Minimum Wages and Informality*

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Abstract

How do minimum wages affect informality? We study the near-doubling of the real minimum wage from 2000 to 2009 in Brazil, where 46% of the workforce is informal. Using labor force surveys covering the informal sector, we show that the minimum wage increases wages for informal employees, with an effect about two-thirds the size of that on formal employees. Wage gains are especially pronounced in areas with greater enforcement capacity, among industries with a low share of informality, and for informal workers with a greater number of formal outside options. In light of these wage spillovers in the informal sector, reallocation away from formal employment is muted: a 10% gain in formal sector wages from the minimum wage translates to 2.8% of workers reallocated from formal to other forms of employment. Examining heterogeneity across workers, reallocation is smaller precisely where wage gains to informal workers are larger, a pattern that contrasts with many existing models of informality.

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1 Introduction

Minimum wages are a popular labor market policy throughout the world, including in low- and middle-income countries with high levels of informality. What are the effects of minimum wage increases in these settings? Standard, perfectly competitive models of dual-sector economies predict that wage floors should induce sizable reallocation from formal to informal employment and reduce wages in the informal sector.[1] At the same time, recent evidence suggests that strict segmentation is a poor characterization of formal vs. informal employment and that gradients of informality may be a more accurate description of labor markets (Meghir et al., 2015; Ulyssea, 2018; 2020; Haanwinckel and Soares, 2021; Feinmann et al., 2024). What are the implications of integration between the formal and informal sector and heterogeneity in informality for the wage and reallocation effects of the minimum wage?

To shed light on this issue, we study large increases in the national minimum wage that occurred in Brazil between 2000 and 2009. These increases moved the country from a regime of low minimum wage bite (a minimum-to-median wage ratio of 0.34) to one of high bite (a minimum-to-median wage ratio of 0.58) in ten years. About 46% of all workers employed in the Brazilian private sector are informal. Within this group of workers, there is substantial heterogeneity in their type of employment and working conditions: about half of informal workers work in jobs that are arguably similar to those of formal workers, while the other half are employed in highly informal sectors. These features of the Brazilian labor market, combined with the availability of rich data capturing formality status and earnings, make Brazil an ideal context for analyzing the effects of minimum wages on informality.

Using a variety of difference-in-differences approaches leveraging the bite of the minimum wage across states and industries, we estimate the effects of the policy on formal workers, informal workers, and the self-employed. We examine the effects of the policy over a 20-year period and more granularly along the wage distribution using bunching designs. Further, we make use of several data sources, including the Census, multiple labor force surveys tracking formality status and formal-to-informal transitions, administrative employer-employee earnings data on the formal sector, and information on labor law enforcement, to build a fuller understanding of potential wage spillovers on informal workers.

We find immediate and substantial wage effects of the minimum wage on informal work-

[1] There is a long tradition that views the informal sector as the disadvantaged sector of a dualistic or segmented labor market. See, e.g., Peattie (1987); Fields (1975; 1990); Turnham and Erocal (1990); Tokman (1992); Portes and Schauffler (1993); La Porta and Shleifer (2014) for overviews and the Harris and Todaro (1970) model.

ers. For an identical increase in bite as in the formal sector, informal wages increase by 66% of the increase in the formal sector. Wage increases for both formal and informal workers are concentrated in the part of the distribution near the minimum wage. We find no evidence of earnings increases for the self-employed. Enforcement intensity, employer compliance practices (namely, pay-setting practices in industries and firms hiring both formal and informal workers) and a measure of integration between the two sectors—the share of each informal worker's outside options that is in the formal sector—all mediate wage effects among informal workers. Wage spillovers to informal workers blunt reallocation out of formal employment in response to the policy: a 10% increase in formal wages from the minimum wage leads to 2.8% of workers moving from formal to other forms of employment. Where wage gains to informal workers are higher, reallocation is smaller. Our findings contrast with existing models of informality, and suggest that partial enforcement, employer compliance practices, and workers' bargaining power play a role in wage determination in the informal sector.

Our analysis unfolds in five main steps. First, we show that the monthly earnings distributions of formal workers *and* informal workers strongly track the minimum wage throughout the period of large increases in the 2000s. We observe full compliance with the policy among formal workers and substantial bunching at the minimum: 20% of the workforce is paid within 10% of the minimum wage in 2009, the peak of the minimum in terms of bite. Compliance is also substantial for informal employees, starting at just under 90% in 1999, falling to 80% in 2009. Nevertheless, the mass at the minimum is even higher among informal workers relative to formal employees—25% in 2009. Moreover, incumbent informal workers experience wage gains when the minimum wage increases, so that the shifting spike at the minimum is not simply driven by changes in the composition of informal workers.

Second, to quantify the magnitude of the wage effect among formal employees, we use a difference-in-differences design exploiting variation in the bite of the reform across states and industries. We measure the bite of the reform for the formal sector as the fraction of formal employees paid at or below the 2009 minimum wage in 1999, across 279 state and industry cells defined pre-reform. We find that a one standard deviation increase in the share of affected workers is associated with a 13.2 log point increase in average monthly wages. Using a bunching difference-in-differences design *à la* Cengiz et al. (2019) reveals that the effects of the 2009 minimum wage are concentrated at the minimum wage for formal workers, with no impacts higher in the wage distribution. Using a similar research design, we find large and immediate wage increases among informal employees and that wage increases are similarly localized around the minimum. A one standard deviation increase in the share of

affected workers is associated with a 11.1 log point increase in average monthly wages. For an equivalent change in the fraction of affected workers, the wage increase among informal employees is about 66% that of the formal wage effect. By contrast, we find no effect of the minimum wage increases on earnings of the self-employed.

Third, our wage effects are robust to a series of specification checks and are consistent across data sources. Using a bunching difference-in-differences approach separately by year, we show that effects on the density of wages show up exactly in the bin containing the statutory minimum for that year. Further, we show consistent effects on wages using census data, where we can also use a microregion-by-industry design, and thus exploit finer geographical variation in the bite of the minimum wage.[2] Wage effects among both formal and informal employees are of the same magnitude within state-by-industry cells as within microregion-by-industry cells, suggesting that wage spillovers on informal workers occur within fine local labor markets or firms, consistent with a recent evidence on minimum wage spillovers (Machin and Giupponi, 2024; Hjort et al., 2026).

Fourth, we shed light on the factors mediating the minimum wage's effects on informal wages. Earlier studies argue that the minimum wage may serve as an anchoring point (a "lighthouse" effect) or numéraire for wage determination in Brazil, especially under hyper-inflation, and have found bunching not only at the minimum wage but also at multiples of it (see, e.g., Neri (1997), Neri et al. (2001), and Soares (2004)).[3] We extend this descriptive evidence to the present, a period characterized by moderate inflation in Brazil, and document continued bunching at the minimum wage in the informal wage distribution, but not at multiples of it.

Although anchoring remains a plausible mechanism in our setting, we provide novel evidence on the role of three additional forces in the paper: enforcement intensity, employer compliance practices, and workers' bargaining power. First, we follow a recent literature that uses distance from labor inspection offices as a measure of enforcement capacity and document that areas with weaker enforcement see smaller wage effects among informal workers (Almeida and Carneiro, 2012; Ponczek and Ulyssea, 2022). Second, we show that more formal industries—in which many informal workers are employed by formal firms

[2]Microregions are groups of geographically contiguous municipalities within a state, as defined by the Brazilian Institute of Geography and Statistics (IBGE).

[3]Similar findings and arguments are presented for other Latin American countries in, e.g., Maloney and Nuñez Mendez (2004) for a comparison of Brazil, Mexico, Argentina, Uruguay and Colombia for select years in the late 1990s, and Kaplan and Pérez-Arce (2014) for the case of Mexico. See Souza and Baltar (1979) for the introduction of the idea that the minimum wage could serve as a reference for wage-setting generally in a context of high inflation and formal indexation institutions ("efeito-farol") in Brazil.

alongside formal workers (the "intensive margin" of informality; Ulyssea, 2018)— see larger wage effects among informal workers. Third, we compute the value of workers' outside options (as in Caldwell and Danieli, 2024) in formal and informal jobs and show that informal workers with a higher share of formal outside options benefit more from the minimum wage.[4]

Lastly, we turn to employment effects, using our research design to study shifts out of formal employment to all other forms of employment. We examine this both with linear probability models as well as a bunching design that transparently documents employment effects along the wage distribution. We find very small effects on formal employment around the part of the distribution close to the minimum wage. Using a conservative approach that takes into account changes in employment across the entire wage distribution, we find modest declines in formal employment. Combined with our estimates on formal sector wage increases, our estimates on declines in formal employment imply an own-wage reallocation elasticity of -0.28. That is, a 10% increase in average formal wages is associated with a 2.8 percent shift towards other modes of employment. To provide some perspective on the magnitude of this elasticity, we simulate a counterfactual evolution of the formal share of employment absent the 2000-2009 minimum wage increases and find that the formalization process would have been sped up by at most one year for the entire private workforce of salaried workers.

Related literature. An extensive literature studies the economic effects of the minimum wage. Although most of it is focused on the United States and Europe, there is growing attention paid to countries with high informality: see Neumark and Mungía Corella (2021) and Broecke et al. (2017) for two recent reviews. Due to the difficulty in measuring the informal sector with microdata (Perry et al., 2007), the recent literature focuses mainly on wage and employment effects in the formal sector (Engbom and Moser, 2022; Saltiel and Urzúa, 2022). Our main contribution to this literature is to quantify how the minimum wage affects the informal sector.

In doing so, we build upon a string of earlier studies documenting, for select years in Brazil, that the informal wage distribution features clear bunching at the minimum wage and that sizable shares of informal workers receive wage readjustments that closely follow minimum wage increases (e.g., Neri, 1997; Neri et al., 2001; Fajnzylber, 2001; Soares, 2004;

[4]Specifically, we construct a measure of workers' outside options that captures the diffusion of workers of a certain type across different jobs in the economy, exploiting the fact that workers with certain education and demographic characteristics who appear in a wide variety of jobs have a stronger position in the labor market.

Lemos, 2009).[5] We extend this descriptive evidence by documenting spikes in the informal wage distribution over a 20-year period combining evidence across several data sources. We further show that compliance with the minimum wage in the informal sector varies by the degree of formality at the industry level and by the formality status of the employer.

Relative to the strand of the literature that, like us, also aims to formally quantify the effects of the minimum wage on formal wages, informal wages, and formalization (Neumark et al., 2006; Lemos, 2009; Bosch and Manacorda, 2010; Hinojosa, 2019; Jales, 2018; Broecke et al., 2017; Neumark and Mungía Corella, 2021),[6] we contribute in three main ways. First, we use variation in the bite of the policy across state and industry cells and apply recent advances in the minimum wage literature to estimate effects throughout the wage distribution (Harasztosi and Lindner, 2019; Cengiz et al., 2019). Second, we highlight the potential mediating role of economic forces that have not been well-documented empirically so far.[7] Third, we use our estimates to compute the own-wage reallocation elasticity, a statistic that we believe should be computed more systematically to summarize the effects of the minimum wage on formal employment in low- and middle-income countries to maximize comparability across studies in different settings.

Our study also has implications for labor market models of informality. We contribute to a growing body of work on the ways that formal and informal firms are highly integrated as opposed to segmented (see Maloney and Nuñez Mendez (2004) for evidence on Latin-American countries). In Machado Parente et al. (2025), which provides a static monopsony model of the labor market, workers are homogeneous while firms differ in productivity. Firms below a certain level of productivity cannot operate profitably at the minimum wage and choose to operate informally. Wages in the informal sector increase due to this influx of relatively higher productivity firms, in other words, through composition effects. Thus, the larger the reallocation effects, the larger the wage increase in the informal sector. Haanwinckel (2024) also models a frictional, integrated labor market, but one in which workers with heterogeneous skills search for both formal and informal jobs from unemployment, and wages are determined by Nash bargaining. In this model, the minimum wage lowers demand for low-skilled workers in the formal sector and raises unemployment. This increase in unemployment lowers the outside option of workers at informal firms, thus lowering their

[5] See Card and Krueger (1995) and Brown (1999) for the existence of a spike at the minimum wage in the uncovered sector in the United States.

[6] A related literature examines non-compliance with the minimum wage in higher-income countries (Clemens, 2021; Clemens and Strain, 2022; Stansbury, 2025).

[7] Another paper that examines the role of outside options in mediating reallocation is Paul-Delvaux (2024), which studies recent national minimum wage increases in Morocco.

wages. As noted in Haanwinckel (2024), the prediction mirrors that of the traditional dual sector model: minimum wages cause reallocation and a fall in informal wages. Lower reallocation would mute the negative wage effect on the informal sector.

Our results are more consistent with a frictional labor market in which formal jobs constitute real outside options for informal workers (for example, Meghir et al. (2015)), and the minimum wage compresses and shifts the formal outside option distribution. The ultimate effect on informal wages depends on the elasticity of formal labor demand (or the arrival rate of formal job offers in a search context). High elasticity of formal labor demand can lead to smaller (or even negative) wage effects on informal workers while a low elasticity generates large, positive wage effects. Our analysis of mediators of informal wage effects and formal employment effects reveals exactly this pattern. Finally, Ulyssea (2018) provides evidence that formality and informality co-exist within the same firm. Our evidence is consistent with compliance practices that also vary across employers, with formal firms paying the minimum wage even to their informal workers. Combining partial enforcement, pay-setting practices in industries and firms hiring both formal and informal workers, and workers' bargaining power is a promising direction for future models of informal and formal labor markets.

In addition to the above, our findings extend the growing literature on spillovers of minimum wages across multiple dimensions. Machin and Giupponi (2024) find large within-firm spillovers of the minimum wage to younger workers. Hjort et al. (2026) document "anchored" wage setting with transmission of minimum wage increases from the headquarters of multinationals to their establishments abroad, and Hazell et al. (2025) find evidence of national wage setting by multi-establishment firms in the U.S. Derenoncourt and Weil (2025), by contrast, find limited spillovers from voluntary firm minimum wages onto competitors. Bassier (2022) studies sectorally bargained wage floors and finds large spillovers to the uncovered competitors of covered firms. We document spillovers of the minimum wage to workers in informal work arrangements, where compliance with labor market regulations is thought to be minimal.

Roadmap. The paper is organized as follows. Section 2 provides the institutional context of the 2000s-era minimum wage increases in Brazil and presents our data. Section 3 analyzes compliance with the minimum wage among the different categories of workers. Section 4 discusses our empirical strategy for estimating wage effects of the minimum wage on different groups of workers. We report our wage results and robustness checks in Section 5. Section 6 explores drivers of the wage effects on informal workers. Section 7 assesses whether the

minimum wage displaced workers from employment to non-employment, and out of formal salaried employment to informal arrangements or to self-employment. We present own-wage reallocation elasticities that combine estimated wage effects with a bunching difference-in-differences design for analyzing employment changes. Section 8 discusses the implications of our results for labor market models of informality. Section 9 concludes.

2 Context and Data

Brazil underwent large minimum wage increases in the 2000s, making the country an ideal context for studying the effects of the minimum wage on informal workers. We provide background on these increases below and detail the data sources we use to measure their effects in both the formal and informal sectors.

2.1 Context on the 2000-2009 minimum wage increases

The minimum wage in Brazil is set in monthly gross terms, at the federal level. It applies to all regions, states, industries, and occupations. While subnational minimums exist in some states and industries, the federal minimum remains the most important wage floor throughout the country.[8]

Legislation and enforcement. Legally, the minimum wage applies to all workers, regardless of whether or not they are employed via a formal contract.[9] Enforcement occurs either through labor inspections or workers' claims. Whether formal or informal, any worker can file a claim against their employer if they are paid below the minimum wage. In 1999, firms found to violate minimum wage laws were subject to penalties of up to 11 times the monthly minimum wage per worker paid below the minimum wage. The amount of the fine doubles in case of recidivism. We provide additional details on the legislation and on the penalties associated with paying below the minimum wage in Appendix A.

[8]Since 2001, five states have raised the minimum wage above the federal level in particular industries and occupations. However, even across studies that have leveraged the richness of the matched employer-employee data, there is no definitive evidence that these wage floors are binding. In particular, Corseuil et al. (2013) reported non-compliance with the floor in Paraná and São Paulo. Finally, we show using our database of state-by-industry minimum wages that the bite of the federal minimum across states and industries is highly correlated with the bite of the highest applicable minimum, taking subnational minimum wages into account. See Section 5.3 for more details.

[9]The 1943 Labor code, Article 76, stipulates that "the minimum wage is the minimum compensation owed and paid directly by the employer to every worker."

Sharp increases from 2000 to 2009. The ratio between the federal minimum wage and the median wage for full-time formal workers rose from 0.34 in 1999 to 0.58 in 2009, leveling off thereafter (see Figure 1a). This was a stark increase: in 1999, the minimum-to-median wage ratio in Brazil was similar to the contemporaneous ratio in the U.S. A decade later, the ratio was close to the contemporaneous ratio in France (OECD, 2025), or, equivalently, the ratio in the U.S. when the minimum wage peaked in 1968 (Derenoncourt and Montialoux, 2021). The magnitude of this increase is comparable to the 2000-2002 minimum wage reform analyzed by Harasztosi and Lindner (2019) in Hungary.

