section 2.4.2 presents OLS estimates. However, these results may not identify a long-term causal effect of slavery. Slavery may have been more prevalent in areas with unobservable historical characteristics, such as extractive institutions or deep-rooted elite power, that also influence current racial disparities. Additionally, slave intensity in 1872 may be measured with error, given the historical nature of the data. To address concerns related to endogeneity of slavery's placement, we adopt an instrumental variable (IV) strategy. Specifically, we use soil suitability for coffee as an instrument for the share of enslaved people in 1872[2].

The instrument is constructed using the potential coffee yield (tons per hectare) under low input conditions, derived at the pixel level and aggregated to the municipality. Formally:

$$Z_m = \frac{1}{N_m} \sum_p y_{p,m}^{low} \tag{2.2}$$

where Z_m denotes the instrument for slavery share in municipality m, N_m is the number of pixels within municipally boundaries, and $y_{p,m}^{low}$ is the potential yield for coffee in pixel p, municipality m under low input conditions. We then use Z_m as a instrument for the historical share of slavery in a 2SLS estimation.

2.5.1 Identification

Before presenting the results of the IV results, we first examine the relevance of the instrument and test for potential threats to the exclusion restriction.

Relevance Restriction. Table 2.4 reports first-stage estimates, where soil suitability for coffee is used as an instrument for the historical slave share. Across all specifications, the coefficient on soil suitability is positive and significant, with F-statistics ranging from 21 to 37, confirming the relevance of the instrument: municipalities more suitable for coffee had significantly higher shares of enslaved people in 1872.

The specification also includes the 2010 Black population share as a control, as it is used in the second-stage regressions. The negative coefficient reflects long-term demographic shifts, especially in regions such as Sao Paulo, highly suitable

[2]We tested other crops historically associated with slave labor as instruments: sugarcane, cotton, cocoa, and rubber. After a series of checks, only coffee survived the instrument validity tests.

for coffee, where post-abolition immigration reduced the relative size of the Black population. This helps isolate the variation in slavery explained by exogenous natural conditions.

Table 2.4: First Stage: Soil Suitability for Coffee and Slave Share

	Share of enslaved population (1872)		
	(1)	(2)	(3)
Soil suitability – coffee (log)	0.059***	0.078***	0.072***
	(0.012)	(0.011)	(0.012)
Black pop. share (2010)		-0.157***	-0.154***
		(0.023)	(0.023)
R-squared	0.055	0.141	0.158
Adj. R-squared	0.053	0.137	0.151
F-statistic	26.47	37.06	21.06
Observations	454	454	454
1872 controls	No	No	Yes

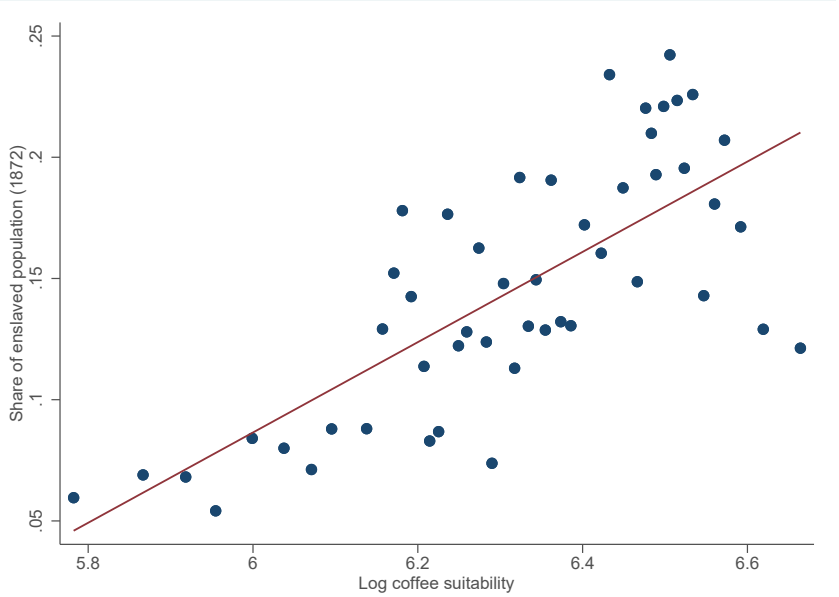
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 2.1 and Table 2.A.1 report first-stage estimates across various subsamples to assess the plausibility of the monotonicity assumption. In all cases, the coefficient on soil suitability remains positive and statistically significant. This supports the assumption that the instrument affects slavery intensity in the same direction across the sample. The results are consistent with the requirements for interpreting the 2SLS estimates as Local Average Treatment Effects (LATE), following Imbens & Angrist (1994).

Exclusion Restriction. Although exclusion restriction is not testable, we discuss its plausibility by testing if possible endogeneity sources are correlated with our instrument: soil suitability for coffee. An argument for using this instrument is that the potential yield measure captures soil suitability under minimal technological input, based primarily on natural factors such as rainfall. It reflects long-term geographic characteristics rather than actual production.

A potential violation of the exclusion restriction is that soil suitability for coffee may have attracted migration flows with distinct racial compositions or social profiles, potentially with some racial bias, which could have affected long-term racial structures regardless of slavery. To address this concern, we regress soil suitability on the share of immigrants in 1872 from different origins. Table 2.5 reports these results. There is no consistent evidence that soil suitability is associated with any particular immigrant group. The estimated coefficients are small in magnitude and mostly statistically insignificant. This suggests that

Figure 2.1: First Stage: Binscatter



the instrument is unlikely to be capturing selective migration effects that could threaten the exclusion restriction.

Table 2.5: Exclusion Restriction Check: Soil Suitability and Immigration

Dependent variable:	Share of immigrants in 1872 by origin				
	(1)	(2)	(3)	(4)	(5)
	European	Italian	Portuguese	Latin American	African
Soil suitab. – coffee (log)	-0.0000406***	-0.00000063	-0.00000471	-0.00000306**	-0.00000215*
	(0.0000106)	(0.00000052)	(0.00000400)	(0.00000147)	(0.00000109)
R-squared	0.187	0.100	0.313	0.013	0.231
Adj. R-squared	0.180	0.092	0.307	0.005	0.225
F-statistic	27.07	13.05	53.45	1.57	35.34
Observations	475	475	475	475	475
1872 controls	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Another potential threat to the exclusion restriction is internal migration. If more suitable municipalities for coffee were more accessible to population inflows, regardless of slavery, this could influence long-term racial composition or outcomes. We do not have data that directly measure internal migration in the 19th century. However, using Américo (2024) data, we proxy it by the distance from each municipality to the nearest railroad line. Railroads played a major role in facilitating internal migration in the late 19th century.

Table 2.6 shows that municipalities with higher soil suitability for coffee were located closer to railroad lines throughout the second half of the 19th century, suggesting that these places were more connected to the transportation

network. This raises a potential concern that the instrument could be capturing long-term effects of migration infrastructure rather than slavery.

Two factors mitigate the threat to identification. First, if accessibility alone explained the outcomes, we would expect a more uniform pattern across racial groups, rather than effects concentrated among Black individuals only. Second, to address this potential, we include the historical distance to the nearest railroad line as a control in the second-stage IV regressions shown in Section 2.5.2. The estimated effects remain stable and statistically significant after this adjustment.

Table 2.6: Exclusion Restriction Check: Soil Suitability and Railroad Access

Dependent variable:	Distance to nearest railroad (km)				
	(1)	(2)	(3)	(4)	(5)
	1854	1860	1870	1880	1890
Soil suitab. – coffee (log)	-1.862***	-0.855***	-0.796***	-0.272***	-0.123***
	(0.189)	(0.073)	(0.069)	(0.048)	(0.034)
R-squared	0.429	0.396	0.330	0.211	0.199
Adj. R-squared	0.423	0.390	0.322	0.203	0.190
F-statistic	71.46	62.43	46.81	25.45	23.62
Observations	386	386	386	386	386
1872 controls	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Moreover, although the correlation between soil suitability and railroad access is statistically significant, its magnitude is modest. The average log coffee suitability increases from 5.88 in the first quartile to 6.55 in the fourth quartile, a 0.67 log points difference. Given the estimated coefficient of –1.86 from the 1854 railroad distance regression, this corresponds to a reduction of approximately 1.25 kilometers in distance to the nearest railroad ($-1.86 \times 0.67 \approx -1.25$ km). Considering that the mean distance to the 1854 railroad network is over 1,000 km, this represents less than 0.2%.

Finally, we examine whether soil suitability for coffee is correlated with the occupational structure in 1872. One potential concern is that coffee suitability may have led to the development of specific types of work, which could ultimately influence long-term outcomes such as incarceration and homicide rates. To test this, I regress soil suitability on the share of workers in different occupations in 1872. Table 2.7 reports the results.

Although some coefficients are statistically significant, their magnitudes are small and there is no clear pattern across occupations. This suggests that soil suitability does not have a systematic relationship with labor market composition.

Table 2.7: Exclusion Restriction Check: Soil Suitability and Labor Market Structure (1872)

Dependent variable:	Occupational shares (1872)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Self-emp.	Employer	Manufacturer	Handcrafter	Agriculture	Domestic	No occupation
Soil suitab. – coffee (log)	-0.00000152	0.00000007	-0.0000128***	0.0000465**	0.000135**	0.0000645*	-0.000292***
	(0.000003)	(0.000002)	(0.000004)	(0.000021)	(0.000055)	(0.000039)	(0.000065)
R-squared	0.144	0.038	0.168	0.047	0.033	0.057	0.076
Adj. R-squared	0.137	0.029	0.161	0.039	0.025	0.049	0.068
F-statistic	19.75	4.60	23.80	5.75	4.01	7.13	9.61
Observations	475	475	475	475	475	475	475
1872 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.5.2 IV Results

In this section, we present the results from our IV strategy. Columns (1) to (3) report 2SLS estimates, with control variables added sequentially across specifications. Column (3) shows our preferred specification, which includes the full set of controls: population density and literacy rate in 1872, along with the historical variables discussed in Section 2.5.1 that help address potential confounding. Among these, we control for distance to the nearest railroad in 1890, capturing historical access to transportation infrastructure at the end of the slavery period, and the local share of agricultural and handcraft workers.

Table 2.8 reports estimates of the effect of the historical share of enslaved population on current incarceration rates, disaggregated by racial group. The coefficient for Afro-Brazilians is positive and statistically significant at the 5% level. Column (3), the preferred specification, shows that an increase of one percent point in the share of enslaved people in 1872 is associated with an increase of 0.609 percentage points in the Afro-Brazilian incarceration rate. Consider a municipality at the 25th percentile of the historical slave share distribution (0.07) compared to one at the 75th percentile (0.19). The estimated difference in incarceration rate between these two municipalities would be approximately $0.609 \times (0.1920 - 0.0707) = 0.0738$. Given that the mean incarceration rate for Afro-Brazilians is 0.65, this represents an increase of more than 11%, suggesting a meaningful long-run effect of slavery on current incarceration outcomes.

The effect is driven by Black individuals (Panel B), with a statistically significant coefficient of 0.513. In contrast, the effect for Mixed-race individuals (Panel C) is smaller and statistically insignificant. This pattern reinforces the interpretation that the legacy of slavery disproportionately affects the Black population today, even after controlling for a range of historical and socioeconomic factors.

Table 2.9 reports 2SLS estimates of the effect of historical slave share on cur-

Table 2.8: 2SLS Estimates: Slave Share and Incarceration Rates (by racial group)

	(1)	(2)	(3)
Panel A: Afro-Brazilians			
Share of enslaved population (1872)	1.216***	1.205***	0.609**
	(0.379)	(0.399)	(0.280)
Afro-Brazilian share (2010)	0.770***	0.768***	0.695***
	(0.067)	(0.070)	(0.063)
R-squared	0.184	0.190	0.422
F-statistic	32.42	29.41	35.88
Panel B: Black only			
Share of enslaved population (1872)	0.822***	0.788***	0.513***
	(0.218)	(0.227)	(0.162)
Black share (2010)	0.160***	0.155***	0.101***
	(0.039)	(0.040)	(0.037)
R-squared	0.113	0.121	0.371
F-statistic	41.99	38.36	43.48
Panel C: Mixed-race only			
Share of enslaved population (1872)	0.394	0.417	0.096
	(0.333)	(0.354)	(0.268)
Mixed-race share (2010)	0.610***	0.613***	0.594***
	(0.059)	(0.062)	(0.061)
R-squared	0.209	0.216	0.423
F-statistic	37.66	33.18	36.41
Observations	238	238	194
1872 controls	No	Yes	Yes
Additional historic controls	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

rent homicide rates by racial group. In Panel A, the coefficient is negative and statistically undistinguishable for zero. Panel B shows a positive and robust relationship between slave share and homicide rates for Black individuals, with all coefficients significant at the 1% level. The magnitude effect is similar with results for Black incarceration. Negative coefficients in Panel C captures a composition effect. These results indicate that the historical legacy of slavery is associated with higher exposure to lethal violence among Black individuals.

The IV estimates reinforce the main patterns observed in the OLS results, especially for Black individuals. In both specifications, the direction and statistical significance of the effects remain consistent, suggesting that OLS estimates are not substantially biased in terms of sign. However, the IV approach presents larger coefficients, indicating that OLS may underestimate the long-run effects of slavery on incarceration and homicide rates. Taken together, these results support the interpretation that slavery's legacy persists through exogenous historical channels. The IV strategy corroborates with the causal interpretation of the relationship between historical slavery and present-day racial disparities.

Table 2.9: 2SLS Estimates: Slave Share and Homicide Rates (by racial group)

	(1)	(2)	(3)
Panel A: Afro-Brazilians			
Share of enslaved population (1872)	0.156	0.039	-0.116
	(0.142)	(0.150)	(0.141)
Afro-Brazilian share (2010)	1.211***	1.196***	1.206***
	(0.028)	(0.028)	(0.031)
R-squared	0.315	0.320	0.322
F-statistic	41.20	38.17	36.77
Panel B: Black only			
Share of enslaved population (1872)	0.445***	0.480***	0.565***
	(0.086)	(0.095)	(0.087)
Black share (2010)	0.083***	0.088***	0.084***
	(0.017)	(0.018)	(0.019)
R-squared	0.147	0.163	0.165
F-statistic	40.94	37.18	34.82
Panel C: Mixed-race only			
Share of enslaved population (1872)	-0.289*	-0.441**	-0.681***
	(0.171)	(0.182)	(0.167)
Mixed-race share (2010)	1.129***	1.108***	1.122***
	(0.034)	(0.034)	(0.037)
R-squared	0.308	0.316	0.326
F-statistic	33.13	32.77	36.06
Observations	238	238	194
1872 controls	No	Yes	Yes
Additional historic controls	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.6 Mechanisms

In this section, we investigate potential mechanisms that explain how slavery still affects violence and incarceration today. One important decision is whether to control for the current share of Afro-Brazilian population. This variable can be seen as part of the effect of slavery itself, so including it might block part of the causal path. But it can also help us examine whether slavery has effects beyond today's racial composition. Because of that, we show mechanisms results with and without controlling for the current shares of Black and Mixed-raced individuals. We test three different hypothesis:

(i) a *structural channel*, in which Afro-Brazilians are more likely to be victims of homicide or engage in crime due to poor socioeconomic conditions and high levels of racial inequality;

(ii) an *institutional channel*, where the persistence of a racist institutional structure, rooted in the slavery regime from the 16th to 19th centuries, shapes current state actions and enforcement practices; and

(iii) a *cultural channel*, based on the inter-generational transmission of racial bias and discriminatory attitudes.