Evolution of the structure of employment. Brazil is characterized by a large informal sector. We follow Ulyssea (2018) and Haanwinckel and Soares (2021) in defining the informal sector as unregistered employees (i.e., those without an official working permit), but we differ from them by including domestic service workers, a key low-wage group likely affected by the minimum wage.[10] We analyze the self-employed separately from informal salaried workers because they set their own wages. The private formal sector, by contrast, is comprised of workers with an official working permit (called the *carteira assinada*). Appendix Figure A1 shows that the formal sector expanded from 1995 to 2015, while the informal sector shrunk. In 1999, 54% of all prime-age workers in the private sector were employed in the formal sector, increasing to 62% by 2009 and to 68% by 2015.

In Appendix Figures A2 and A3, we provide additional details on the evolution of all adults' work status and on the broader macroeconomic context during these years. Employment and labor force participation rose over this period while unemployment fell. GDP grew significantly around the same time as the minimum wage hikes, and the country gradually expanded social assistance through the introduction of the cash transfer program Bolsa Família. We discuss the importance of controlling for these macroeconomic factors and policy changes in Section 5.3.

2.2 Data

A rich set of data sources facilitates studying minimum wage effects on formal and informal workers in Brazil. We describe these sources below, as well as the long-run series we construct on informal workers distinguishing those likely employed by formal firms vs. informal firms. Appendix B provides additional details on the data sources we use and documents that the

[10] Domestic service workers account for 17% of all informal employees in our sample.

different sources are both consistent with each other and well-suited to study the effect of the minimum wage increases.

PNAD and census data. We use and combine a variety of publicly available data on the Brazilian labor force. Our main analysis uses the *Pesquisa Nacional por Amostra de Domicílios* (PNAD), for the years 1995-2015. PNAD is an annual national household survey, similar to the Current Population Survey in the United States.[11] It contains information on all individuals regardless of their labor market status. The main advantage of this data source is that it contains information on workers employed in the informal sector, and since 2011, asks informal workers about the formality status of their firm, a question that we later use to study heterogeneity in compliance by firm formality status. The measure of earnings we use is a measure of gross monthly wages earned in September each year.

We also exploit Census micro-data in 2000 and 2010 to cross-check the pattern and magnitudes of our wage results with what we observe in PNAD.

Urban Informal Economy survey (ECINF) 1997 and 2003. ECINF is a survey of small establishments (up to five employees) with information on firms' formality status that was conducted in 1997 and 2003. We use these data to show that informality shares at the industry level (as measured in PNAD) align well with the formality status of the employer of informal employees in ECINF 1997 and 2003 (see Section 6.2).

Matched employer-employee data. This dataset is called *Relação Anual de Informações Sociais* (RAIS) and contains information on employment spells, earnings, and the number of contracted hours for the universe of workers employed in the formal sector in Brazil. We use this data source to cross-check that the monthly earnings distributions as reported by firms match well the monthly earnings distributions reported by workers in the household survey data.

Monthly employment survey data. This survey called *Pesquisa mensal de emprego* (PME) is a household survey conducted monthly in six metropolitan areas: Belo Horizonte, Porto Alegre, Recife, Rio de Janeiro, Salvador and São Paulo. We use PME-Nova from 2002 to 2015 and leverage its longitudinal format to document transitions in and out of the formal and the informal labor force, as well as in and out of employment.

[11] PNAD is not conducted during the year the Census is enumerated, so there is no survey in 2000 and 2010.

Minimum wage database. We compile a database of minimum wages from 1940 (the introduction of the federal minimum in Brazil) to 2020. The database contains the values of the federal minimum wage each month in nominal terms using information published by the Brazilian Institute of Geography and Statistics (IBGE) website.[12]

Sample. Our sample includes all prime-age workers, aged 25 to 54. Workers younger than 25 may be enrolled in higher education; this share is small but increasing during our period of study (1995-2015). Table 1 shows that 10% of private formal workers in 1999 had completed a college education. This figure is 17% in 2015. We pool individuals into two racial groups, white and non-white.[13] Monthly earnings are winsorized at the 1st and 99th percentiles and deflated using the price index published by the Brazilian Institute of Geography and Statistics (IBGE). We focus on full-time workers (i.e., working more than 40 hours a week) for our main results on the wage effects of the policy as the federal minimum wage is set in terms of monthly earnings for workers with full-time contracts of 44 hours a week. About 89% of formal employees worked full-time in 1999 (see Table 1).[14] When we study the employment effects of the policy, however, we consider the entire private workforce, including part-time workers.

3 The bite of the minimum wage among informal workers

While compliance with the minimum wage is not a given in the informal sector, lighthouse effects (where wages of informal workers also bunch at the minimum) have been detected in select years in Brazil (see, e.g., Neri (1997), Neri et al. (2001), Soares (2004), Lemos (2009), and Jales (2018)). We expand on this previous work by systematically documenting compliance as well as the bite of the minimum wage within the earnings distribution of formal workers, informal workers, and the self-employed during the large increases in the minimum wage in the 2000s.

Figure 1b plots the extent of non-compliance with the minimum wage—the share strictly below the minimum—over time across the three groups of workers using PNAD. Figure 2

[12] At this address: https://www.ibge.gov.br/estatisticas/downloads-estatisticas.html.

[13] Following Gerard et al. (2021a), we pool "Pretos" (i.e. Black persons) and "Pardos" (i.e. Brown persons or mixed race with African ancestry) together to form the "non-white" category. We exclude individuals identifying as "Amarelos" and "Indigenas" (less than 2% of the population).

[14] In principle, the minimum wage is adjusted proportionally for part-time workers. However, PNAD does not collect a measure of hours worked each month—only weekly—preventing us from measuring the bite of the policy without significant measurement error.

plots monthly earnings distributions for each group of workers for the years 1995, 1999, 2001, and 2009 in the same data.[15] The x-axis shows log monthly wage bins in R$2019 (the wage bins are 10 log points wide).

Formal employees. In terms of compliance, virtually no workers report being paid below the minimum wage in the private formal sector. Figure 1b shows that non-compliance with the minimum wage does not exceed 1% among formal employees. Furthermore, the minimum wage causes a large spike in the monthly earnings distribution of formal workers (see Figure 2a). The share of workers paid within 10% of the federal minimum wage in the private formal sector fluctuated between 6.2% and 7.8% between 1995 and 1999; it sharply increased in the 2000s and peaked at 20% in 2009.[16] Appendix Figures B2 -B8 confirm that we find near-perfect compliance and a nearly identical spike using the monthly contracted wage in the universe of the matched employer-employee data (i.e., earnings reported by employers) at the national and regional levels.

Informal employees. Figure 1b shows that the share of informal workers paid strictly below the minimum wage went from 16.4% in 1999 to 28.1% in 2009. Figure 2b confirms this pattern of the co-existence of non-compliance with the presence of a large spike at the minimum wage. Interestingly, the spike moves to the right with the minimum wage hikes and increases in magnitude over time. The share of workers paid within 10% of the minimum wage rose from 16% in 1999 to 25% in 2009.[17]

Self-employed workers. We find that the minimum wage is not as strong a reference wage among the self-employed. Figure 2c shows that the share of self-employed paid within 10% of the minimum wage is in the vicinity of 5% in the late 1990s. By 2009, the spike at the minimum wage reaches around 10%; however, it is of similar magnitude as that of other spikes along the earnings distribution, and it is not the largest one.[18]

Bite of the minimum among incumbent informal employees. The above evidence shows that the wage distributions of informal employees track the rising minimum wage in the

[15] Monthly earnings distributions for every year from 1995-2015 are available in our slides here.
[16] In 2009, the share of workers at exactly the minimum wage or below is 13.4%.
[17] In 2009, the share of workers at exactly the minimum wage or below is 42.1%.
[18] We also observe in PNAD that a small fraction of the self-employed earn less than the minimum wage and that this fraction is concentrated among the "informal" self-employed, rather than those that declare paying their taxes to the government.

2000s. To what extent does the shifting spike at the minimum reflect the wages of incumbent informal workers as opposed to changes in the composition of workers? We leverage the panel aspect of the PME to shed light on this question (see Neri, 1997, for a similar exercise in one year in the 1990s). For each minimum wage change between 2002 to 2016, we identify workers paid within 10 log points of the initial minimum wage and examine where in the wage distribution they fall the following year. Appendix Table B1 reports the results: 77.2% of informal employees that were at the minimum wage in the first year they are surveyed are at or above the new minimum in the following year. Thus, informal employees at the minimum wage experienced wage gains when the minimum increased, and the shifting spike at the minimum cannot be entirely explained by changes in the composition of employees.

The above evidence above demonstrates clearly that the minimum wage influences wage determination also in the informal sector. In the next section, we turn to formally quantifying its causal effects on the formal and informal wage distributions.

4 Estimating the wage effects of the minimum wage

We study the effects of the 2001-2009 minimum wage increase on wages separately for each group of workers—formal employees, informal employees, and the self-employed. Our unit of analysis is the local labor market, defined as state-by-industry cells. There are over 300 local labor markets in our data, encompassing the 27 states of Brazil and 12 major industry classifications.[19] We use our sample of full-time, prime-age workers in PNAD that covers the years 1995 to 2015.

4.1 Identification strategy to study the effects on average wages

Our empirical strategy is based on a difference-in-differences design with continuous treatment, in which we compare the evolution of workers' wages across local labor markets that were differentially affected by the policy change, due to variation in the proportion of workers paid at or below the 2009 minimum wage in the pre-reform period.

[19] The industry groups are as follows: agriculture, forestry and fishing; mining and extraction; manufacturing; construction; wholesale and retail trade; hotels and restaurants; transportation, storage, and communications and electricity, gas, water and waste management; financial services and insurance, business and repair services and real estate; public administration and defense; education, health and social work; private household services; entertainment, recreation and other services, or unknown or missing. We omit from our analysis any state-industry cells with 0 workers in that employment group in that cell. We also group together the following geographically close pairs of states Acre and Rondonia, Amazonas and Roraima, as well as Amapa and Para so as to have a sufficient number of observations at the state-group-by-industry level.

Treatment variables. We use the fraction of workers paid at or below the 2009 federal minimum wage in 1999 in each state-by-industry cell as our measure of exposure to the policy. We compute this treatment variable separately for each group of workers and use each group's respective treatment variable to measure the effect of the reform on wages.

Treatment at the state-by-industry level captures variation in bite across local labor markets for each group of workers, respectively. Separate treatment variables for formal, informal, and self-employed workers reflect the fact that bite and compliance differ across these groups of workers, as seen in the monthly wage distributions in Figure 2. Appendix Figures C1a, C1b and C1c report summary statistics for each treatment variable. There is indeed variation in the shares of workers in 1999 paid at or below the 2009 minimum wage across workers of different employment types: the average share of affected workers is 0.21 in the formal sector, 0.48 among informal employees and 0.37 among the self-employed. Further, there is substantial variation in the share affected across state-by-industry cells for each type of workers: the standard deviation is 0.19 for formal employees, 0.24 for informal employees, and 0.24 among the self-employed. In all cases, the density distribution of our treatment variables is fairly dispersed, with the treatment variable for formal workers exhibiting right-skewness.[20]

Model. We estimate the following empirical model for each group of workers:

$$\text{Monthly Earnings}_{it} = a + \sum_{\substack{\tau=1995 \\ \tau \neq 1999}}^{2015} \beta_{\tau}^{\text{wage}} \text{Share Affected}_{s(i)j(i)} \times \mathbb{1}_{[t=\tau]} + \mathbb{X}_{it}'\Gamma + \rho_{s(i)j(i)} + \mu_{j(i)t} + \varepsilon_{it} \quad (1)$$

Monthly Earnings$_{it}$ is the log monthly earnings for individual i in industry j, state s, and year t. Share Affected$_{s(i)j(i)}$ is the share of private sector workers paid below the 2009 minimum wage at the state-by-industry level in 1999, which we interact with a yearly indicator, $\mathbb{1}_{[t=\tau]}$. $\beta_{\tau}^{\text{wage}}$, measures the effect of the reform in year τ (relative to 1999, the omitted year) and corresponds to the intention-to-treat (ITT) estimand. $\mathbb{X}_{isjt}$ includes a set of individual-level controls (gender, race, education, and experience and its square) and time-varying state-level controls (log GDP per capita by state and its square to account for potential differential effects of GDP growth across states). ρ_{sj} and μ_{jt} are state-by-industry and industry-by-year fixed effects.[21] ε_{it} is the error term, which we cluster at the state-by-industry level.

[20] We show the distribution of the standardized treatment variables that enter our calculations for the wage and the employment effects in Appendix Figure C2.

[21] The inclusion of the industry-by-year fixed effects departs from the standard approach that only includes group-level fixed effects and time fixed effects. Controlling for industry-specific trends over time serves two purposes: (i) addressing potentially different trends due to industry-specific shocks (e.g., Brazil experienced an

Our identifying assumption is that absent the minimum wage increases, wage growth would have been the same across local labor markets with different initial levels of workers paid at or below the 2009 minimum wage. Under this assumption, the coefficients of interest β_τ^{wage} identify the effect of the bite of the new minimum wage on average monthly earnings at time t, relative to 1999. The coefficients β_τ^{wage} for $\tau = 1995, ..., 1998$ allow us to test the parallel trends assumption that there is no differential monthly earnings' growth across local labor markets with different exposure to the minimum wage increase before the policy change. The coefficients β_τ^{wage} for $\tau = 2001, ..., 2015$ document the evolution of average monthly earnings during the minimum wage increase and up to 6 years after the 2009 peak, relative to 1999.

4.2 Identification strategy to study the effects on the distribution of wages

To add further evidence that our empirical strategy identifies the effect of the minimum wage rather than other forces acting on wages, we examine effects on the probability density of wages. Our results allow us to confirm that the increase in wages comes from a shift of workers around precisely the wage bins affected by the minimum wage. Advances in the minimum wage literature have highlighted this benefit of a "bunching" approach, particularly for studying employment effects, which we do in Section 7 (Harasztosi and Lindner, 2019; Cengiz et al., 2019).

Formally, we estimate the following model separately for each group of workers:

$$\mathbb{1}_{it} = \sum_{\substack{\tau=1995 \\ \tau \neq 1999}}^{2015} \sum_{\eta=-4}^{12} \tilde{\beta}_{\tau\eta}^{\text{wage}} \text{Share Affected}_{s(i)j(i)} \times \mathbb{1}_{[t=\tau]} \times \mathbb{1}_{[k(i)=\eta]} + \tilde{\rho}_{s(i)j(i)k(i)} + \tilde{\mu}_{j(i)tk(i)} + \tilde{\varepsilon}_{it} \quad (2)$$

with $\mathbb{1}_{it}$ being the probability that the wage of a worker i from state s, industry j, and year t falls in a specific wage bin k, defined in increments of 10 log points. Our treatment variable is Share Affected$_{sj}$, the share of affected workers at the state-by-industry level in 1999, as defined above. $\tilde{\beta}_{\tau\eta}^{\text{wage}}$ is the effect of the reform in year τ (relative to 1999, the omitted year) for wage bin η, where η is normalized so that bin 0 starts at the minimum wage. $\tilde{\rho}_{sjk}$ and $\tilde{\mu}_{jtk}$ are state-by-industry-by-wage-bin and industry-by-year-by-wage-bin fixed effects. We cluster our standard errors $\tilde{\varepsilon}_{it}$ at the state-by-industry level. By design, for each year τ, the sum of the coefficients of interest across wage bins is 0: $\sum_{\eta=-4}^{\eta=12} \tilde{\beta}_{\tau\eta}^{\text{wage}} = 0$.

export boom in the early 2000s); (ii) correcting for potential treatment effect heterogeneity across industries (see Sun and Shapiro (2022) and Dube and Lindner (2024) for a discussion of this potential endogeneity problem in the context of the minimum wage). This heterogeneity could arise in particular if industries face different output demand elasticities (see p.20 in Krueger (1994)).

5 Results on wage effects and robustness checks

5.1 Results on average wages and passthrough estimates

Formal employees. Figure 3a shows the evolution of the estimated β_τ^{wage} coefficients from 1995 to 2015 (white circles), and the associated 95 percent confidence intervals. From 1995 to 1999, there is no differential wage growth between differentially exposed local labor markets. Starting in 2001, there is an immediate increase in the strongly exposed cells relative to the weakly exposed ones. The relative increase is gradual from 2001 to 2009 as the minimum wage continues to increase. After the minimum wage peaked in 2009, our point estimates level off. Table 3 reports the point estimate for the year 2009, when the minimum wage peaks. A one-standard-deviation increase in the share of formal workers paid at or below the minimum wage (corresponding to a 19 percentage point change on a basis of 21%) is associated with a 13.2 log point increase in monthly earnings among formal workers.

Informal employees. Figure 4a shows a similar pattern of estimated wage increases for informal workers. From 1995 to 1999, we estimate no differential wage growth between more strongly and more weakly treated local labor markets. Wage increases begin in 2001, and our point estimates level off by the end of the decade. Table 3 reports that in 2009, a one standard deviation increase in the share of informal workers paid at or below the minimum wage (corresponding to a 24 percentage point change on a basis of 48%) is associated with a 11.1 log point increase in monthly earnings among these workers.

Self-employed workers. Figure 5a shows no clear evidence of wage increases among the self-employed following the minimum wage hikes in the 2000s. The point estimate in 2009 displayed in Table 3 is small and negative, but statistically indistinguishable from zero.