To investigate these hypotheses, we examine how the historical intensity of slavery correlates with present-day socioeconomic gaps, institutional behavior, and cultural attitudes.

2.6.1 Structural channel

Tables 2.10 and 2.11 examine whether the legacy of slavery operates through structural socioeconomic inequalities. I regress several present-day socioeconomic and racial imbalance outcomes on the historical slave share. Table 2.10 presents IV estimates for a set of current socioeconomic indicators. In most cases, the coefficient on slave share increases in magnitude and retains the same sign after controlling for the current share of the Afro-Brazilian population. The R-squared values also increase, suggesting that present-day racial composition explains an important part of the variation in these outcomes. The estimates for HDI and GDP per capita are positive and statistically significant. However, this does not imply that slavery caused more development. Rather, enslaved labor was historically concentrated in regions that were already more economically dynamic, specially our instrument, where coffee was concentrated in Southeast. The results suggest that the long-run gains in development are unevenly distributed, municipalities with larger Black populations present less HDI and GDP per capita.

Table 2.11 shows the IV coefficient for schooling imbalance positive and significant. Although with low statistical power, the results of this section are in line with Laudares & Caicedo (2023) who also find that places with more enslaved people present more racial inequalities in education. However, the results provide limited support for the structural channel, suggesting that although slavery may be linked to general underdevelopment, the racial disparities in homicides and incarceration are not fully explained by persistent socioeconomic inequality itself.

2.6.2 Institutional channel

To assess the institutional channel, we examine whether municipalities with higher historical slave shares experience more police violence and fewer anti-racism policies. Table 2.12 presents 2SLS estimates of the effect of slavery on the share of deaths caused by police intervention. As in Section 2.4, the coefficients for

Table 2.10: IV Estimates: Slave Share and Socioeconomic Outcomes

	Human Development Index		Gini Index		Unemployment Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Slave share (1872)	-0.156	0.348***	-28.99	-6.973	62.96	122.1
	(0.122)	(0.0638)	(27.01)	(20.66)	(307.9)	(239.6)
Black pop. share (2010)		-0.214***		-9.357**		-25.13
		(0.0141)		(4.551)		(52.78)
R-squared	0.065	0.573	0.045	0.292	0.033	0.201
Adj. R-squared	0.048	0.564	0.027	0.280	0.015	0.187
Observations	386	386	386	386	386	386
	GDP per capita		Poverty rate		Youth schooling (18–24)	
	(7)	(8)	(9)	(10)	(11)	(12)
Slave share (1872)	43,449**	66,913***	-165.5	-818.7	-3,351	0.959
	(19,249)	(15,043)	(807.7)	(621.0)	(2,891)	(2,191)
Black pop. share (2010)		-9,971***		277.6**		-1,424***
		(3,314)		(136.8)		(482.6)
R-squared	0.133	0.568	0.118	0.253	0.088	0.318
Adj. R-squared	0.116	0.558	0.100	0.240	0.070	0.306
Observations	386	386	386	386	386	386
1872 controls			Yes			
Additional historical controls			Yes			

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2.11: IV Estimates: Slave Share and Racial Imbalances

	Income Imbalance		Poverty Imbalance		Schooling Imbalance	
	(1)	(2)	(3)	(4)	(5)	(6)
Slave share (1872)	-0.200	0.320	0.843	1.134	1.097*	0.845*
	(1.026)	(0.794)	(1.219)	(0.947)	(0.657)	(0.499)
Black pop. share (2010)		-0.221		-0.124		0.107
		(0.175)		(0.209)		(0.110)
Observations	386	386	386	386	386	386
R-squared	0.015	0.017	0.027	0.021	-0.086	-0.043
Adj. R-squared	-0.004	-0.003	0.009	0.002	-0.105	-0.060
1872 controls			Yes			
Additional historical controls			Yes			

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Black and Mixed-race individuals have opposite signs, capturing a composition effect. However, this analysis relies on a smaller sample, as police-related deaths are not observed in all municipalities. Moreover, there is limited variation in this outcome, as shown in Figure 2.A.3, in almost half of municipalities, more than 90% recorded homicides by police intervention involved Afro-Brazilian individuals.

Table 2.13 presents regressions using the share of municipalities within each AMC that have adopted at least one anti-racist action, such as specific legislation, targeted public policies, or a municipal racial equity fund. The IV estimates are not statistically significant, but the positive coefficients suggest that municipalities with a higher historical slavery may be more likely to adopt

Table 2.12: IV Estimates: Slave Share and Police Lethal Violence (Share of Total Deaths)

	Afro-Brazilian		Black only		Mixed-race only	
	(1)	(2)	(3)	(4)	(5)	(6)
Slave share (1872)	1.974**	-0.701	1.113**	0.523	0.861	-1.224**
	(0.963)	(0.537)	(0.553)	(0.429)	(0.893)	(0.592)
Black pop. share (2010)		1.033***		0.228**		0.805***
		(0.115)		(0.092)		(0.126)
Constant	0.284	0.213	-0.121	-0.137	0.405**	0.350**
	(0.220)	(0.153)	(0.126)	(0.122)	(0.204)	(0.169)
R-squared	-0.303	0.395	0.010	0.113	-0.056	0.308
Adj. R-squared	-0.360	0.365	-0.005	0.068	-0.071	0.273
F-statistic	2.30	13.84	1.36	1.60	2.31	8.92
Observations	168	168	168	168	168	168
1872 controls			Yes			
Additional historical controls			Yes			

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

anti-racist actions today. However, the causal relation is unclear. On one hand, these actions may be a response to persistently high levels of racial inequality or violence. On the other hand, they could reflect greater racial awareness or stronger political participation by Afro-Brazilians.

Table 2.13: IV Estimates: Slave Share and Anti-Racism Actions

	Share of municipalities in AMC with any action	
	(1)	(2)
Slave share (1872)	0.872	0.722
	(0.612)	(0.471)
Black pop. share (2010)		0.064
		(0.104)
R-squared	0.031	0.042
Adj. R-squared	0.013	0.022
Observations	386	386
1872 controls	Yes	
Additional historical controls	Yes	

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

2.6.3
Inter-generational transmission

To assess the cultural channel, we examine whether municipalities with higher historical slave shares affected contemporary racial attitudes and bias. We use self-reported data from the ENEM socioeconomic questionnaire, which includes items on racial discomfort and perceived racism. Table 2.14 shows that municipalities with higher historical slave shares are associated with lower proportions of individuals who openly identify themselves as racist or report knowing someone who is. Slavery is also negatively associated with the share

of people who feel uncomfortable sharing space with individuals from other racial groups. To validate if this result is due to racial bias rather than general discomfort with social diversity, we compare the share of students who reported only racial discomfort with the share who reported non-racial discomfort (e.g., gender, religion). The association appears only for racial discomfort, supporting the interpretation that this mechanism reflects persistent racial attitudes on the legacy of slavery.

To address concerns related to self-reported survey data, especially on this sensitive topics about racism, we leverage an alternative data source. Equidade.Info is an ongoing, nationally representative survey of public schools in Brazil. It includes Implicit Association Test (IAT) scores[3] for teachers and school principals. As Bertrand, Marianne and Chugh, Dolly and Mullainathan, Sendhil (2005) explains, discrimination can arise not only from explicit, intentional actions but also from unconscious mental processes. The IAT test is widely used for measuring this implicit form of discrimination (Alesina *et al.*, 2024; Duryea *et al.*, 2025).

Although IAT data offer an ideal measurement of implicit bias, our analysis faces important limitations. We were only able to recover 405 IAT scores from educators, covering 49 municipalities, preventing us from conducting formal regressions. However, Figure 2.A.4 presents descriptive statistics from this data. Contrasting the previous result based on self-reports, the group of educators showing stronger implicit preference for white individuals tends to be located in municipalities with higher historical slavery shares. Interestingly, educators with the strongest implicit preference for Black individuals are also located in areas with high slavery intensity, although this group is small and may not be representative.

2.7 Conclusion

Estimating the long-run effects of slavery poses significant empirical challenges, particularly due to data limitations and the difficulty of isolating mechanisms. Despite these constraints, we document robust evidence that historical slavery intensity contributes to present-day racial disparities in incarceration and homicide victimization. We explore three plausible channels—structural, institutional, and cultural—and find suggestive evidence for each, though we acknowl-

[3]The Implicit Association Test (IAT) measures the strength of automatic associations individuals hold between concepts, such as race, and positive or negative attributes, providing a proxy for implicit bias.

Table 2.14: IV Estimates: Slave Share and Racial Bias

	Declares Racist		Declares Racist (Alt.)		Knows a Racist	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Self-identification and Exposure						
Slave share (1872)	-0.0115	-0.0479***	0.0157	-0.0343	-0.197	-0.490***
	(0.0236)	(0.0163)	(0.0252)	(0.0232)	(0.133)	(0.148)
Black pop. share (2010)		0.0527		0.0355		0.179***
		(0.0345)		(0.0327)		(0.0538)
R-squared	0.024	0.052	0.014	0.033	0.032	0.063
Adj. R-squared	0.006	0.034	-0.004	0.015	0.014	0.045
F-statistic	5.89	8.10	3.89	7.23	2.24	4.88
	Any Discomfort (Race)		Discomfort (Only Race)		Discomfort (Non-racial)	
	(7)	(8)	(9)	(10)	(11)	(12)
Panel B: Discomfort with Difference						
Slave share (1872)	0.00368	-0.0174**	-0.0471**	-0.0469**	-0.0303	-0.0303
	(0.0205)	(0.00827)	(0.0197)	(0.0192)	(0.0211)	(0.0211)
Black pop. share (2010)		-0.00947		-0.00819		-0.00122
		(0.0283)		(0.0299)		(0.0306)
R-squared	0.040	0.038	0.059	0.059	0.041	0.041
Adj. R-squared	0.022	0.020	0.041	0.041	0.023	0.023
F-statistic	6.83	6.64	7.48	7.46	6.83	6.83
	Concern with Race		Concern with Violence		Concern (Race or Violence)	
	(13)	(14)	(15)	(16)	(17)	(18)
Panel C: Concern with Race and Violence						
Slave share (1872)	0.0163	0.0137	-0.0135	-0.0187	0.00141	-0.0108
	(0.0228)	(0.0288)	(0.0234)	(0.0301)	(0.0218)	(0.0274)
Black pop. share (2010)		-0.0142		0.00489		-0.00611
		(0.0334)		(0.0366)		(0.0321)
R-squared	0.030	0.030	0.029	0.029	0.028	0.028
Adj. R-squared	0.012	0.012	0.010	0.010	0.010	0.010
F-statistic	5.23	5.23	5.11	5.11	4.95	4.95
Observations				354		
1872 controls				Yes		
Additional historical controls				Yes		

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

edge the potential endogeneity of some mechanisms, such as municipal racial equity policies or self-reported racism. Nonetheless, our analysis shows that the legacy of slavery remains embedded in Brazil's contemporary racial inequalities, underscoring the importance of historical institutions in shaping modern outcomes.

Appendices

2.A
Additional Figures

Figure 2.A.1: Share of enslaved people in 1872

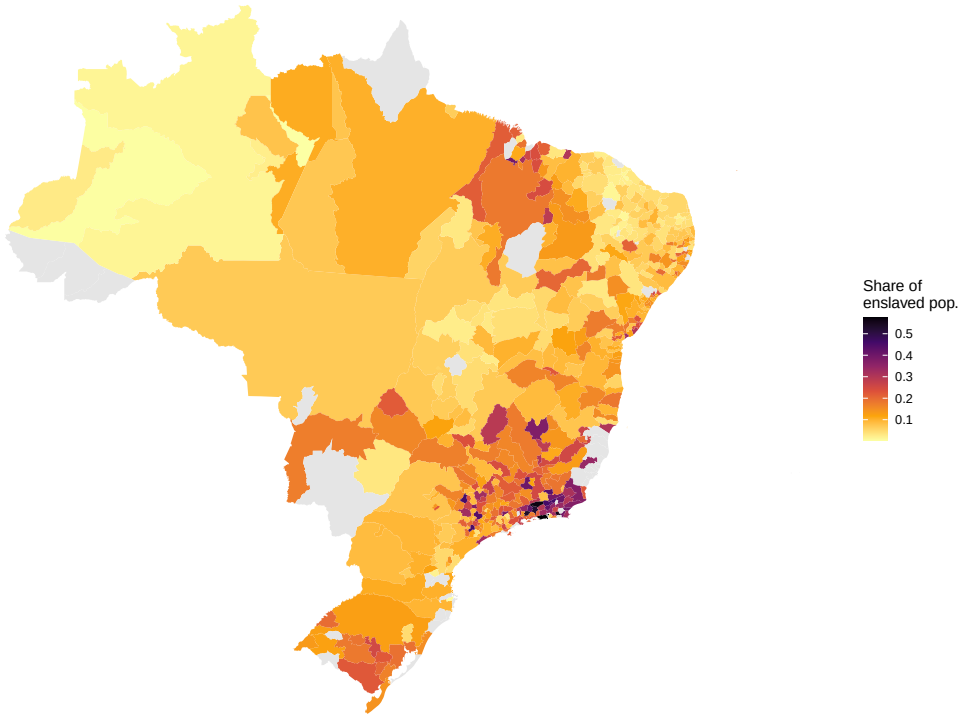


Figure 2.A.2: Physical and Mental Stereotypes of African Ethnic Groups in the 1920 Brazilian Census