Passthrough of minimum wage increases from the formal to the informal sector. We quantify the passthrough of the federal minimum wage increases from formal into informal wages in 2009 using the coefficient estimates reported above. Among informal employees, an equivalent change in the share of affected workers (19 rather than 24 percentage points) would yield a 8.8 log point increase in wages, or 66% of the effect for formal workers.

5.2 Results on the distribution of wages

Formal employees. In 2009, a one-standard-deviation increase in the bite of the reform among formal employees is associated with an increase of 14 percentage points at exactly the 2009 minimum wage bin (see Figure D3d).[22] This one-standard-deviation increase is not associated with any increase above the wage bin that contains the 2009 minimum wage, indicating that the wage effects are concentrated at the bottom of the distribution. The 14 percentage point increase at exactly the 2009 minimum wage bin comes entirely from workers working below the 2009 minimum wage pre-reform. This result highlights the full-compliance with the minimum wage in the formal sector even when the minimum wage peaks in 2009. The lack of upper-tail effects serves as a useful placebo check for the research design.

Informal employees. Results are similar among informal employees, although the effects are smaller in magnitude: in 2009, a one-standard-deviation increase in the bite of the reform is associated with an increase of nearly 5 percentage points at exactly the 2009 minimum wage bin (see Figure D4d). Interestingly, increased exposure to the reform is associated with a higher probability of being paid right below the minimum wage. At the same time, there is movement out of bins significantly below the minimum wage. These results help reconcile positive wage effects with growing non-compliance for informal employees: workers do see a wage increase; for some of them, they get paid the minimum wage even as it increases; for others, this increase reflects shifts from lower wage bins to those just below. The effects on wage bins higher than the minimum wage are small in magnitude and not statistically different from zero, in further support of the research design.

Self-employed. Figure 5b shows that we find little evidence that the minimum wage strongly affected the wage distribution of self-employed workers.

5.3 Robustness checks.

We conduct an array of robustness tests to make sure that our wage increases capture the causal effect of the minimum wage and are of the correct magnitudes.

[22] The complete series of graphs for formal employees for the years 1995-2015 are available in our slides here. They confirm that, prior to the reform, there is no change in the distribution of wages across wage bins. Starting in 2001, higher bite of the minimum wage pre-reform is associated with greater probability of wages falling in the bin that contains that year's minimum wage. The complete series of graphs for informal is also available in our slides.

Consistency with other data sources and designs. Figure 3a overlays our wage effects using PNAD with comparable estimates using census data. Among formal employees, it shows that wage effects using the Census are smaller than in PNAD, but are still of the same order of magnitude. These wage effects must be understood relative to 2000—the omitted year when we use census data (only available in 2000 and 2010). A one-standard-deviation increase in the fraction of workers paid at or below the minimum wage in 2000 (corresponding to a 19 percentage point change on a basis of 24%) is associated with a 10.8 percent relative increase in the wages of strongly affected state-by-industry cells (see Appendix Table D1). We also leverage the precision of the census data to show similar effects when treatment is defined within microregion-by-industry, a finer aggregation of firms compared to state-by-industry cells.[23]

Figure 4a shows our results using census data among informal employees. The wage effects appear well aligned for this sector as well. The orders of magnitudes are also similar when we use a microregion-by-industry design in the Census, suggesting that the spillover effects of the minimum wage to the informal sector happen within finer local labor markets. Figure 5a shows similar consistency across data sources for the self-employed—although the effect is more imprecisely measured using the state-by-industry design.

We also show consistent results on changes to the probability density of wages using census data in Appendix Figure D1. Changes to probability density of wages in 2010 relative to 2000 among formal and informal employees are virtually identical. Among the self-employed, there is more evidence of a spike in the minimum wage; however, our results over time in PNAD suggest this spike does not consistently appear.

Robustness to other treatment variables. With a continuous treatment variable, one may worry that even the least affected state-by-industry cells are treated. If the effect of marginal increases in treatment intensity is not constant either within or between state-by-industry cells, our results estimated using Equation 1 may suffer from misspecification of the func-

[23]There are 558 microregions defined in the census data, and in total we leverage variation across 6,536 microregion-by-industry cells in our regressions. A one-standard-deviation increase in the fraction of affected formal workers in this microregion-by-industry design corresponds to a 21 percentage point change on a basis of 24%—figures that are remarkably aligned with the respective figures using the fraction of affected workers at the state-by-industry level and with the shares computed in PNAD (see also Appendix Figure C1). For the informal employees, using the state-by-industry design (using the microregion-by-industry design), a one-standard-deviation increase in the fraction of affected workers corresponds to a 22 (25) percentage point change on a basis of 48% (48%). Finally, for the self-employed, using the state-by-industry design (using the microregion-by-industry design), a one-standard-deviation increase in the fraction of affected workers corresponds to a 22 (24) percentage point change on a basis of 35% (35%).

tional form and might be biased (see, e.g., Haanwinckel (2025)[24] and Callaway et al. (2025)). Following the logic of Callaway et al. (2025), we consider an alternative binary treatment specification in which we define the control group as the first quartile of the original treatment variable—so as to make the control as "clean" as possible in our setting—and treatment as belonging to the top three quartiles. Appendix Figure D2a shows that the wage effect among the formal workforce has exactly the same pattern as the wage effect in our baseline difference-in-differences. Reassuringly, Appendix Figure D2b also shows that the estimated wage effect is greater when comparing the top two quartiles (instead of the top three quartiles) to the bottom quartile of the treatment intensity variable (20 log points vs. 15 log points in 2009).

Robustness to mean reversion. Mean reversion can arise if low-wage cells exhibit greater growth than high-wage cells simply by virtue of being in the bottom of the wage distribution. Alternatively, mean reversion can stem from measurement error in our treatment variable.

With regards to the first source of mean reversion, it is possible that lower wage jobs experienced faster relative wage growth in Brazil for reasons unrelated to the minimum wage (due to regional wage convergence, for example, as emphasized by Haanwinckel (2025)). Our bunching difference-in-differences design, which estimates changes in the probability of being in a given wage bin (see Equation 2), allows us to test whether our wage effects are directly related to minimum wage policy or if they simply reflect faster relative growth at the bottom of the wage distribution. Appendix Figures D3a and D3b document precise zero effects in the probability of being in any given wage bin in the pre-period years 1995 and 1998 (relative to 1999)—when the minimum wage remained stable—and for all wage bins below the 2009 minimum wage and right above.[25] By contrast, for 2001 and 2009, Appendix Figures D3c and D3d show that our treatment variable is associated with an increased probability of being at the statutory minimum wage associated with each year.[26] Appendix Figures D5- D7 show these same results for intensive-informal, extensive-informal, and self-employed workers, respectively. The results in these figures show that our treatment variable—the share of workers below the 2009 minimum wage in 1999—is associated with an increased probability of being at the statutory minimum wage associated with each year, for the years 1995, 1998, 2001, and 2009, respectively. Because the mass tracks the various levels of minimum wages

[24]Note, however, that Haanwinckel (2025) focuses on potential misspecification arising from designs using the fraction of affected workers at the regional level, not at the state-by-industry level.

[25]This result is also true for the pre-period years 1996 and 1997 that we report in our slides here.

[26]This result is true for all the post-period years 2001-2015 that we report in our slides here.

over the period of large increases, we view our design as capturing the effects of minimum wage policy on the wage distribution, rather than mere "catch-up" at the bottom of the wage distribution.

The second type of mean reversion may be a concern if some state-by-industry cells that are classified as strongly treated in 1999 are in fact weakly treated in some other year before the policy (say, 1995), due to measurement error in wages in PNAD.[27] If this is the case, then our estimated wage effects from the difference-in-differences model presented above do not capture the causal effect of the minimum wage but simply reflect mean reversion. In the spirit of Dustmann et al. (2022) and Derenoncourt and Weil (2025), we show in Appendix Figure D8 that defining the treatment variable in 1995 does not affect the pattern of our wage effects along the wage distribution. We find—as expected in the absence of measurement error—precise 0 effects in the probability of being in any given wage bin in 1995 and 1998, as in Appendix Figure D3a and D3b, and mass right in the bin that contains the minimum wage in 2001 and 2009. We show the exact same pattern of results when defining the treatment variable in 1996, 1997 and 1998 in Appendix Figures D9, D10 and D11 respectively, alleviating concerns regarding a possible measurement error in the treatment variable.

Sensitivity to exposure to subnational minimum wages. In Appendix A.2 (see the paragraph "State-level minimum wages since 2001"), we motivate our focus on federal as opposed to state minimum wages in Brazil. Four states had instituted regional minimum wages by 2009, varying by occupation. Only Rio Grande do Sul has regional minimum wages that also vary by industry—a feature that is the most directly related to our state-by-industry design. We collect all the regional minimum wage floors by fine industry categories (using CNAE 2.0 codes, a five-digit classification system) and create a regional minimum wage database (see Appendix A.3). We map these five-digit industry code into the (coarser) industry categories used in PNAD. We show that when assigning regional wage floors to the entire industry category we use in PNAD—therefore arguably leading to an upper bound of the fraction of affected formal workers—the treatment variable that uses the regional wage floors is highly correlated with the treatment variable that uses the federal minimum wage alone. The correlation coefficient is 0.96. We also note that the share of the formal private workforce in our sample in Rio Grande do Sul represents 7.6% of the Brazilian formal workforce in 1999, leading us to conclude that taking into account regional minimum wages would not greatly affect our results.

[27] The consistent results using census data also alleviate this concern, given the much larger sample size.

Robustness to potential confounding factors. In Table 3, we report our baseline wage estimates for the three groups of workers in 2009 and assess their robustness (in columns (2) to (4)) to three potential confounders that could affect wages at the same time as the minimum wage increases and that could differentially affect strongly versus weakly treated cells.

First, one may worry that our wage effects are confounded by the rise in educational attainment (Firpo and Portello, 2019; Haanwinckel, 2024) and differential changes in the skill composition of the workforce over time. If, for example, workers in the weakly treated state-by-industry cells experience a large increase in their level of education relative to workers in strongly treated cells, then we might worry that our baseline wage effect overestimates the causal effect of the minimum wage as some of the increase may instead be attributable to shocks affecting the skill distribution. Our baseline specification in Equation 1 alleviates this concern by including a set of time-varying individual-level controls (gender, race, education, and experience and its square). Moreover, when we remove these individual-level controls (see Table 3 column (2)) from our regression equation, the wage effects among all types of workers remain fully aligned with our baseline estimates, suggesting that composition effects are unlikely to be driving our results.

Second, one may worry that Bolsa Família—the major Brazilian cash transfer program gradually scaled up during the 2000s—differentially affected workers' outside options across our highly vs. weakly exposed cells. Data on per-capita expenditures of Bolsa Família at the state level, divided by state GDP, indeed show that the generosity of this transfer is much higher in the Northeast and the North—the poorest region in Brazil, where the minimum wage also tends to be more binding—than in the South or Southeast (see Appendix Figure A3b). If Bolsa Família leads to greater labor force withdrawal among high poverty households with low potential earnings, the earnings of workers in these state-by-industry groups may increase purely through compositional effects, leading to an upward bias in our baseline estimates. Alternatively, if increased Bolsa Família payments stimulate economic activity and labor demand (Gerard et al., 2021b), they could raise workers' earnings differentially across state-by-industry groups. We find no evidence of any sizeable bias among formal employees, informal employees or the self-employed when we include state level controls on the per-capita level of Bolsa Família transfers (see Table 3 column (3)).

Finally, one may worry that our wage effect is confounded by the rise of policies aimed at reducing informality—namely the increase in the number of labor inspections starting in the second half of the 1990s, combined with the fact that enforcement is not randomly

allocated across the country.[28] We collect data on the number of inspectors by state in 2002 from Ponczek and Ulyssea (2022) and include this number interacted with a year fixed effect in our regression. Doing so does not affect the magnitudes of our wage effects for any of the four groups of workers (see Table 3 column (4)).

6 Drivers of the wage effect in the informal sector

Why did informal workers experience wage gains from minimum wage increases in Brazil during the 2000s? Such gains may be surprising given that non-compliance with labor law is a defining feature of informal employment. Many existing models of labor markets with informality predict wage declines in the informal sector after minimum wage increases pursuant to the reallocation of employment out of the formal sector.

As discussed in the introduction, earlier studies argue that the minimum wage may serve as an anchoring point (a "lighthouse" effect) or numéraire for wage determination in Brazil, especially under hyperinflation, and have found bunching not only at the minimum wage but also at multiples of it. The period that we study starts after the implementation of the 1994 Plano Real, which put an end to many years of hyperinflation in Brazil, and is characterized by moderate inflation levels. It is thus possible that other mechanisms mediate our findings.

We cannot directly test anchoring effects, but we can replicate earlier tests of numéraire effects in more recent years by examining whether earnings bunch at multiples of the minimum wage. Using R$10 bins to distinguish bunching at multiples of the minimum wage from bunching at round numbers, we plot the distributions of monthly earnings and contracted wages in RAIS (from 1995 or 2002 until 2017) and of monthly earnings in the 2000 and 2010 Censuses, separately for formal employees, informal employees, and the self-employed.[29] Appendix E describes our methodology and results in detail. While we detect small spikes at two and three times the minimum wage among formal employees in RAIS in 2002 (Appendix Figure E1), their magnitude is comparable to the round-number spikes found throughout the distribution, and they if anything fade over the period of large minimum wage increases. The 2010 Census data yield the same conclusion for formal employees (Appendix Figure E2a) and extend it to informal employees (Appendix Figure E2b) and the self-employed (Appendix Figure E2c). Taken together, these results provide little evidence that the minimum wage still

[28] Almeida and Carneiro (2012) stress in particular that enforcement may be stricter in places where violations of the law are more prevalent—as the bulk of inspections are triggered by anonymous reports of illegal activity (see also Cardoso and Lage (2005)) or in places with higher quality institutions. In both cases enforcement might be correlated with labor market outcomes.

[29] We focus on RAIS and the Censuses to maximize sample size.

acts as a strong numéraire for wage setting in the distribution more broadly, consistent with our finding of no spillover effects higher up in the distribution.

Although this evidence does not rule out that the minimum wage still acts as a key anchor for wage determination among an important subset of workers outside the formal sector, we turn to exploring three alternative economic forces in this section. Specifically, we consider the potential role of enforcement intensity, employer compliance practices, and workers' bargaining power in mediating the minimum wage's effects on informal wages.

6.1 Enforcement intensity, compliance practices, and bargaining power

We lay out the empirical approaches that we use to assess the potential role of these three mediators here, before presenting the results in the next subsection.

Enforcement. The minimum wage applies by law to all workers in Brazil, irrespective of their formality status (see Section 2.1). Yet, limited enforcement capacity is one reason informality persists in low- and middle-income countries. Labor inspections in Brazil are largely triggered by anonymous worker reports and conducted out of regional offices. Thus, in areas where enforcement capacity is stronger, employers may be more likely to comply with minimum wage policy to avoid worker complaints. To assess the impact of enforcement capacity on minimum wage effects on informal workers, we follow a recent literature on enforcement and informality in Brazil that uses variation in estimated travel times faced by local labor inspectors in different parts of the country to proxy for enforcement strength (Almeida and Carneiro, 2012; Ponczek and Ulyssea, 2022).[30] Specifically, we follow Ponczek and Ulyssea (2022) and calculate the maximum distance across municipalities within a micro-region and merge this measure of enforcement capacity into the 2000 and 2010 Census data. We then examine heterogeneity in the wage effects of the minimum wage on informal workers splitting micro-regions by above- versus below-median enforcement capacity.

Employer compliance practices. A growing body of research provides evidence that employers are often reluctant to pay different wages to workers, especially when they perform similar tasks. Meghir et al. (2015) and Ulyssea (2018) provide evidence of an overlap in the

[30] Because inspections are triggered by anonymous worker reports, variation in the number of inspections across different areas of the country may simply capture variation in non-compliance (Almeida and Carneiro, 2012). Thus, the number of inspections in a given state-by-industry cell is endogenous and more likely positively correlated with non-compliance than indicating enforcement capacity. Furthermore, such a measure of enforcement capacity would be confounded by variation in workers' willingness to report, or reporting bias.

productivity distribution between formal and informal workers, including within the many firms hiring both types of workers. In that context, the wage effect on informal workers may be stronger in sectors that also employ a large share of formal workers and among firms that also employ formal workers. While we are not able to follow specific firms that employ formal vs. informal employees (or both) or to observe the formality status of workers' employers in most years (measured as registration with tax authorities), we can assess informality shares at the industry level and demonstrate how this aligns with formality status of the employer.

Calculating the share of workers employed formally in each of the 12 major industry groups, we note that the top quartile of industries with the highest shares of informality in 1999 consists of agriculture, domestic services and construction. Among full-time employees, 71% of agricultural employees are informal; the corresponding figures are 63% and 46% for domestic services workers and construction workers. Among full-time and part-time employees, these shares are 83%, 71% and 51%. These three sectors also account for 80% of the informal workers with monthly earnings strictly below the minimum wage in 1999.[31] As we discuss further below, these sectors are also those where informal firms are concentrated.

We therefore define agriculture, domestic services and construction as "high-informality" industries and all other ones as "low-informality" industries, and hypothesize that the effects of the minimum wage on informal wages will be less pronounced in high-informality industries. In years where the data are available, we further explore the role of employer formality status, hypothesizing that registered firms —those that can hire workers formally— are more likely to comply with the minimum wage even for workers they employ informally.