Essa diversidade de caracteres morphologicos se acompanha de egual diversidade de attributos mentaes. Os grupos negros differem muito pelo temperamento, pela moralidade, pela intelligencia, pela actividade. Ha tribus de negros indolentes, como os gêgis e os angolas, como as ha de negros laboriosos, como os timinins, os minas, os dahomeyanos. Os minas, os yorúbas, os egbas, os krumanos, os felanins possuem temperamento docil e civilizavel, são negros pacificos, affeitos á obediencia e á humildade; já os haussás, os efans, os gallas mostram qualidades de altivez, rebeldia e mesmo ferocidade, que os fazem pouco apreciados pelos senhores, ou insusceptiveis de captiveiro. O gráo de moralidade tambem varia muito de tribu a tribu e, si ha negros de costumes honestos, como os yorubas, os egbas, os haussás, ha-os de caracter pouco resistente e facilmente corrompiveis, como os gêgis e os angolas. Estes são, porém, superiormente dotados no ponto de vista intellectual, ao passo que outros, como os gêgis, os krumanos, os cabindas, revelam a inferioridade mental, propria aos typos mais baixos da raça negra.

morphologicas e attributos psychologicos inconfundiveis. Os negros da tribu yebú, por exemplo, ou os da tribu cassange, ou haussá, embora reforçados e entroncados, têm a feialdade repulsiva dos typos negros puros. Os da nação mina, ou fula, ou achanti, ou felanin, são typos, ao contrario, de grande belleza, pela proporcionalidade das fórmas, pela suavidade dos traços, pela esvelteza da estatura, pela côr mais clara e pelos cabellos menos encarapinhados do que os das outras nações. No ponto de vista da pigmentação, a variedade é tambem enorme: ha desde o negro retincto e luzidio, como os loandas, os papels, os balondas, até ao azeitonado, como os gêgis e dahomeyanos e fellahs, ou mesmo ao bronzeado, como os minas, os achantis, os felanins, os agoins. No tocante á compleição e á estructura, ha typos athleticos e robustissimos, com os dahomeyanos, os haussás, os krumanos, os achantis, os gallas, e typos mais franzinos e debeis, menos solidos de estructura, como os monjolos e os angolas. Em relação á belleza plastica, nenhum delles sobreleva os jolofos e os sêrêres, cuja soberba compleição tem a pureza, a graça e a nobreza do typo europeu.

Note: Excerpts from the 1920 Brazilian Census discussing supposed morphological, psychological, and moral differences among African ethnic groups, based on pseudoscientific and racist classifications typical of early 20th-century thought. The text is written in archaic Portuguese.

Figure 2.A.3: Histogram of the share of Afro-Brazilian homicide due police intervention within municipality

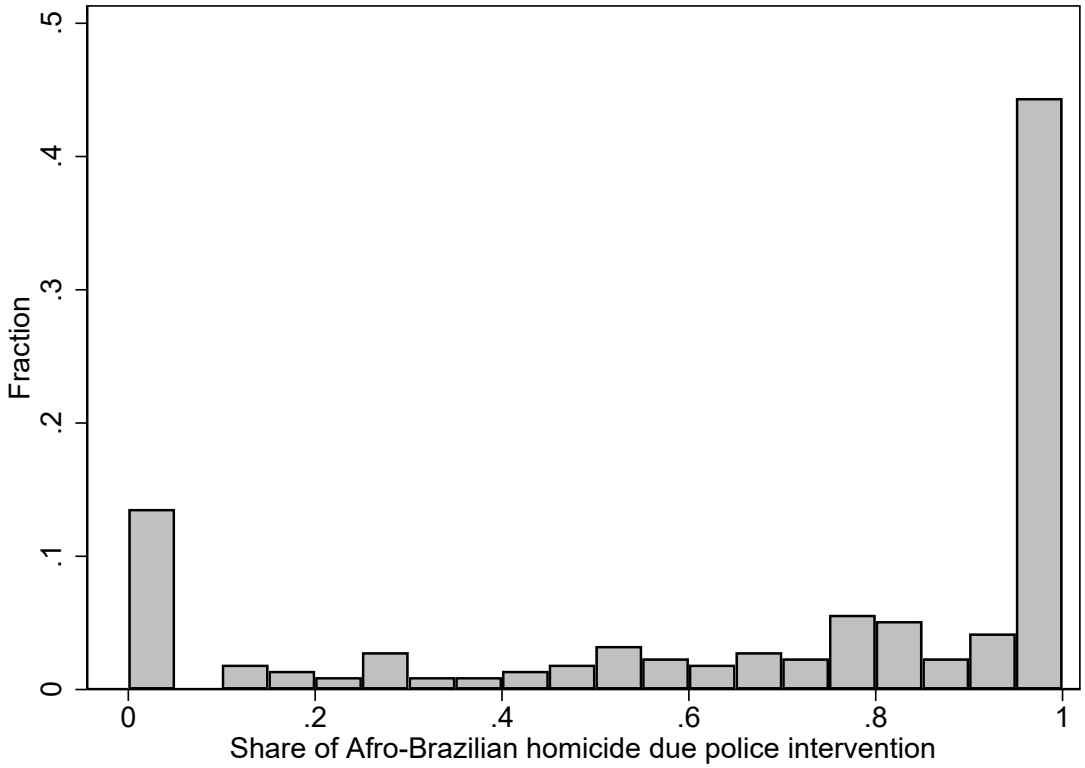
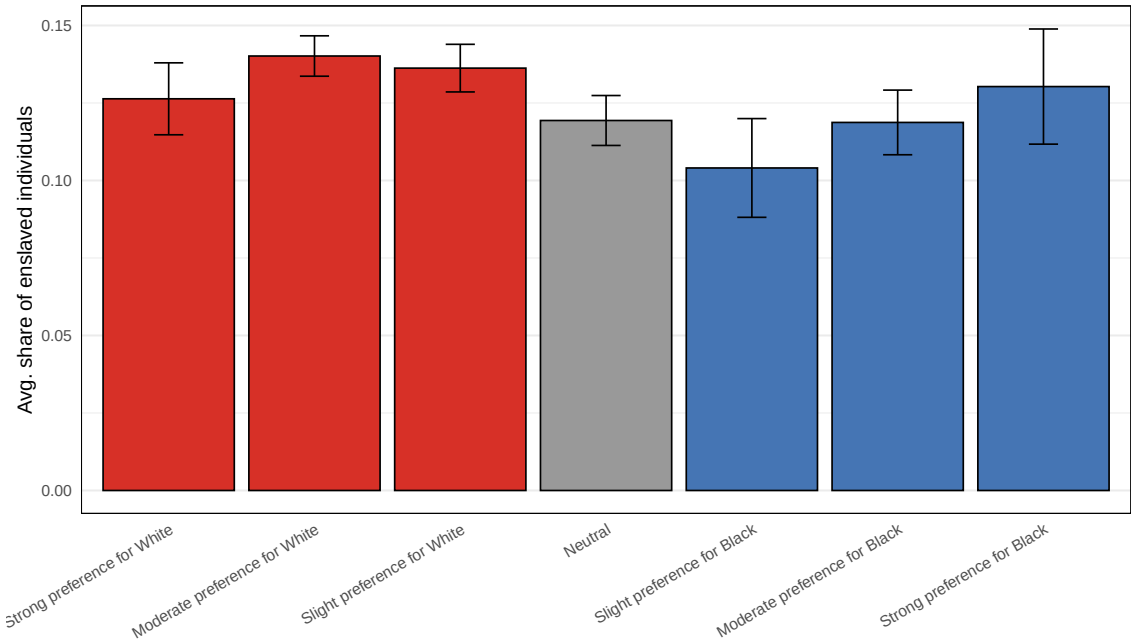


Figure 2.A.4: Implicit Racial Bias and the Average Share of Enslaved People



2.A
Additional Tables

Table 2.A.1: Monotonicity test for different sub-samples

	Population		Free Black		Literate		Area		Pop. density		Black & Brown		Black only	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Soil suitability – coffee	0.0868**	0.0508***	0.0472***	0.117*	0.0518*	0.0640**	0.107**	0.0367**	0.0318**	0.106*	0.0554***	0.186***	0.0280**	0.142***
	(0.0303)	(0.0148)	(0.0121)	(0.0478)	(0.0224)	(0.0204)	(0.0402)	(0.0121)	(0.0106)	(0.0442)	(0.0129)	(0.0198)	(0.00918)	(0.0338)
Observations	226	228	219	235	231	223	232	222	224	230	217	237	226	228
Adj. R^2	0.067	0.048	0.044	0.111	0.044	0.059	0.056	0.047	0.051	0.044	0.063	0.233	0.030	0.042

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3

Local and Destination Climate Shocks and Emigration Decisions: Evidence from Brazilian Semi-Arid

Abstract. This paper investigates how climate shocks and labor market structure shape internal migration in Brazil's semi-arid region. Using the bilateral migration framework from Borusyak *et al.* (2022), I estimate the impact of aridity shocks and labor market changes on out-migration rates, accounting for conditions in both origin and destination regions. To capture the relative attractiveness of destinations, I compute a migration-adjusted shock that subtracts from the local shock a weighted average of shocks in connected municipalities, with weights based on observed pre-shock migration flows. I construct a panel of municipalities using census microdata combined with weather and labor market data from 2000 to 2010. Results show that local aridity shocks increase out-migration, but the effect weakens when adjusting for destination conditions. Similarly, income growth in connected destinations raises emigration, while higher income at the origin helps retain population. These findings highlight the importance of modeling migration as a bilateral process shaped by both push and pull forces.

Keywords: out-migration; climate shocks; aridity; labor market.

3.1 Introduction

Climate change is expected to have economic and social effects, particularly in developing countries where adaptive capacity is limited. Among the possible responses, labor migration emerges as a key mechanism through which households respond to climate-related income shocks. When local economies do not fully absorb productivity shocks, emigration becomes a potential response.

The traditional literature examines how these shocks affect migration, focusing on either economic factors (Yagan, 2019) or climate-related disruptions (Gröger & Zylberberg, 2016). However, conventional regressions linking out-migration solely to local shocks are likely biased. Because migration decisions are bilateral phenomena, the conditions in potential destination locations also matter in determining out-migration decisions.

This issue has been solved in the literature focused on immigration. A growing set of papers uses a shift-share approach (Imbert & Ulyssea, 2023; Corbi *et al.*, 2024), where immigration in the destination is instrumented by shocks in origin regions. But what if we want to study out-migration?

There is extensive evidence on how out-migration flows and labor market composition respond to shocks. Although the effects of climate shocks remain ambiguous (Chakraborty, Tanika and Pandey, Manish, 2022), most studies on aridity shocks find a positive relationship between aridity and the decision to emigrate (Souza Costa Olivieri *et al.*, 2020; Falco *et al.*, 2022), and a negative relationship between droughts and agricultural labor supply (Albert *et al.*, 2021; Basu, 2023). However, this entire body of evidence relies on exploiting local shocks, without accounting for conditions in potential destinations that may also influence out-migration decisions.

Borusyak *et al.* (2022) develop a structural framework to analyze how local shocks affect migration decisions in the presence of endogenous location choice. Their empirical strategy is based on a bilateral adjustment, where the local shock is compared to a migration-weighted average of shocks in potential destination regions. This adjustment captures the idea that migration responds not only to factors at the origin but also to the relative attractiveness of destinations.

This paper applies this framework to investigate how aridity shocks and changes in labor market structures affect emigration decisions. The analysis is based on Brazilian Census microdata from 2000 and 2010, which allow us to reconstruct retrospective migration flows and measure municipality-level labor market conditions such as employment rates and hourly income. Following the

bilateral logic, we compute the relative shock by subtracting from the local shock a migration-weighted average of shocks in destination municipalities. These weights are based on migration flows observed before the shock. This allows us to isolate how much of the observed emigration is driven by local push factors versus the pull of more attractive destinations.

Focusing on Brazil's semi-arid region, I estimate a TWFE model of aridity shocks on emigration rates and find a positive coefficient for local aridity, suggesting that worsening climatic conditions lead to increased out-migration. The coefficient remains positive, though with smaller magnitude, when using the relative shock specification that adjusts for aridity levels in destinations. Using a first-difference specification between 2000 and 2010 with the accumulated aridity index, I find that the destination shock is significantly associated with emigration changes, highlighting the importance of taking into account factors shaping migration responses to climate-related shocks.

For labor market variables, the analysis focuses on structural changes rather than temporary shocks. As predicted by the original framework, once I adjust for changes in real income at migration destinations, the coefficient on relative income growth shifts in magnitude and aligns with the expected direction: municipalities with higher income growth tend to retain more of their population. When examining the destination-side shock directly, we find that greater increases in income at typical destinations are associated with higher out-migration from origin municipalities.

Related Literature. This paper contributes to the literature that estimates the impact of climate and labor market shocks on migration. Existing empirical work often includes migration-weighted average shocks as controls (Greenland *et al.*, 2019; Albert *et al.*, 2021). Based on the framework developed by Borusyak *et al.* (2022), this paper explicitly uses the migration-adjusted shock as a regressor, emphasizing the idea that emigration is a bilateral decision and the shock is interpreted relative to conditions at potential destinations. The paper highlights the importance of accounting for migration incentives that depend on both push and pull factors.

3.2 Background

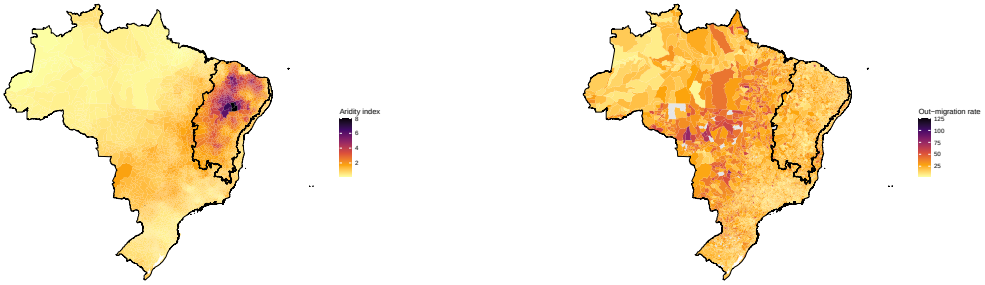
The Brazilian semi-arid region is defined based on aridity and precipitation indexes (Brasil, 2005). It is drier than the rest of the country and historically expe-

riences more frequent and severe droughts. Labor markets in the region are also weaker, with higher informality, lower wages, and overall worse socioeconomic indicators (Corbi *et al.*, 2024). These characteristics make the region relevant to study how climatic shocks and labor market structure interact to shape emigration patterns.

Historically, the semi-arid experienced substantial out-migration flows. Empirical evidence shows that emigration rates in the region respond positively to aridity shocks (Bastos *et al.*, 2013; Souza Costa Olivieri *et al.*, 2020). These studies focus on the long-run relationship between droughts and migration, tracing patterns since the 1970s. In contrast, my analysis focuses on more recent years.