Competition. Finally, we test the notion that competitive forces mediate the wage spillovers to informal workers. We compare mediation via a notion of informal workers' formal outside options to competitiveness as measured by labor market concentration in the formal sector.

Formal outside options. One way to model integrated formal-informal labor markets is through formal jobs serving as outside options for workers in the informal sector. Informal employers who are competing with formal employers to hire workers must take formal wage

[31] Agriculture alone accounts for 44%; domestic services for 29%; and construction for 7%. Appendix Figure B1b reveals that the share of informal workers paid strictly below the minimum wage in the top quartile of industries classified by their level of compliance with the minimum wage is 23% in 1999 and increases to 40% in 2009. It is three times more than in all other industries combined. In these industries, there is strong compliance with the minimum wage: only 7.3% of informal workers are paid strictly below the minimum wage in 1999; the monthly earnings distributions in Appendix Figure B1a exhibit a large spike at the minimum wage that moves with minimum wage hikes and increases in magnitude over time. The share of workers paid within 10% of the minimum wage increased from 14% in 1999 to 24% in 2009.

offers into account when recruiting workers. To explore formal outside options as a mediating factor for the minimum wage's effect on informal wages, we adapt the approach of Caldwell and Danieli (2024) for estimating an outside options index (OOI) at the worker level to the context of Brazil. We use the 2000 Census, which contains a rich set of characteristics of workers and their jobs, including the information on workers' formality status and on one's municipality of work (as opposed to one's municipality of residence). Appendix G provides full details on our estimation of OOI and provides descriptives and validation checks on the OOI.

Specifically, for each worker type x_i, the Outside Options Index (OOI) is a relative entropy measure based on the type-specific job distribution $f_{Z|X}(z_j \mid x_i)$ out of an economy-wide job distribution $g(z_j)$, such that more negative values indicate that workers of type x_i are concentrated in a narrower set of jobs than the market as a whole. Because the integrand is additive over job characteristics z_j, the index decomposes cleanly into formal and informal components, from which we calculate the share of a worker's concentration attributable to the formal sector. We estimate the index on prime-age private-sector workers in the 2000 Census, defining worker types by race, gender, age, education, and municipality of residence and job types by occupation, industry, formality, and municipality of work. The resulting measure is higher for men, for white workers, and rising in education—an education gradient driven primarily by lower concentration in the informal sector—and we validate it in the PME, where a one-standard-deviation increase in the formal share of outside options is associated with a 40–66% rise (relative to the baseline mean) in the likelihood of transitioning from informal to formal employment.

Intuitively, informal workers who share many characteristics with workers in formal jobs may exercise some bargaining power when it comes to employer adherence to the minimum wage. If employers decline to pay these workers the minimum wage, they may be better positioned to leave those jobs for a formal job where the employer complies with labor regulations. These workers may thus be more likely to receive a wage increase when the minimum wage rises. We compare workers with an above-median vs. below-median share of formal outside options, conditional on overall OOI and examine minimum wage effects on earnings for these two groups.

Heterogeneity across high vs. low concentrated labor markets. Another way to explore the effects of competition is through variation in labor market concentration. Prior literature has found no effect of concentration on the minimum wage earnings elasticity (Azar et al.,

2024). Nevertheless, we may expect to see smaller wage effects of the minimum wage on informal workers in labor markets where formal employment is highly concentrated versus those where it is less concentrated. In concentrated labor markets, there are fewer potential formal employers for informal workers, and thus a lower probability of earning the minimum wage.

We use RAIS data to measure formal labor market concentration in the pre-reform period 1999. We calculate labor market concentration at the state by industry cell by calculating the employment shares of the top 4 establishments within each cell. We then classify state-by-industry cells as above- vs. below-median labor market concentration across cells and test for heterogeneity in wage effects on informal workers across the two groups.

6.2 Results on mediators of informal wage effects

Table 4 reports our results on mediation by enforcement capacity, industry informality type, labor market concentration, and workers' formal share of outside options. Column 1 reports the results on enforcement. In areas with weaker enforcement, the wage effect of the minimum wage is over a third smaller than in areas with stronger enforcement (9.6 log points as opposed to 14.7 log points), with the interaction effect significant at the 1% level. This indicates substantial mediation by underlying enforcement capacity across micro-regions.

Column 2 reports the results on industry informality share. Wage effects in high-informality sectors are 50% lower compared to those in low-informality sectors (7.5 log points compared to 15.1 log points), and the interaction effect is significant at the 1% level. Thus, industry informality share appears to be a sizable moderator of the minimum wage's effects on informal employees.

In column 3, we report our results on the share of informal workers' outside options consisting of formal jobs. Workers with an above-median formal share of outside options have wage effects that are 52% higher than for workers with a below-median formal share of outside options, and the interaction effect is significant at the 1% level. This measure of proximity to the formal sector at the individual-level for informal workers is a strong mediator of the wage effect of the minimum wage among those workers and highlights a potential role for worker bargaining power in sharing the gains from minimum wage increases.[32]

Finally, in column 4, we examine the role of concentration in mediating wage effects in the

[32]In Appendix Table G4, we also include a triple interaction between strongly treated, post, and above-median overall OOI to test whether overall worker bargaining power mediates minimum wage earnings effects for informal workers. The results show that overall OOI also mediates the wage effects of the minimum wage for informal workers and there is an additional effect of having a high share of formal outside options.

informal sector. In state-by-industry groups with above-median formal sector establishment concentration, wage effects are 27% higher (12.7 log points as opposed to 10 log points) than in state-groups with below-median concentration; however, the interaction effect is insignificant. Nevertheless, the sign of the effect is the opposite from what might be expected if less concentrated markets provide more potential formal employers for informal workers.[33]

In column 5, we include all four interactions in a single regression. Interactions on all moderators remain significant and of similar magnitudes with the results discussed above. The only exception is the interaction exploring the role of labor market concentration: the coefficient remains insignificant and drops in magnitude.

Additional results on employer compliance practices. We provide additional evidence on the role of industry and firm pay-setting practices in mediating informal wage effects in Figure 6. It shows the effect of the minimum wage on informal earnings in low- and high-informality industries following the specifications described in equations 1 and 2. Figure 6a shows the effect of the minimum wage on average earnings in low-informality industries. In low-informality industries, from 1995 to 1998, there is no differential wage growth between more strongly versus more weakly treated local labor markets. Average wages then increase sharply in 2001 relative to 1999 and continue increasing over the next decade, leveling off around 2010. Figure D5d shows the effect of the 2009 minimum wage on the probability density of wages among this group of informal workers, relative to 1999. A one-standard-deviation increase in the bite of the reform is associated with an increase of nearly 7 percentage points at exactly the 2009 minimum wage bin. The pattern of wage increases along the wage distribution is strikingly similar to the one observed in the formal sector, although the effects are smaller in magnitude. Figure 6c shows that in high-informality industries, there is also no differential wage growth between more strongly versus more weakly treated local labor markets in the years prior to large minimum wage increases. Wages grow with minimum wage increases, but in contrast to informal workers in low-informality industries, these wage gains take several years to materialize. Only in 2004 do the point estimates become statistically distinguishable from zero.

Interestingly, Appendix Figure D6d reveals that a higher bite of the reform among informal employees further away from the formal sector is associated with a higher probability of being right below the minimum wage. At the same time, there is movement out of bins significantly

[33]Our results are consistent with the findings of Azar et al. (2024), who find no significant difference in the minimum wage earnings elasticity across more vs. less concentrated markets in the U.S.

below the minimum wage. These results reconcile positive wage effects with growing non-compliance among informal workers: workers in high-informality industries do see a wage increase, but this increase reflects shifts from lower wage bins to those just below (as well as slightly above) the minimum wage.

How does this industry heterogeneity in pay-setting relate to differences across employers? In select years of PNAD, from 2011-2015, information on the formality status of the employer is available. A second source of information on employer formality is ECINF in 1997 and 2003, which follows both formal and informal employers as well as their employees (whose formality status is also known). Employers who are registered with tax authorities demonstrate one form of compliance with the law. Are these employers more likely to comply with the minimum wage even for their informal employees?

Appendix Figure F1 shows the monthly earnings distributions in low- vs. high-informality industries overlaid on those of informal workers at formal vs. informal firms. These series match very well. Finally, we compare the monthly earnings distributions of informal workers in low- and high-informality industries in PNAD to those of informal workers in formal versus informal employers in ECINF (using the employer type) 1997 in Appendix Figure F2 (respectively in 2003 in Appendix Figure F3). Results show that prior to the large minimum wage hikes, minimum wage compliance is almost perfect among informal employees employed in formal firms, and that non-compliance is concentrated among informal employees in informal firms.

7 Minimum wage effects on the allocation of employment

In the setting of a low- or middle-income country, the potential for minimum wages to benefit workers and reduce poverty hinges not only on the policy's effect on wages, but also on its effects on formalization, specifically the reallocation of employment away from the formal sector. We assess this using two different empirical strategies: a bunching difference-in-differences design adapted from Cengiz et al. (2019) and the approach we use in Section 5.2, and a linear probability model at the individual worker level. We use the first approach to examine changes in the number of formal jobs along the wage distribution. The second approach allows us to explicitly consider reallocation from the formal sector towards alternative modes of employment. We also use the second approach to compute the own-wage reallocation elasticity: the percent change in formal vs. other employment associated with a percent increase in the formal wage from the minimum wage.

The own-wage reallocation elasticity summarizes the extent of reallocation out of formal jobs, or changes in formalization, in response to minimum wage policy. This elasticity can be compared to the own-wage employment elasticity estimated in many high-income country settings to quantify the employment losses caused by minimum wage increases. In lower-income countries where compliance with labor law may be incomplete, a relevant displacement margin is the reallocation of jobs out of the compliant, formal sector into other sectors of the economy. We believe this parameter, if collected across many low- and middle-income country settings with minimum wage increases, can help assess the potential negative effects of minimum wages on the share of formal employment in the economy.

7.1 Estimating effects of the minimum wage on the allocation of employment

Reallocation effects using a bunching approach. To assess reallocation out of the formal sector using a bunching approach, we first aggregate the worker-level microdata to a yearly count of workers in formal employment at the wage-bin-by-state-by-industry level. As in Section 5.2, wage bins are 10 log-point increments of monthly earnings. Our outcome variable is formal employment in a given wage-bin-by-state-by-industry cell divided by economy-wide employment in 1999 in that state-by-industry group. This normalization yields a straightforward interpretation of our results as reallocation towards or away from formal employment separately for each wage bin that is attributable to the minimum wage reform. To quantify changes in the allocation of formal jobs along the earnings distribution, we estimate the following specification:

$$\frac{E^{\text{f}}_{sjtk}}{E^{\text{all}}_{sj,1999}} = \sum_{\substack{\tau=1995 \\ \tau\neq 1999}}^{2015} \sum_{\eta=-4}^{12} \alpha_{\tau\eta} \text{Share Affected}_{sj} \times \mathbb{1}_{[t=\tau]} \times \mathbb{1}_{[k=\eta]} + \zeta_{sjk} + \nu_{jtk} + \epsilon_{sjtk} \tag{3}$$

with $\frac{E^{\text{f}}_{sjtk}}{E^{\text{all}}_{sj,1999}}$ being the number of formal workers in state s, industry j, year t, and wage bin k, relative to 1999 total employment in that state-by-industry cell. Our treatment variable is Share Affected$_{sj}$, the share of workers below the 2009 minimum wage at the state-by-industry level in 1999. $\alpha_{\tau\eta}$ is the effect of the reform in year τ relative to base year 1999 in wage bin η. ζ_{sjk} and ν_{jtk} are state-by-industry-by-wage-bin and year-by-industry-by-wage-bin fixed effects. We cluster our standard errors at the state-by-industry level.

As with our wage analysis in Section 4, our identifying assumption is that changes in the frequency distribution of wages in less vs. more highly exposed cells would mirror

each other in the absence of large minimum wage increases. We probe the plausibility of this assumption by examining pre-trends in the number of workers above and below the minimum wage, which we discuss in greater detail below.

We assess effects on reallocation in the part of the distribution at or below the 2009 minimum wage as well as overall reallocation across the whole distribution. Following Cengiz et al. (2019), we define the missing formal jobs by summing up the difference-in-differences coefficients across all wage bins below the minimum wage: $\Delta b = \sum_{\eta=-4}^{\eta=-1} \alpha_{2009,\eta}$. We define the excess formal jobs at the minimum wage as $\Delta a = \alpha_{2009,0}$, and at or above the minimum wage as $\Delta a^* = \sum_{\eta=0}^{\eta=16} \alpha_{2009,\eta}$. From these definitions, we define two reallocation effects. We define directly affected reallocation as $\Delta f = \frac{\Delta a + \Delta b}{\bar{b}_{1999}}$, where $\bar{b}_{1999}$ is the sample average share below the 2009 minimum wage in 1999, averaged across state-by-industry cells. The interpretation of Δf is the percent change in directly affected formal employment, or reallocation from or to formal employment at or below the minimum wage. We further define an overall reallocation effect as $\Delta f^{\text{all}} = \sum_{\eta=-4}^{\eta=16} \alpha_{2009,\eta}$.

Reallocation effects using a linear probability model. Our bunching approach yields estimates of changes in the number of formal jobs both along and across the whole wage distribution. To more explicitly assess reallocation to other modes of employment or to non-employment, we turn to a linear probability model of the overall reallocation effect.

We estimate two separate models using PNAD data to quantify the reallocation effect out of the formal labor force. The first one quantifies reallocation out of the formal labor force towards other types of employment. Specifically, we estimate the following equation using labor force survey data:

$$\text{Formal employee}_{it} = a^{\text{emp}} + \sum_{\substack{\tau=1995 \\ \tau \neq 1999}}^{2015} \beta_{\tau}^{\text{emp}} \text{Share Affected}_{s(i)j(i)} \times \mathbb{1}_{[t=\tau]} + \mathbb{X}_{it}' \Gamma^{\text{emp}} + \rho_{s(i)j(i)}^{\text{emp}} + \mu_{j(i)t}^{\text{emp}} + \varepsilon_{it}^{\text{emp}} \tag{4}$$

where the outcome is an indicator for formal employee vs. informal employee or self-employed. We use the same treatment variable as above, at the state-by-industry level; as well as the same individual-level controls and state GDP controls $\mathbb{X}_{it}$ as for the estimation of the wage effects (see Equation 1). We also include the same fixed effects: state-by-industry $\rho_{s(i)j(i)}^{\text{emp}}$ and industry-by-year fixed effects $\mu_{j(i)t}^{\text{emp}}$. Standard errors are clustered at the state-by-industry level. Our coefficient of interest is $\beta_{\tau}^{\text{emp}}$ divided by the average formal employment

share in 1999, i.e., the percent change in the share of formal employees among the total private workforce associated with a one-standard-deviation increase in the share of affected workers.

The second one quantifies reallocation out of the formal labor force towards other types of employment or towards non-employment, to capture potential responses on the extensive margin of employment. We use the following model:

$$\text{Formal employee}_{it} = a^{\text{epop}} + \sum_{\substack{\tau=1995 \\ \tau \neq 1999}}^{2015} \beta_{\tau}^{\text{epop}} \text{Share Affected}_{s(i)} \times \mathbb{1}_{[t=\tau]} + \mathbb{X}_{it}' \Gamma^{\text{epop}} + \rho_{s(i)}^{\text{epop}} + \mu_t^{\text{epop}} + \varepsilon_{it}^{\text{epop}} \tag{5}$$

where the outcome is an indicator for formal employee vs. informal employee, self-employed, unemployed or not in the labor force. Importantly, the treatment variable is now defined at the state level as we cannot assign treatment to the non-employed, who do not have an industry. Accordingly, we include state and year fixed effects, and the standard errors are clustered at the state level. The set of individual-level controls is the same as above.

We adapt both models to be estimated with census data as well, where we only have the years 2000 and 2010. This allows us to probe the consistency of our results across data sources.

Own-wage reallocation elasticity. We use the estimates from the linear probability models described above to compute the own-wage reallocation elasticity, e.g.:

$$\frac{\Delta\%\text{Reallocation out of formal}}{\Delta\%\text{Formal Wage}} = \frac{\beta_{2009}^{\text{emp}}}{\beta_{2009}^{\text{wage}}}.$$

How do we assess and interpret the magnitude of empirically estimated reallocation elasticities? Reviewing evidence primarily in high-income countries, Dube (2019) characterizes own-wage employment elasticities of less than -0.4 as "small," those between -0.4 and -0.8 as medium, and those more negative than -0.8 as large. For lack of a more direct set of comparison estimates, we use the same benchmark to assess our reallocation elasticities.

7.2 Results on the allocation of employment

Effect of the minimum wage on the formal share of employment. Figure 7a examines the share of formal employment. The outcome is the number of formal employees in that wage bin in 2009 divided by total employment in that state-by-industry cell in 1999, aggregated across all sectors of employment. Reallocation in the part of the distribution that is very close

to the minimum wage is effectively zero: $\Delta f = -0.4\%$. The effect on reallocation across all wage bins is a statistically significant reduction in the share formal of $\Delta f^{\text{all}} = -4.4\%$. This larger negative formal employment effect includes small declines in formal jobs across bins in the middle of the earnings distribution. These declines could reflect employment spillovers of the minimum wage up the distribution. Alternatively, they may indicate the presence of confounding shocks to state-industry cells with greater exposure to the minimum wage. In Appendix Figures H1 and H2, we probe which parts of the economy exhibit declines in formal employment in the middle of the distribution. Excluding each region sequentially from the analysis shows that the effects are driven by the Northeast. Reassuringly, the total reallocation effect that we estimate using census data, where we have sufficient power to include region-by-year fixed effects to absorb any confounding regional shocks, is similar (see Appendix Figure H3).