Figure 3.1 displays the average aridity and out-migration rates across Brazilian municipalities from 2006 to 2010. The semi-arid region is outlined. As expected, aridity remains concentrated in this region. Interestingly, and in contrast to earlier findings, recent data show no clear pattern of higher out-migration from the semi-arid. This aligns with recent empirical evidence from Tafner *et al.* (2025), which shows that targeted policies, such as conditional cash transfers (*Bolsa Família*) and climate adaptation programs, have strengthened local resilience and reduced emigration.

Figure 3.1: Spatial Distribution of Aridity and Out-migration in Brazil (2006–2010)



(a) Aridity Index (b) Out-migration Rate

Note: The maps show the average aridity index and out-migration rate across municipalities between 2006 and 2010. The outlined area represents the official boundaries of the Brazilian semi-arid region.

Out-migration rates appear higher in areas near the current agricultural frontier, suggesting new dynamics on migration that fall beyond the scope of this paper. Because most prior studies focus on the semi-arid and use conventional estimation strategies, this paper restricts attention to this region while applying a new empirical framework that addresses potential endogeneity in local shock regressions. This allows for a clear comparison with existing evidence.

3.3
Data and Sample Construction

3.3.1
Implementation

Standard regressions rely on $\hat{L}_l = \alpha + \beta\hat{z}_l + \epsilon_l$, where $\hat{L}_l$ is the proportional change in population in location l, and $\hat{z}_l$ is an exogenous local shock. But migration is bilateral, destination conditions matter. This regression omits the shocks faced by potential destinations. Workers decide whether and where to migrate based on differences between their current location and alternatives. Ignoring this bilateral structure leads to biased estimates of migration responses.

Borusyak *et al.* (2022) construct a structural model taking account of this problem. In their framework, each individual chooses a location to maximize utility, where utility is a function of income adjusted by a location-specific shock. Migration is costly and the model accounts for relative attractiveness of alternative locations. The model leads to a logit-type choice structure, where the share of workers who leave origin l depends on the utility gap between l and potential destinations.

A variable $\hat{z}_{-l}$, the weighted shock exposure from connected municipalities, is essential to recover the causal effect of shocks in out-migration. In their key result, the proportional change in population in location l is a function of the differences between $\hat{z}_l$ and $\hat{z}_{-l}$ where $\hat{z}_{-l}$ is the average shock in destination municipalities, weighted by historical migration flows.

3.3.2
Data

Previous section shows that to empirically estimate the model, we need migration flows between cities to construct the measurement of z_{-l}. To do this, this paper uses two main databases to compute all migration flows, and construct emigration data and shocks, described below.

Census microdata. I use migration data from Brazil's 2010 Census microdata, which identifies individuals as migrants if they were not born in the municipality where they currently reside. The data also includes the duration of residence and the last municipality of residence, which allows me to track migration flows across municipalities and years. I aggregate these flows to construct municipality-year out-migration rates, defined as the number of emigrants per 1,000 residents

based on the 2000 population.

INMET. I collect meteorological data from INMET, which provides granular monthly observations from weather stations. I aggregate these into municipality-year measures and use them to compute the Aridity Index, defined as total evaporation over total precipitation during the year. This index captures aridity more effectively than precipitation alone because it accounts for the soil's ability to retain water Boffa *et al.* (2022).

To estimate migration-weighted shocks, I first computed bilateral migration flows from municipality of origin to destination using the 2010 Census. I focus on moves between 2001 and 2005 to ensure these flows are predetermined relative to our analysis period (2006–2010). For each origin municipality, we calculate the share of emigrants going to each destination. These shares are used as weights in the construction of migration-weighted shocks. Finally, by origin municipality, I aggregate the Aridity Index using this migration-weights to determine our non-local shock. Figure 3.A.1 shows an example of calculation.

Finally, I build a panel dataset at the municipality-year level for 2006–2010, containing the number of emigrants, the out-migration rate, the local aridity shock, the migration-weighted average shock faced by emigrants for each origin, and the difference between the local and weighted shocks. In addition, I identify municipalities that belong to Brazil's semi-arid region.

3.3.3 Empirical Implementation

In practice, we cannot observe the structural parameters of Borusyak *et al.* (2022)'s model directly. We instead use the model to guide the construction of an empirical specification that preserves its core logic. I use the Aridity Index as shock z_l and the average shock at destinations weighted by pre-determined migration flows from l, z_{-l}, to estimate the following regression:

$$EmigrationRate_{lt} = \alpha_l + \lambda_t + \beta(z_{lt} - z_{-lt}) + \epsilon_{lt} \tag{3.1}$$

where α_l and λ_t represent fixed effects of origin and year, respectively. I also estimate alternative specifications. The first includes only the local shock, z_{lt}, replicating traditional reduced-form migration regressions. The second includes the weighted destination shock z_{-lt} to assess how destination-side conditions affect migration flows.

3.4 Results

3.4.1 Aridity Index and Out-Migration

Table 3.1 presents the main regression results for municipalities in Brazil's semi-arid region, estimating the effect of aridity shocks on emigration rates using a two-way fixed effects specification with municipality of origin and year fixed effects. Each column corresponds to a different specification of the emigration regression. Column (1) reports the standard approach that includes only the local aridity shock as a predictor. The estimated coefficient is small and statistically insignificant, suggesting that local conditions alone do not explain emigration patterns. Column (2) implements the bilateral migration specification, using the relative shock: the difference between the local shock and the migration-weighted average shock in destination municipalities. The coefficient remains small and statistically indistinguishable from zero. Finally, column (3) includes only the average destination shock as independent regressor. Here, the estimated effect of the destination shock is positive, though not statistically significant.

Table 3.1: Regression Results – Semi-arid Region

	(1)	(2)	(3)
Local shock	0.041		
	(0.159)		
Relative shock (z_l - z_{-l})		-0.063	
		(0.253)	
Destinations' shock			0.193
			(0.284)
Observations	7,164	7,164	7,164
R^2	0.505	0.505	0.505
Adjusted R^2	0.377	0.377	0.377
Municipality FE	✓	✓	✓
Year FE	✓	✓	✓

Note: Robust standard errors clustered by municipality in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

While none of the coefficients in Table 3.1 are statistically significant, they exhibit signs in the opposite direction to the theoretical expectations. One potential explanation lies in the temporal mismatch between migration responses and the measured shocks. Migration is more likely to react to persistent, cumulative shocks rather than short-term fluctuations. However, the panel specification in

Table 3.1 relies on contemporaneous aridity shocks, which may not fully capture the longer-term climatic pressures that drive emigration. Temporary variation in aridity in a single year may not be sufficient to generate observable migration responses, particularly given adjustment costs to migrate. To address this limitation, we estimate a first-difference model where the change in emigration rates between 2000 and 2010 is regressed on the change in accumulated aridity over the preceding five-year periods (2006–2010 versus 1996–2000). This specification better capture accumulated climate variation over time. Results from this alternative specification are presented in Table 3.2.