Figure 7b shows the dynamic effect of the policy on missing mass below and excess mass around the minimum wage in the formal share of jobs. Because the minimum wage grows over time from 2001-2009, the real wage bin in which the minimum wage falls also increases over time. For the purposes of this exercise, therefore, we focus our attention on the 2001 minimum wage, the first minimum wage of the post-period. Missing mass is defined by aggregating coefficients across all wage bins below the 2001 minimum wage; and excess mass is defined by aggregating coefficients across the three wage bins that contain the minimum wage from 2001 to 2009. The figure shows flat pretrends in both missing and excess mass followed by a shift out of the bins below the 2001 minimum wage and into the bins above the 2001 minimum.

Estimation results on own-wage reallocation elasticities. Table 5 reports our results using the linear probability models described in equations 4 and 5. The table reports reallocation effects towards other types of employment (first column) and towards other types of employment, unemployment or non-employment (fourth column), across data sources. We combine these reallocation estimates with wage effects of the policy on formal workers (using the model from Equation 1 in Section 4) to estimate the own-wage reallocation elasticity for the formal sector.

Panel A reports our estimates of the overall reallocation effect, the wage effect on formal workers, and the own-wage reallocation elasticity (columns 1-3, respectively), using data from PNAD. We estimate a decline in the share of formal employment of 3.6%, highly consistent with the estimate from our bunching analysis above. Combining this estimate with the

estimated wage effect for formal workers of 12.8 log points, we find an own-wage reallocation elasticity of -0.28 in 2009.[34] That is, for a 10% increase in average wages as a result of the policy, there is a 2.8 percent shift into other modes of employment out of the formal salaried sector. Panel B reports an essentially identical reallocation elasticity of -0.28 using census data.

Columns 4 uses the linear probability model in Equation 5, with treatment defined at the state level, to examine reallocation away from formal employment to both other forms of employment as well as non-employment. Effects on formal employment are extremely similar across the two designs. Using PNAD, we find a decrease in formal employment of -0.038 (column 4) as opposed to -0.036 (column 1), and the two effects are not statistically distinguishable. Because of a smaller wage effect using the state design, we estimate a slightly larger reallocation elasticity of -0.37. We also estimate the state design in the census and once again find an extremely similar effect on employment: a decline of -0.025 (column 4) vs. -0.028 (column 1), which are also statistically indistinguishable from each other. As in the PNAD data, the wage effect using the state design in the census is smaller than that of the state-by-industry design. Because the employment effect is slightly less negative, we also get an essentially identical own-wage reallocation elasticity of -0.28.

Our estimated own-wage reallocation elasticities are highly consistent with the bulk of the evidence from minimum wage studies in higher income countries. Dube (2019), surveying this literature, reports that over 70% of estimated own-wage employment elasticities are smaller (more positive) than -0.40 and classifies these as "small" employment effects.

Across both our designs for assessing reallocation, our evidence points to modest reductions in formal employment after the minimum wage increases in Brazil. Where does formal employment shift to after the policy? The fact that we estimate similar effects when looking at reallocation among employed workers (first column of Table 5) versus reallocation inclusive of the non-working population (fourth column) suggests the policy had minimal effects on overall employment and labor force participation.

To better understand reallocation towards non-formal employment, we examine the relationship between the mediators we studied in Section 6 and reallocation. Table 6 reports these results. Factors that mediate the wage effect among informal workers also mediate reallocation out of the formal sector. In particular, reallocation effects are smaller precisely where

[34] The reason the wage effect differs slightly from that reported in Table 3 is that here we estimate the effect for both full-time and part-time formal workers while Table 3 reports the wage effect for full-time formal workers only.

wage effects among informal workers are larger. Namely, areas with weaker enforcement and high-informality industries tend to show higher reallocation towards informality or self-employment. Reallocation towards informal employment is lower for workers with a high share of formal outside options, consistent with evidence from other contexts (Paul-Delvaux, 2024).[35] We also explore what specific type of non-formal employment the workforce shifted towards in Appendix Table H2, by estimating linear probability models where the outcome is employment of a given type vs. all others. We use the treatment variable specific to each group of workers, as in Section 4. Though we cannot trace reallocation within non-formal employment with great precision, our results point to increases in informal employment, and decreases in self-employment.

Weekly hours elasticity. We also check for intensive-margin effects on employment, specifically examining the effects of the minimum wage on the number of hours worked, using the weekly hours variable available in PNAD. We estimate the effect on the log of weekly hours using the same specification as our baseline effect on wages (see Equation 1 in Section 4.1). Appendix Table H3 shows a precise zero effect of the large minimum wage increases on weekly hours worked in the formal sector—a result consistent with Engbom and Moser (2022) on contracted hours. Weekly hours elasticities are small and not statistically significant by 2009 in all other sectors. Appendix Figure H4 shows no pre-trends in our estimated effect on weekly hours.

Implications for the formalization process. Given our estimates of reallocation away from the formal sector, we can ask the question: what would have been the formal share in the economy in the absence of the 2000s minimum wage increases? To answer this question we estimate yearly counterfactual formal and informal shares implied by our own-wage reallocation estimates.[36] These calculations rely on three assumptions, motivated by our findings: (i) the minimum wage did not have overall disemployment effects, consistent with our findings in Table 5; (ii) the shift out of formal employment is absorbed by informal salaried employment, consistent with our results in Appendix Table H2; and (iii) there are no

[35] Interestingly, higher formal establishment concentration is associated with more reallocation towards informal employment among employed workers, but an overall positive reallocation to formal employment when considering both employed and non-employed individuals (see Appendix Table H1, consistent with other evidence of minimum wage effects on employment in more concentrated markets (Azar et al., 2024)). Areas with weaker enforcement have greater reallocation out of formal employment towards other forms of employment or non-employment while there is no significant association between industry formality type or workers' formal share of outside options and this form of reallocation.

[36] Annual reallocation elasticity estimates are displayed in Appendix Table H4.

general equilibrium effects of the minimum wage, i.e., the minimum wage doesn't interact with other economic forces that could influence the formal share of the economy.

Results are shown in Figure 8. Under these assumptions, we find that absent the 2000-2009 minimum wage increases, the formal share would have been 64.3% in 2009 instead of the actual share of 62.1%. Specifically, our -0.28 own-wage reallocation elasticity in 2009 implies that the 70.9% minimum wage increase from 1999-2009 (as measured by the Kaitz index) is associated with a 13.2% increase in average formal wages and a 3.6% shift out of formal employment. The counterfactual formal share of 64.3% in 2009 corresponds to the level that was observed in 2010.[37] Thus, absent the minimum wage increases, the formalization process would have been sped up by one year for the entire private workforce of salaried workers.

8 Implications for Labor Market Models of Informality

What do sizable informal wage effects and limited reallocation imply for models of informality? Our results are inconsistent with dual, segmented labor markets where minimum wage hikes increase informal employment and lower informal wages (Harris and Todaro, 1970; Fields, 1975; 1990). The more recent literature models informality as an endogenous sector choice by firms, workers, or both (Meghir et al., 2015; Ulyssea, 2018; Haanwinckel and Soares, 2021; Machado Parente et al., 2025). Are these models able to rationalize our findings?

Two models, presented in Haanwinckel and Soares (2021) and Machado Parente et al. (2025), explicitly consider the effect of minimum wage increases in the same period that we study. Haanwinckel and Soares (2021) is a search model with wages determined by Nash bargaining. Workers search for jobs in both the informal and formal sectors, from unemployment. A minimum wage in the formal sector can thus influence informal wages through the reservation value of unemployment, which includes expected wages in the formal sector weighted by the probability of receiving a formal job offer. While the minimum wage increases the expected wage in the formal sector, the policy also lowers demand for unskilled formal labor, raising unemployment and reducing formal vacancies (and thus, the probability of receiving a formal offer). As calibrated, the net effect is a reduction in informal wages along with a large increase in informality, reproducing "the traditional view of the informal sector" as an alternative to unemployment (Haanwinckel and Soares, 2021). Using the output from the estimated model, which considers a 61.2% increase in the minimum

[37] More precisely, we do not observe the formal share in 2010 in PNAD, but this is the level at which this share would have been, under the assumption that the formalization process is linear between 2009 and 2011.

wage holding all other parameters fixed to the baseline period, implies that a 10% increase in the formal wage driven by the minimum wage results in a decline in average informal wages of 10.6% and a reallocation of 7.78% of formal workers to informal employment.[38]

In Machado Parente et al. (2025), minimum wage increases push firms at the bottom of the formal productivity distribution to reallocate to the informal sector. The workers in these firms drive informal wages up via a composition effect, but this increase is accompanied by a large decline in formal employment. The counterfactual estimates from the model suggest that a 10% increase in the formal wage driven by the minimum wage leads to a 20.8% increase in informal wages caused by the 19.4% of formal workers reallocated to informal employment.[39]

In contrast to both of these cases, we find that for a 10% increase in formal wages from the minimum wage, average informal wages increase by about 6.7% and 2.8% of formal workers reallocated towards non-formal employment. Crucially, we show in Section 3 that increases in informal wages following a rise in the minimum wage also reflect changes in the wage of incumbent informal workers, rather than pure composition effects. Moreover, a smaller effect on reallocation in Machado Parente et al. (2025) is associated with smaller effects on the informal wage, while we observe the opposite pattern empirically: where the informal wage response is strongest, reallocation is smallest.

Two other leading papers in the literature consider integrated formal and informal labor markets. Meghir et al. (2015) is a Burdett-Mortensen wage posting model with on-the-job search. Workers search in both sectors and shocks to formal wages enter the informal wage determination in two ways. One is directly through the option value of a formal job. An increase in the minimum wage increases the value of a formal job offer. If the job destruction effects of the minimum wage are muted as in many monopsony models, the impact on arrival rates is limited and the higher arrival-rate weighted value of a formal offer bids up the wage in the informal sector needed for employers of informal workers to retain their workers. Our results are thus more aligned with a model where formal jobs constitute a real outside option for informal workers.[40] In Appendix I.2, we provide simplified representations of the mechanisms in each of these models, including this last case whose predictions match our empirical results.

Finally, Ulyssea (2018) gives another rationale for why minimum wage increases might

[38] See Appendix I.1 for details on these calculations.

[39] See Appendix I.1 for details on these calculations.

[40] With sufficiently inelastic formal labor demand, a model like Haanwinckel and Soares (2021) might also deliver positive wage effects on informal workers with limited reallocation.

spill over to informal workers that has to do with employer compliance practices. It distinguishes between firms that are registered businesses and those that are not, and shows that the former may also hire informal workers, forming the intensive margin of informality, while the latter make up the extensive margin. Thus, partial compliance with the law (business registration) coexists with non-compliance with other aspects of the law (labor regulation). Ulyssea (2018) notes that within firms that hire both informal and formal workers, the average wage gap between the two groups of workers falls to zero when controlling for workers' skill, gender, seven-digit industry dummies, and a quadratic in age (See Table 2 column (3) in Ulyssea (2018)). Thus, if firms apply similar pay-setting practices across workers within the same occupation, workers in minimum wage occupations would receive the same pay regardless of formality status. When the minimum wage is largely applied to informal workers as well, employers have less to gain from switching to the informal sector or hiring workers in informal arrangements. Our findings on compliance with the minimum wage in low-informality industries and at formal firms align well with this intensive vs. extensive margin view of informality.

In sum, our empirical evidence is consistent with a role for both partial compliance and formal outside options in directly influencing informal workers' pay in the wake of minimum wage increases. To fully model the effects of minimum wages in low- and middle-income settings, it's necessary to consider either partial enforcement, compliance practices at the firm or industry level, or strong anchoring or norms that generate adherence to the minimum wage in the informal sector. Furthermore, in settings where formal jobs are a plausible outside option for informal workers, a binding minimum wage in the formal sector places upward pressure on the informal wage, but the formal employment elasticity is a key determinant of whether an offsetting effect occurs through the loss of formal jobs. Frictional models of informality that capture the above features are a promising avenue for future work.

9 Conclusion

This paper studies how the minimum wage affects wages and the allocation of employment in a middle-income country with substantial and varying forms of informality. Our context is Brazil, which experienced large minimum wage increases in the 2000s and whose economy is characterized by a sizable and heterogeneous informal sector—a large fraction of which consists of salaried employees of firms—and the availability of detailed labor force surveys and administrative matched employer-employee data with information on formality status.

We provide evidence on the bite of the minimum wage across all types of workers, including those working outside the formal sector or who are self-employed. We use differential bite of the 2009 minimum wage across state-by-industry cells to quantify the effect of the minimum wage increases on each of these groups. We find that informal workers also see large wage gains. In particular, informal workers see gains of about 66% of the formal wage increase. We find no clear evidence of increased wages for the self-employed.

We then provide evidence on factors mediating the wage effects in the informal sector, shedding light on the extent to which minimum wages might raise informal workers' wages in other contexts. We find evidence for three different channels, including enforcement capacity, informal workers degree of formal outside options, and firm or industry compliance tendencies. We do not find evidence that norms more broadly conceived drive wage effects among informal workers nor does the degree of formal sector labor market concentration seem to moderate spillovers to informal workers.

Given the significant wage effects of the minimum wage among informal workers, we turn to the formal-to-informal reallocation effects of the minimum wage next. We estimate the own-wage reallocation elasticity—the extent to which employment shifts from the formal to the informal sector in response to wage increases in the formal sector. For a 10% increase in formal sector wages, 2.8% of formal workers are reallocated to the informal sector or self-employment. These effects are relatively modest in the context of minimum wage employment effects. We believe the substantial wage effects and the large degree of de facto compliance with the minimum wage outside of formal sector employment undergirds these small reallocation effects.

New models of the labor market with formal-to-informal worker wage spillovers would be useful for understanding the economic effects of labor market regulations in countries with a large informal workforce. Close attention should be paid to employer compliance practices and the enforcement infrastructure, which may vary across countries, as well as to heterogeneity across informal workers in their outside options in the formal sector.

We nevertheless caveat that the period we study is one of economic growth, and wage effects in the informal sector might be more muted in worse economic conditions, leading to more reallocation away from the formal sector. Research on own-wage reallocation elasticities in other low- and middle-income countries will deepen our understanding of when and why minimum wages bind outside of formal employment and will further our understanding of minimum wage effects in developing economies.

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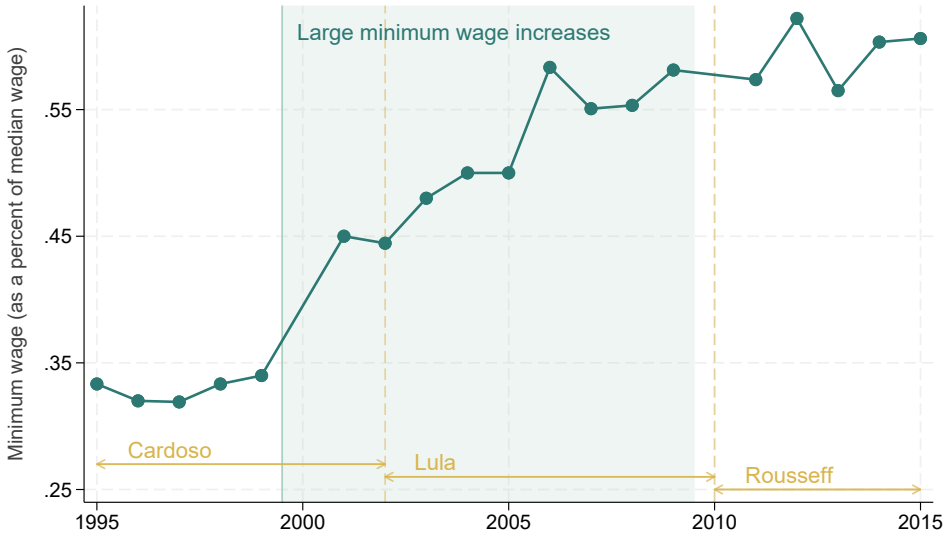
Figure 1: Evolution of the minimum wage, as a share of the median wage (Kaitz index), and of the shares strictly below the minimum, 1995-2015

(a) Evolution of the minimum wage, as a share of the median wage (Kaitz index), 1995-2015



(b) Shares of workers strictly below the minimum wage, 1995-2015

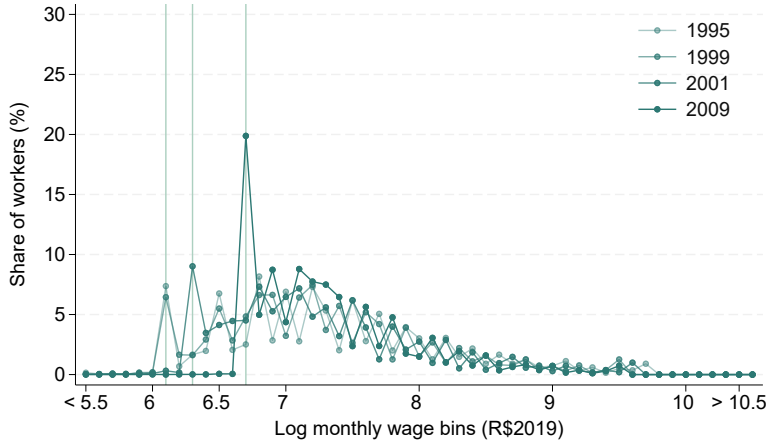
Sources: PNAD 1995-2015.

Sample: Adults aged 25-54 employed in the private sector, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Panel (a): Formal employees only. Panel (b): Formal, informal employees and the self-employed.

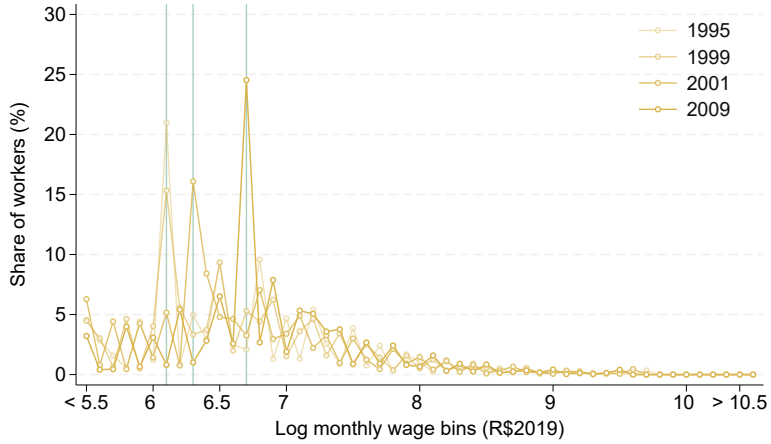
Notes: Panel (a): The Kaitz index calculated in the formal sector increases from 34% in 1999 to 58.1% in 2009. Panel (b): The share of formal employees strictly below the minimum wage is 0.7% in 1995, 0.7% in 1999, 0.9% in 2001, and 0.2% in 2009. The respective shares are 12.8%, 16.4%, 20.5%, and 28.1% for informal employees; and 11.7% , 15.5% , 19.2% and 25.1% for the self-employed.

Figure 2: Monthly earnings distributions among formal and informal employees

(a) Formal employees



(b) Informal employees



(c) Self-employed

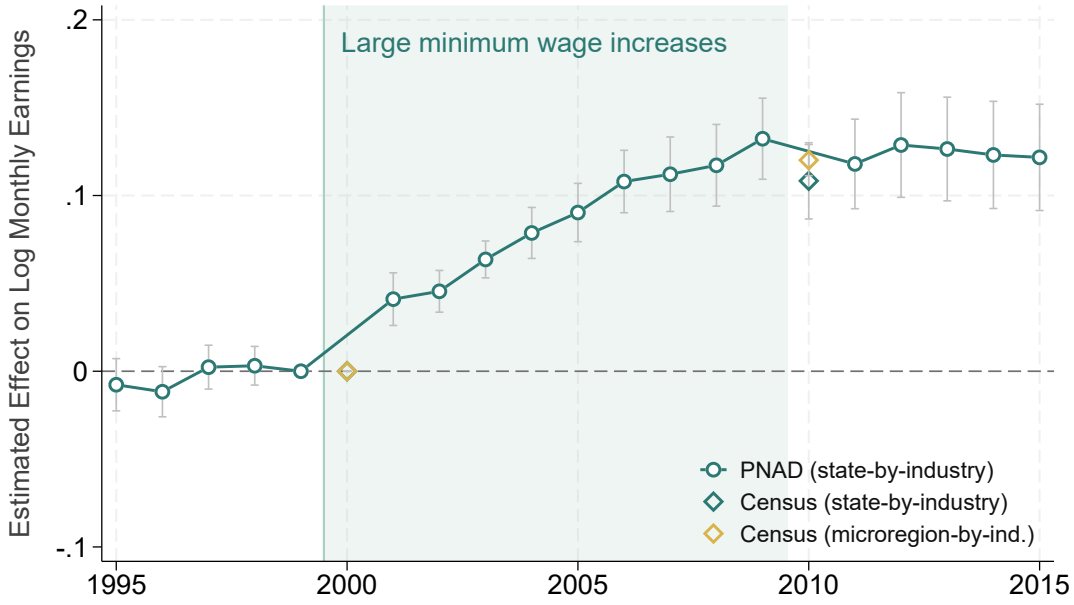
Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Sample (a) further restricts to formal employees; sample (b) is restricted to informal employees; and sample (c) is restricted to the self-employed.

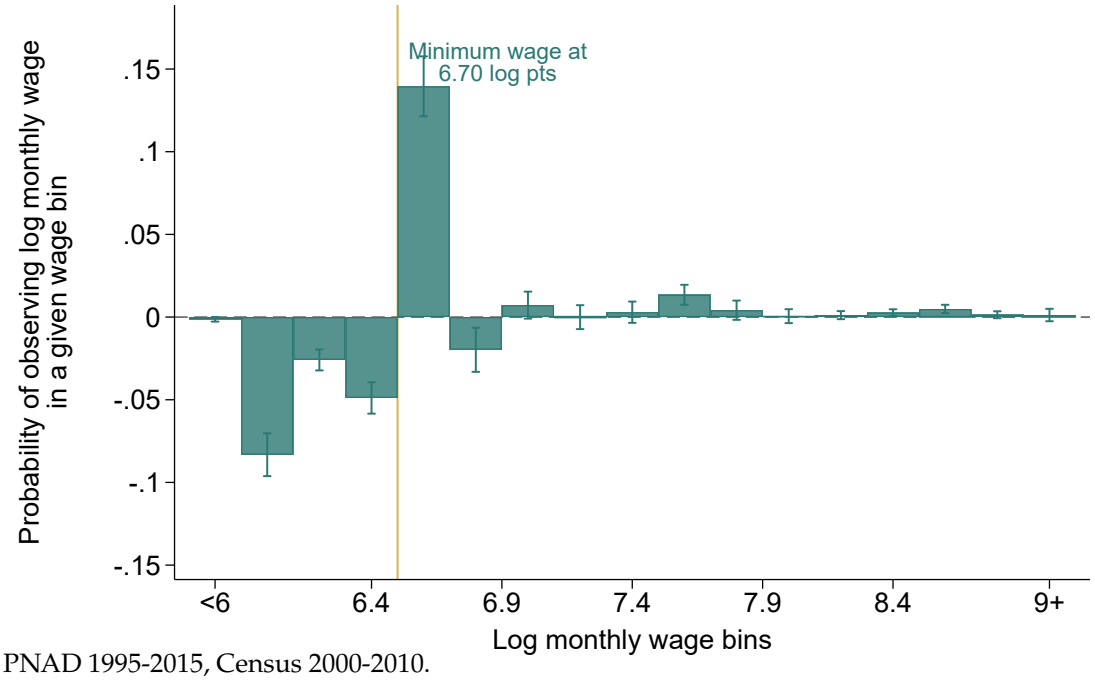
Notes: The complete series of monthly earnings distributions from 1995 to 2015 is available in our slides here. The wage bin (10 log points wide) in which the minimum wage falls in each year is materialized by a vertical bar. The share of workers in the wage bin where the minimum wage falls and that can be directly read on the y-axis should therefore be understood as the share of workers within 10% of the minimum wage. The exact share of workers at or below the minimum wage are 7.8% in 1995, 6.2% in 1999, 8.4% in 2001, and 13.4% in 2009 among formal employees. The respective shares are 29.8%, 26%, 33% and 42.1% among informal employees, and 15.2%, 14.2%, 19.2% and 23.6% among self-employed.

Figure 3: Results on wages among formal employees, 1995-2015

(a) Effect on average wages



(b) Effect on the probability to be in a certain wage bin, 2009



Sources: PNAD 1995-2015, Census 2000-2010.

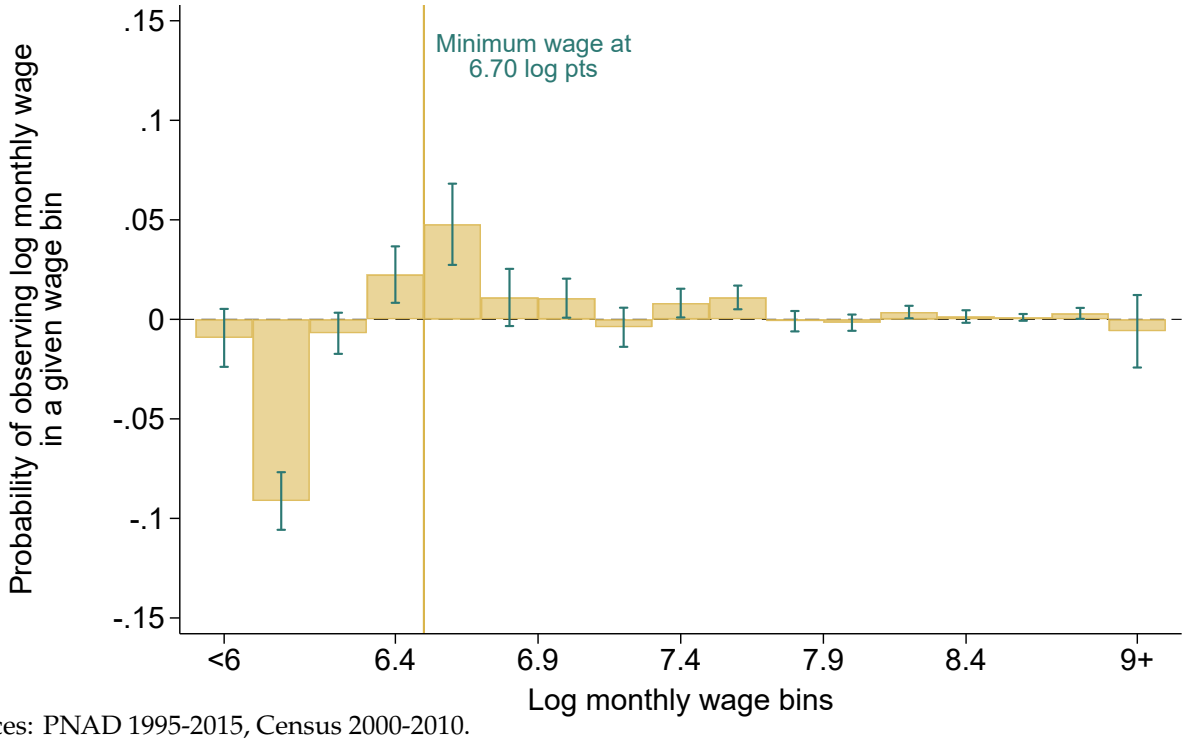
Sample: Formal employees aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Panel (a) shows the main results from our difference-in-differences design at the state-by-industry level assessing the effect of the 2000-2009 minimum wage increases on average wages (see Equation 1 in Section 4.1) using PNAD data (circles). It overlays these results with comparable estimates using census data (green diamonds), and with census data using variation at the microregion-by-industry level (yellow diamonds). See Section 4.1 for more details on robustness to Census data. Panel (b) shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 4.2). The complete 1995-2015 series of graphs is available in our slides here.

Figure 4: Results on wages among informal employees, 1995-2015

(a) Effect on average wages

(b) Effect on the probability to be in a certain wage bin, 2009



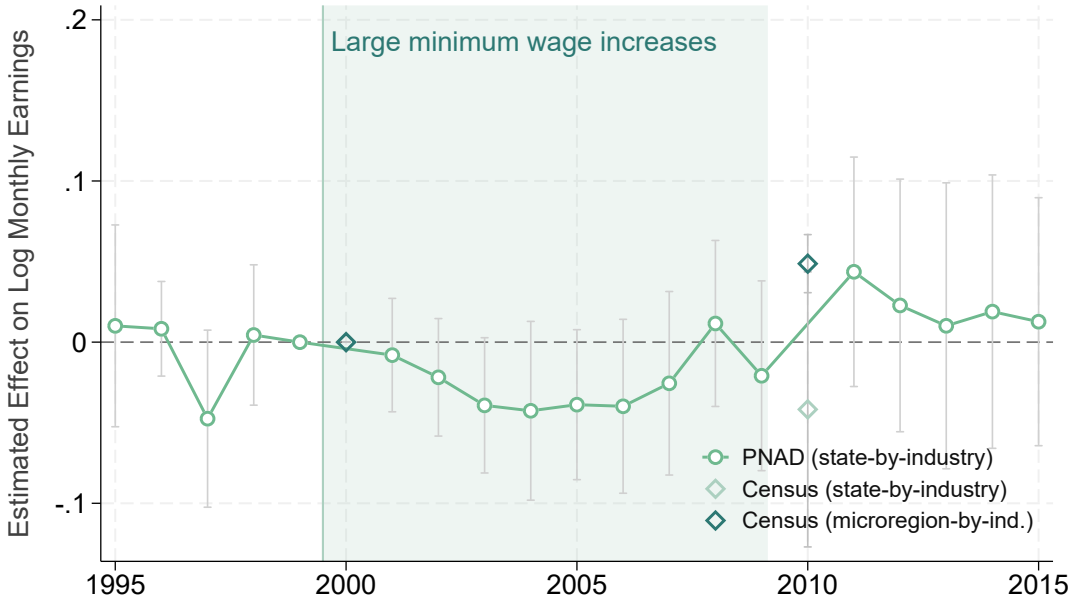
Sources: PNAD 1995-2015, Census 2000-2010.

Sample: Informal employees aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Panel (a) shows the main results from our difference-in-differences design at the state-by-industry level assessing the effect of the 2000-2009 minimum wage increases on average wages (see Equation 1 in Section 4.1) using PNAD data (circles). It overlays these results with comparable estimates using census data (yellow diamonds), and with census data using variation at the microregion-by-industry level (green diamonds). See Section 4.1 for more details on robustness to Census data. Panel (b) shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 4.2). The complete 1995-2015 series of graphs is available in our slides here.

Figure 5: Results on wages among the self-employed, 1995-2015

(a) Effect on average wages



(b) Effect on the probability to be in a certain wage bin, 2009

Sources: PNAD 1995-2015, Census 2000-2010.

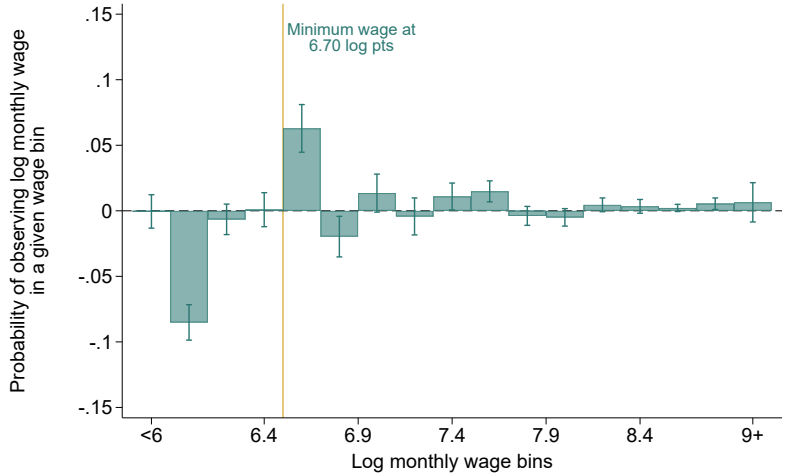
Sample: Self-employed adults aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Panel (a) shows the main results from our difference-in-differences design at the state-by-industry level assessing the effect of the 2000-2009 minimum wage increases on average wages (see Equation 1 in Section 4.1) using PNAD data (circles). It overlays these results with comparable estimates using census data (light green diamonds), and with census data using variation at the microregion-by-industry level (dark green diamonds). See Section 4.1 for more details on robustness to Census data. Panel (b) shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 4.2). The complete 1995-2015 series of graphs is available in our slides here.