Table 3.2: Effect of Aridity Changes on Migration Rate (First Differences)

	(1)	(2)	(3)
Aridity – local	-0.026		
	(0.017)		
Aridity – relative		0.033	
		(0.025)	
Aridity – destination			-0.093***
			(0.025)
Observations	735	735	735
R^2	0.003	0.002	0.018
Adjusted R^2	0.002	0.001	0.017

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

In Table 3.2, Column (1) presents the standard specification using only the local aridity shock. The coefficient is negative, contrary to expectations, and statistically insignificant. Column (2) reports results using the relative shock defined as the local shock adjusted by aridity conditions in typical destinations. Although not statistically significant, the coefficient has the expected positive sign, suggesting that municipalities experiencing a larger increase in aridity relative to their destination alternatives exhibit greater increases in emigration rates. Finally, Column (3) isolates the effect of destination shocks alone. The coefficient is negative and statistically significant, indicating that when the average climatic conditions in destination municipalities worsen, origin locations retain more of their population.

3.4.2
Labor Market and Out-Migration

To explore the relationship between labor market dynamics and migration, we estimate a first-difference model regressing the change in the emigration rate

between 2000 and 2010 on the change in local labor market conditions over the same period. To account for the importance of migration destinations, I follow the structure of Borusyak *et al.* (2022) and adjust local changes by subtracting the migration-weighted average change in labor conditions in destination municipalities. Due to the limitation of having only census data for the years 2000 and 2010, in this analysis, the variables capture longer-term structural changes in the labor market. Since the original framework proposes a shock-based design, we interpret the results as descriptive associations. Rather than identifying causal effects, this analysis extends the logic of the structural framework model to highlight how shifts in labor market conditions in both origin and destination areas affect migration responses. Another advantage of this approach is that Census microdata allows me to identify overall and rural-specific labor market characteristics.

Table 3.3 shows that labor market conditions are strongly associated with changes in out-migration. As expected, municipalities with greater increases in employment retained more residents, and the magnitude of this effect declines once we account for labor market conditions in potential destinations. Out-migration appears to be less sensitive to changes in the agricultural labor market. This result is consistent with findings from Tafner *et al.* (2025), who show that programs such as *Bolsa Família* and rural insurance contributed to reducing emigration in Brazil's semi-arid region. However, the coefficient on employment conditions in destinations has a sign opposite to what we anticipated. A possible explanation is endogeneity: improvements in labor market outcomes in typical destinations may be partially driven by the arrival of migrants themselves, as documented by Imbert & Ulyssea (2023).

Table 3.3: Effect of Employment Rate on Migration (Overall and Rural)

	General	Rural	General	Rural	General	Rural
Employment rate – local	-0.686***	-0.112***				
	(0.140)	(0.028)				
Employment rate – relative			-0.488***	-0.099***		
			(0.147)	(0.028)		
Employment rate – destination					-2.828***	-0.453***
					(0.486)	(0.149)
Observations	735	734	735	734	735	735
R^2	0.032	0.022	0.015	0.017	0.044	0.013
Adjusted R^2	0.030	0.021	0.013	0.016	0.043	0.011

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4 presents the results on the relationship between changes in hourly income and changes in migration rates. The findings are consistent with the prediction in Borusyak *et al.* (2022) that focusing solely on local shocks can lead to

biased estimates. Once we adjust for income variation in migration destinations, the coefficient on local income growth becomes negative, indicating that higher real income growth is associated with lower emigration. The effects are more pronounced in rural labor markets, suggesting that rural workers are more sensitive to income changes. Additionally, the results show that stronger income growth in destination areas increases emigration from origin municipalities, reinforcing the importance of destination areas in out-migration analysis.

Table 3.4: Effect of Hourly Income on Migration (Overall and Rural)

	General	Rural	General	Rural	General	Rural
Hourly income – local	0.319***	0.217***				
	(0.064)	(0.081)				
Hourly income – relative			-0.054	-0.101***		
			(0.034)	(0.036)		
Hourly income – destination					0.163***	0.176***
					(0.036)	(0.039)
Observations	735	735	735	735	735	735
R^2	0.033	0.010	0.003	0.010	0.027	0.027
Adjusted R^2	0.032	0.008	0.002	0.008	0.026	0.025

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Finally, Table 3.5 accounts for the relative shocks in both climate and labor market conditions simultaneously. The results confirm that controlling for destination conditions alters the interpretation of local labor dynamics: relative increases in employment rates and hourly wages are associated with reductions in emigration. This effect is especially pronounced in rural labor markets, where changes in both employment and income show stronger and more precisely estimated coefficients. The aridity shock remains statistically insignificant, but its positive sign is consistent with theoretical expectations.

3.5 Conclusion

This paper examines how aridity shocks and labor market conditions affect out-migration from Brazil's semi-arid region, using a bilateral migration framework that accounts for destination-side conditions. Using recent data from 2000 to 2010, the analysis captures a period when climate resilience policies, such as conditional cash transfers and climate adaptation programs, may have reduced how strongly migration responds to local shocks. In line with this, I find that local aridity shocks no longer significantly affect out-migration, although the estimated sign remains consistent with expectations. When applying a conven-

Table 3.5: Effect of Climate and Labor Conditions on Migration (Column 3 Only)

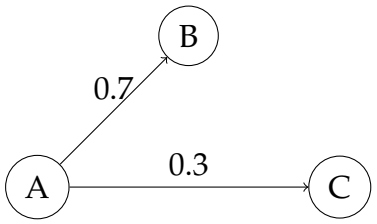
	General	Rural
Aridity – relative	0.018	0.017
	(0.029)	(0.029)
Employment rate – relative	-0.518***	-0.104***
	(0.148)	(0.028)
Hourly wage – relative	-0.063*	-0.103***
	(0.035)	(0.031)
Observations	735	735
R^2	0.021	0.030
Adjusted R^2	0.017	0.026

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

tional model that includes only local shocks, the estimated coefficients are often imprecise and can even change signs. Once I account for conditions in destination regions using the migration-adjusted shock, the direction of effects aligns with theory. Structural changes in local labor markets, especially income growth, also play an important role: municipalities with stronger income growth retain more of their population, while rising incomes in typical destinations increase out-migration. These findings highlight the importance of modeling migration as a bilateral process and suggest that ignoring destination conditions can distort conclusions about migration responses to both climatic and economic shocks, especially in settings with increasing climate resilience.

Appendices

Figure 3.A.1: Migration from A and weighted shock calculation



Explanation:

- Municipality A emigrants: 70% to B, 30% to C.
- Weighted shock:

$$z_{-A} = 0.7z_B + 0.3z_C$$

Conclusion

This dissertation presents three empirical studies that advance our understanding of how institutions, history, and climate shocks shape labor market and socioeconomic outcomes in Brazil. The first chapter contributes to the debate on Labor Economics by showing how firms respond to increases in labor protections. The findings suggest that regulations can generate unintended consequences, such as reducing new hires and increasing separations, or changes in compensation composition, as also discussed in Cahuc *et al.* (2019) and Carvalho *et al.* (2018).

The second chapter highlights the persistence of historical slavery in shaping contemporary racial disparities in Brazil. While the legacy of slavery has been extensively studied in other contexts, this chapter contributes new evidence by linking 19th-century slave intensity to present-day racial gaps in violence and incarceration. Although translating this into direct policy recommendations is not straightforward, the findings help us better understand the structural roots of Brazil's racial inequalities.

The third chapter shows that out-migration is shaped not only by local push factors, but also by the relative attractiveness of destination regions. This has implications for how we design and interpret migration studies and suggests that policies aimed at retaining population in vulnerable areas should also consider attractiveness in typical destinations. Together, the three chapters outline a research agenda in Labor and Development Economics, using applied microeconomic methods to address policy-relevant questions in the context of a developing country.

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