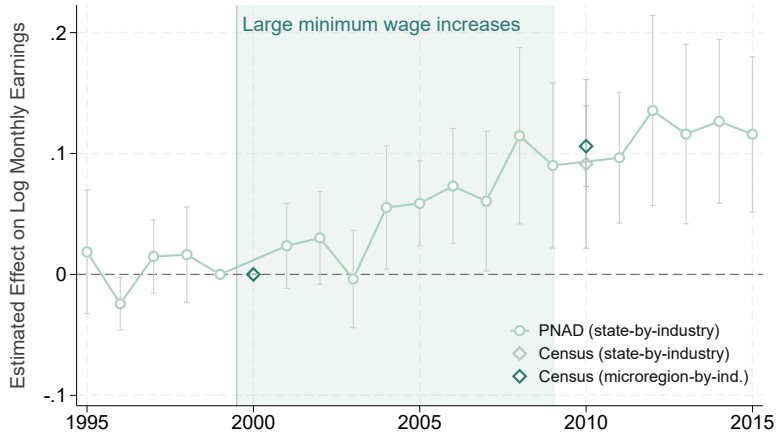
Figure 6: Wage effects and compliance by industry type

(a) Average wages among informal employees in low-informality industries

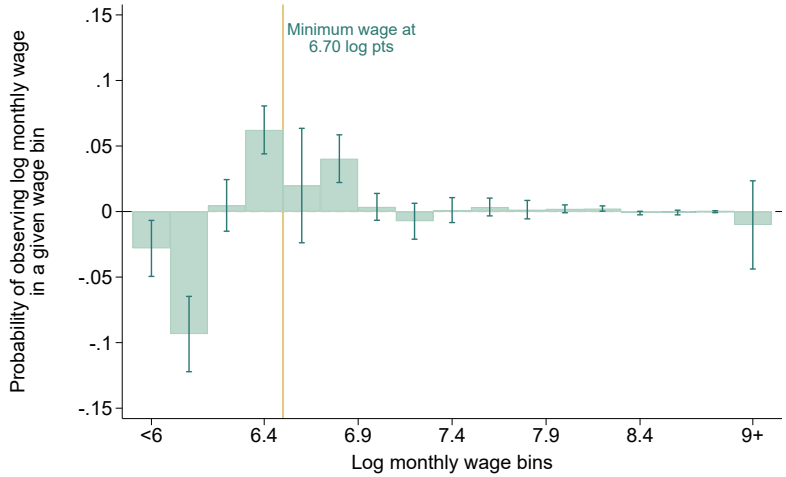
(b) Probability of being in a certain wage bin for informal employees in low-informality industries



(c) Average wages for informal employees in high-informality industries



(d) Probability of being in a certain wage bin for informal employees in high-informality industries



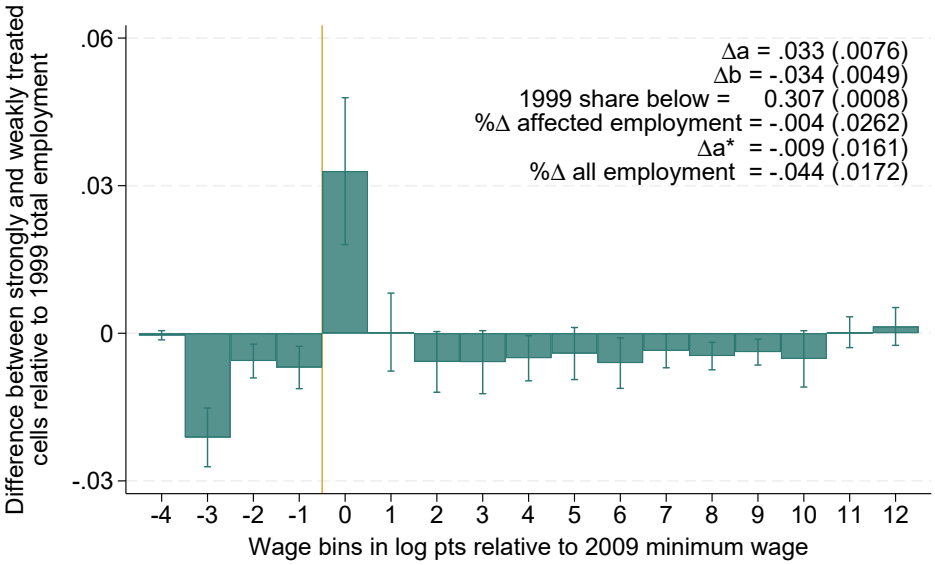
Sources: PNAD 1995-2015, Census 2000-2010.

Sample: Adults aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Informal employees in high-informality industries only in panels (a) and (b); informal employees in high-informality industries in panels (c) and (d). See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries.

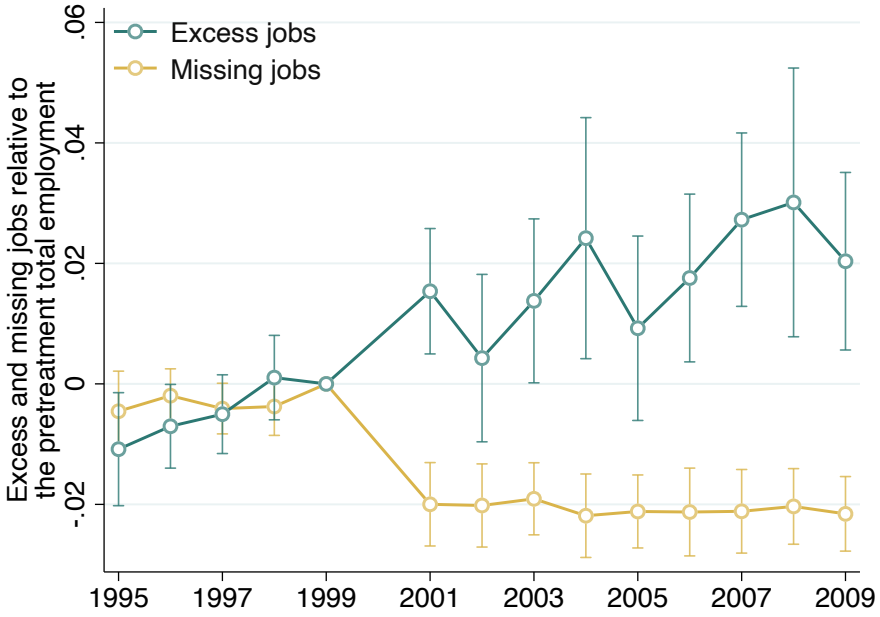
Notes: Panels (a) and (c) show the main results from our difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on average wages (see Equation 1 in Section 4.1). Panels (b) and (d) show the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 4.2).

Figure 7: Effect of the minimum wage on formal share of total employment

(a) Effect on the allocation of formal jobs, 2009



(b) Evolution of excess vs. missing formal mass, 1995-2015

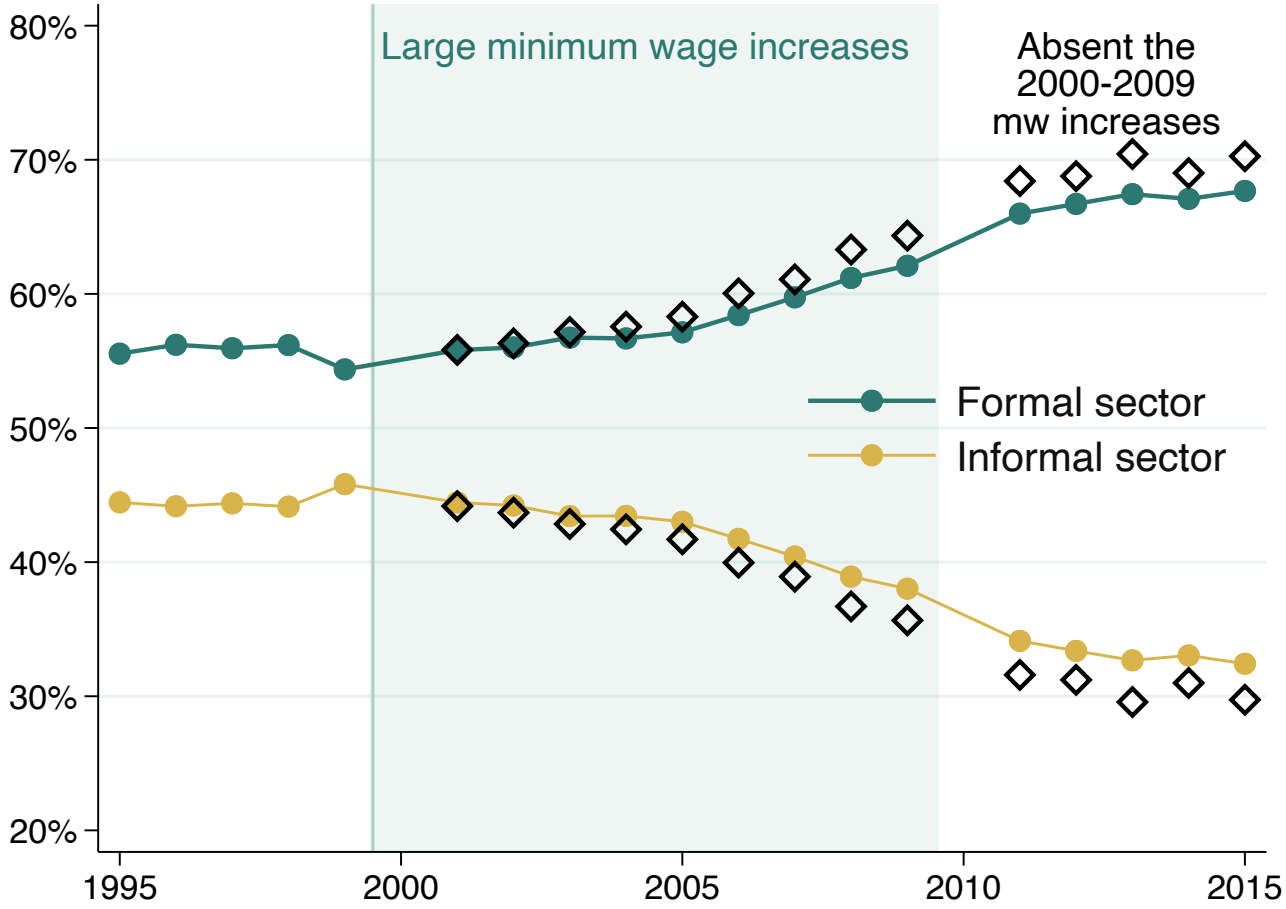


Sources: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, working either part-time or full-time, with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of jobs (see Equation 3 in Section 7.1). Panel (a): The figure documents the effect of the 2000-2009 increases on the reallocation of employment away from formal employment. The outcome variable is the number of formal employees in each state-by-industry-by wage bin in 2009 over the total number of workers in 1999 in that state-by-industry cell, across all sectors of employment (formal or informal employees, or self-employed). Panel (b): The figure shows the effect on missing formal jobs below the minimum wage (yellow line); and its effect on excess formal jobs at the minimum wage (green line) over 1995 to 2015, out of all 1999 employment. Here we define missing and excess jobs relative to the 2001 minimum wage (i.e. the first year of the minimum wage increase). We effectively aggregate three bins that contain the minimum wage over the period 2001-2015 to defined excess jobs at the minimum wage.

Figure 8: Evolution of the formal sector vs. informal sector, and counterfactual shares



Sources: PNAD 1995-2015.

Sample: Adults aged 25-54 employed in the private sector, white or non-white, working either part-time or full-time, with no missing monthly earnings variable, and with no missing experience variable. The formal sector is comprised of formal employees, and the informal sector is comprised of informal employees. The public sector, the self-employed, and entrepreneurs are excluded (to see the evolution of overall employment, see Appendix Figure A2).

Notes: This is the exact same figure as Figure A1, with the counterfactual formal and informal shares overlaid post-1999, i.e. the formal and informal shares implied by our own-wage reallocation estimates absent the 2000s minimum wage increases (see Appendix Table H4 for our annual own-wage reallocation elasticity estimates and the discussion in Section 7.2, paragraph "Implications for the formalization process". We estimate that, absent the minimum wage increases, the formal share in 2009 would be 64.3% instead of the observed 62.1%.

Table 1: Workers' characteristics – Part I , 1999

	Across workers' types			Among informal employees by distance to formal sector	
	Formal employees	Informal employees	Self-employed	Low-informality industries	High-informality industries
Median monthly earnings (in R$2019)	2,029	743	1,610	1,310	401
Age	36.3	37.0	39.3	36.0	37.6
Work experience	22.6	26.2	27.7	22.8	28.3
Tenure	6.2	6.6	9.7	4.3	8.0
Gender					
Male	0.63	0.42	0.70	0.52	0.36
Female	0.37	0.58	0.30	0.48	0.64
Race					
White	0.62	0.49	0.55	0.57	0.44
Nonwhite	0.38	0.51	0.45	0.43	0.56
Education					
Less than high school	0.64	0.85	0.80	0.67	0.96
High school completed	0.26	0.11	0.15	0.24	0.03
College completed	0.10	0.04	0.05	0.08	0.01
Region					
North	0.03	0.05	0.05	0.06	0.04
Northeast	0.16	0.33	0.34	0.28	0.36
Southeast	0.56	0.38	0.38	0.43	0.34
South	0.19	0.16	0.16	0.14	0.17
Midwest	0.06	0.08	0.06	0.08	0.09
Full-time/part-time status					
Full-time	0.89	0.61	0.71	0.71	0.54
Part-time	0.11	0.39	0.29	0.29	0.46
Firm size					
Conditional on non-missing					
Small firm (9 workers or less)	0.22	0.64	n.a.	0.61	0.77
Large firm (10+ workers)	0.78	0.36	n.a.	0.39	0.23
Missing	0.23	0.69	1.00	0.32	0.91
Registration with tax authorities					
Yes	n.a.	n.a.	0.18	n.a.	n.a.
No	n.a.	n.a.	0.82	n.a.	n.a.

Source: PNAD 1999.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed, working either part-time or full-time. Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e.,in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries).

Notes: Median monthly earnings in R$2019 winsorized at 1% and 99% levels, deflated using the inpc series.

Table 2: Workers' characteristics – Part II, 1999

	Across workers' types			Among informal employees	
	Formal employees	Informal employees	Self-employed	Low-informality industries	High-informality industries
Workers near the minimum wage					
Strictly below 100% of the mw (%)	0.01	0.16	0.15	0.07	0.24
Strictly below 115% of the mw (%)	0.42	0.63	0.50	0.51	0.72
Between 105% and 115% of the mw (%)	0.30	0.25	0.24	0.27	0.23
Between 90% and 105% of the mw (%)	0.12	0.34	0.21	0.23	0.44
Strictly below 90% of the mw (%)	0.00	0.04	0.05	0.02	0.06
Industry					
Agriculture, forestry and fishing	0.06	0.37	0.23	0.00	0.59
Mining and extractive industries	0.01	0.00	0.00	0.01	0.00
Manufacturing	0.24	0.07	0.05	0.18	0.00
Construction	0.05	0.07	0.13	0.00	0.11
Wholesale and retail trade	0.13	0.08	0.19	0.22	0.00
Hotels and restaurants	0.03	0.03	0.05	0.08	0.00
Transportation, communication and electricity, gas, water	0.10	0.03	0.06	0.08	0.00
Finance, insurance, real estate and repair services	0.11	0.05	0.12	0.13	0.00
Public administration	0.03	0.03	0.00	0.08	0.00
Education, health and social work	0.11	0.05	0.02	0.14	0.00
Domestic services	0.07	0.19	0.00	0.00	0.30
Entertainment, recreation and other services	0.05	0.03	0.13	0.09	0.00
Occupation					
Managerial	0.05	0.02	0.00	0.05	0.01
Scientific and artistic	0.05	0.03	0.05	0.07	0.00
Mid-level technicians	0.06	0.03	0.04	0.09	0.00
Administrative service workers	0.15	0.04	0.00	0.09	0.00
Service workers	0.22	0.25	0.06	0.18	0.30
Retail service workers	0.06	0.06	0.26	0.16	0.00
Agriculture workers	0.06	0.36	0.23	0.01	0.57
Manufacturing, construction and repair workers	0.31	0.19	0.35	0.30	0.12
Armed forces and other occupations	0.03	0.02	0.01	0.06	0.00

Source: PNAD 1999.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed, working either part-time or full-time. Further restricted to workers working full-time (i.e. 40 hours a week or more) and no missing monthly earnings variable and no missing experience variable for the statistics presented in the section "Workers near the minimum wage."

Table 3: Wage effects of the minimum wage by worker type, 2009

	Baseline	**Robustness checks**		
	(1)	(2)	(3)	(4)
Strongly treated × 2009				
Formal employees	0.132***	0.134***	0.129***	0.135***
	(0.012)	(0.011)	(0.013)	(0.012)
	7.309	7.309	7.309	7.309
	705,536	705,536	705,536	705,536
Informal employees	0.111***	0.123***	0.139***	0.120***
	(0.016)	(0.016)	(0.016)	(0.017)
	6.668	6.668	6.668	6.668
	286,340	286,340	286,340	286,340
Self-employed	-0.021	-0.005	0.027	-0.009
	(0.030)	(0.031)	(0.031)	(0.028)
	7.055	7.055	7.055	7.055
	329,581	329,581	329,581	329,581

Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on average wages (see Equation 1 in Section 4.1). For each category of workers, the first row represents the point estimate; the second row displays the standard error in parentheses; the third row is the mean dependent variable; and the fourth row is the number of observations used in the regression.

Table 4: Mediators of wage effects on informal workers

	(1) Enforcement	(2) Industry informality share	(3) Share OOI_F	(4) Estab. LM concentration	(5) All mediators
Strongly treated × *Post*	0.147***	0.151***	0.097***	0.103***	0.087***
	(0.007)	(0.017)	(0.022)	(0.026)	(0.022)
× weaker enforcement	-0.051***				-0.050***
	(0.007)				(0.014)
× high-informality industry		-0.076***			-0.083***
		(0.029)			(0.024)
× high share OOI_F			0.054***		0.049***
			(0.010)		(0.014)
× high estab. concentration				0.024	0.007
				(0.024)	(0.016)
Mean dep. var.	6.781	6.779	6.785	6.782	6.867
N	1,515,557	1,589,202	1,301,147	1,245,925	983,845
State(-group) × industry FEs		X	X	X	X
Micro-region × industry FEs	X				
Industry × year FEs	X	X	X	X	X

Source: Census 2000-2010.

Sample: Informal employees aged 25-54, white or non-white, employed in the private sector, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable..

Notes: Columns 1-4 report the triple-difference estimate of the wage effect of the 2009 minimum-wage peak among informal employees, by a different proposed mediator of incomplete passthrough. Column 5 reports the effect for all four mediators in one regression. "Strongly treated" is the standardized state × industry exposure to the federal minimum wage interacted with the post-2009 (or 2010) indicator. Each moderator is constructed as an indicator for more exposed state(micro-region) by industry cells. Column 1 contrasts micro-regions where the maximum distance to a labor-enforcement office is higher (weaker enforcement, above vs. below median); column 2 estimates the effect separately for the three most informal industries (agriculture, construction & domestic services); column 3 contrasts demographic-occupation cells in which workers' outside options are disproportionately concentrated in the formal sector vs. those where they are not; and column 3 estimates the effect separately for more concentrated labor markets. Column 5 includes all of the above mediators in one regression. All specifications control for individual covariates (education, work experience and its square, log state GDP per capita and its square, white, female) and include state(-group) × industry and industry × year fixed effects, except col. (1) which uses micro-region × industry fixed effects. Standard errors (in parentheses) are clustered at the same level as the absorbing fixed effects.

Table 5: Own-wage reallocation elasticities out of the formal labor force

	Towards other sectors of employment			Towards other sectors or non-employment		
	%Δ emp.	%Δ wage	Elast.	%Δ emp.	%Δ wage	Elast.
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. PNAD, 2009						
	-0.036**	0.128***	-0.282**	-0.038***	0.102***	-0.373**
	(0.015)	(0.011)	(0.123)	(0.015)	(0.020)	(0.192)
	1,835,377	790,389	1,835,584	2,564,493	791,288	2,564,493
Panel B. Census, 2010						
	-0.028**	0.099***	-0.282*	-0.023	0.088***	-0.257
	(0.013)	(0.010)	(0.152)	(0.023)	(0.017)	(0.302)
	9,791,319	4,463,483	9,791,319	14,997,254	4,463,483	14,997,254
State × industry treat. var.	X	X	X			
State treat. var.				X	X	X
Individual-level controls	X	X	X	X	X	X
State GDP controls	X	X	X	X	X	X
State × industry FEs	X	X	X			
Industry × year FEs	X	X	X			
State FEs				X	X	X
Year FEs				X	X	X

Source: PNAD 1995-2015 and Census 2000-2010.

Sample: Adults aged 25-54, white or non-white; columns (1)-(3) further restricted to those employed in the private sector, either formal employees, informal employees or self-employed; workers working either part-time or full-time and no missing monthly earnings variable, no missing experience variable; columns (4)-(6) includes, on top of the employed, those who are unemployed or not in the labor force.

Notes: The table shows the percent change in the share of formal employees among the total private workforce in column 1 (see equation 4 in Section 7.1) and corresponding wage effect (column 2) and reallocation elasticity (column 3). The table also shows the percent change in the share of formal employees out of the working age population in column 4 (see equation 5 in Section 7.1) and the corresponding wage effect (column 5) and reallocation elasticity (column 6). Panel A shows results estimated using PNAD, and panel B shows results using Census. Columns 1-3 use treatment defined at the state-by-industry level; columns 4-6 use treatment defined at the state level.

Table 6: Mediators of own-wage reallocation elasticities out of the formal labor force

	(1) Enforcement	(2) Industry informality	(3) Share OOI_F	(4) Estab. LM concentration	(5) All mediators
Panel A. Private workforce					
Strongly treated × *Post*	-0.009***	-0.004	-0.012**	-0.009	-0.010*
	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
× weaker enforcement	-0.008***				-0.006
	(0.003)				(0.005)
× high-informality industry		-0.013**			-0.010*
		(0.007)			(0.006)
× high share OOI_F			0.003		0.010**
			(0.005)		(0.005)
× high estab. concentration				-0.013*	-0.010
				(0.007)	(0.006)
Mean dep. var.	0.447	0.439	0.440	0.434	0.443
N	9,409,661	9,791,319	8,181,813	8,672,904	7,013,741

Source: Census 2000-2010.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed; workers working either part-time or full-time and no missing monthly earnings variable, no missing experience variable.

Notes: The table shows the relationship between our four wage effect mediators and formal employment vs. non-formal employment. The first four columns report each effect separately, the final column reports the effect of all four in a single regression, as in 4.

ONLINE APPENDIX

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Appendix A Additional details on the minimum wage

A.1 Political and macroeconomic context of minimum wage increases

The 2000-2009 minimum wage increases were implemented during an exceptionally buoyant period for the Brazilian economy. The 1994 Plano Real spurred rapid growth in the Brazilian economy until a recession in 2014: GDP per capita was 50% higher in 2009 than in 1995 and 75% higher in 2014 than in 1995. During that period, the unemployment rate exhibited a steady decline, from 10.2% in 1999 to 6.7% in 2014 (see Figure A3a).

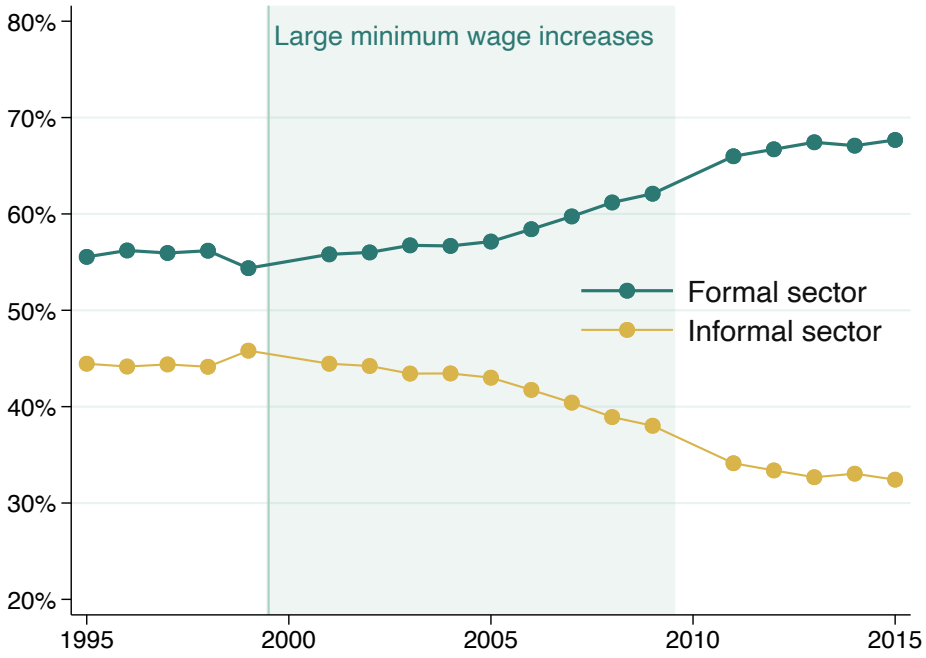
On the demand side, trade is often considered a key factor that spurred economic growth during the 2000s. On the supply-side, many changes happened in the labor market from 1995 to 2015. The private labor force increased by 57%, as the population was growing. There was a relative increase in the share of non-white workers within this labor force and an increase in educational attainment for the entire population, with the gains most concentrated among non-white individuals.[1] There was a decline in the size of the informal sector (see Appendix Figure A1).[2] Finally, there was an increase in conditional cash transfer programs (with the creation of *Bolsa Famìlia* in 2004) (see Appendix Figure A3b).

We take all of these changes into account in our analysis of the effects of the minimum wage.

[1] The share of the private formal labor force with a college education increased from 10% in 1999 (see Table 1) to 17% in just 16 years.

[2] There are many reasons that can explain this decline. For example, Lula enacted enforcement policies at the beginning of the 2000s (in particular, among domestic service workers in 2003).

Figure A1: Evolution of the formal sector vs. informal sector, 1995-2015



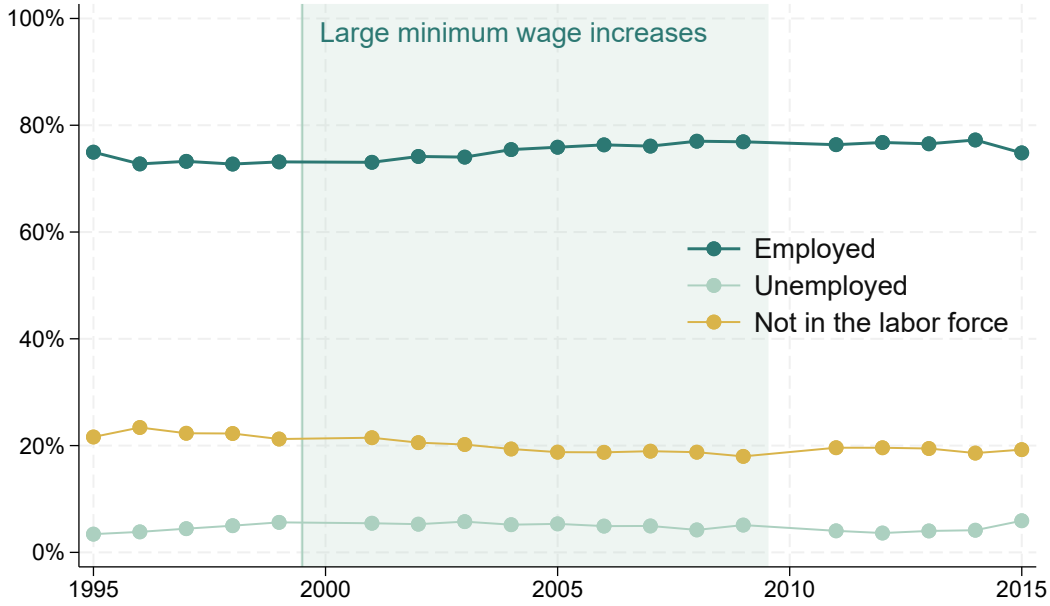
Sources: PNAD 1995-2015.

Sample: Adults aged 25-54 employed in the private sector, white or non-white, working either part-time or full-time, with no missing monthly earnings variable, and with no missing experience variable. The formal sector is comprised of formal employees, and the informal sector is comprised of informal employees. The public sector, the self-employed, and entrepreneurs are excluded (to see the evolution of overall employment, see Appendix Figure A2).

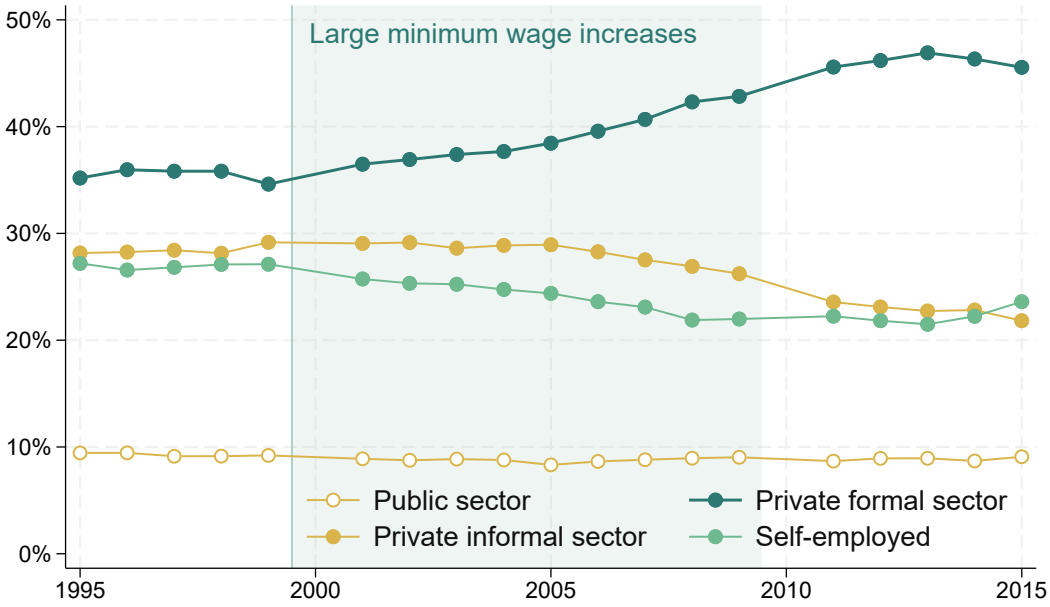
Notes: In 1999, the share of informal employees among employees in the private sector is 45.8%. This share is 38.0% in 2009.

Figure A2: Evolution of employment in Brazil (1995-2015)

(a) Employment status



(b) Employment structure



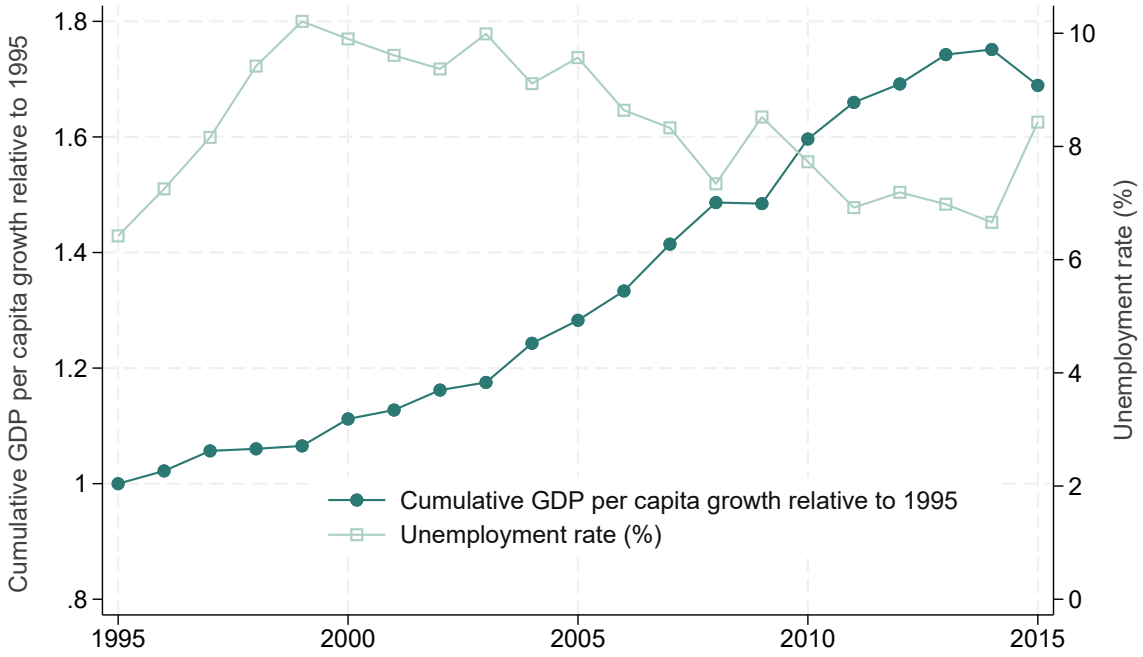
Sources: PNAD 1995-2015.

Sample: Panel (a): Adults aged 25-54, white or non-white. Panel (b): further restricted to employed individuals, with no missing monthly earnings variable, and with no missing experience variable.

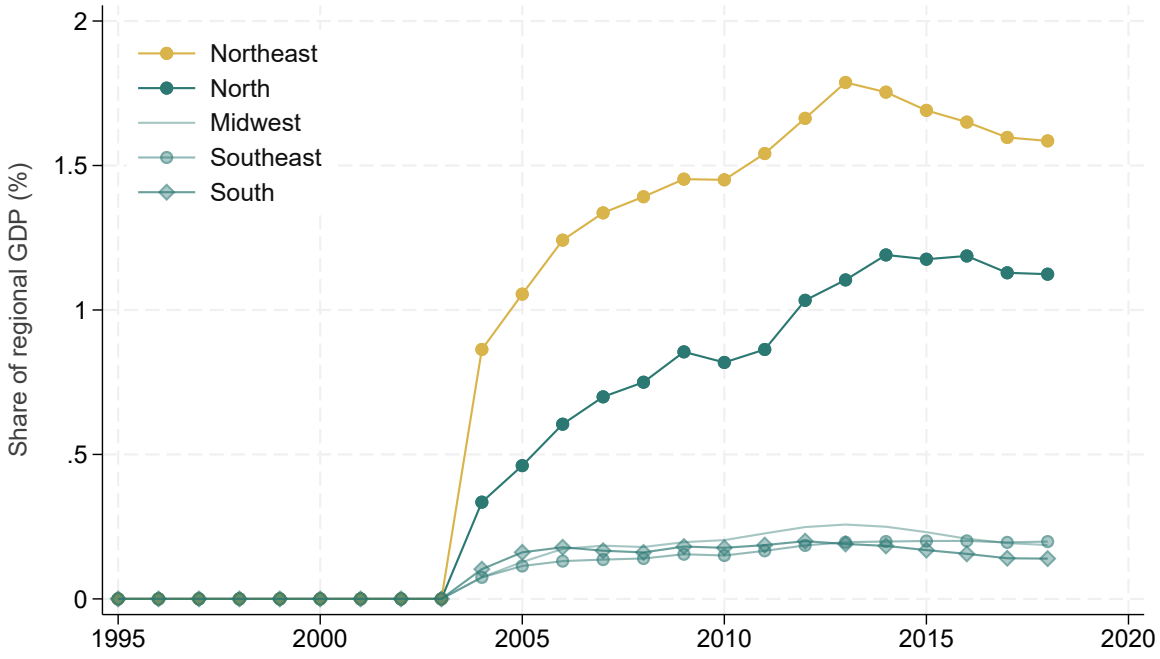
Notes: Panel (a): In 1999, 55.1% of adults were employed, 5.9% were unemployed and 39.0% not in the labor force. In 2009, these shares were 57.0%, 5.16% and 37.9% respectively. Panel (b): among employed adults, 34.6% were employed in the private formal sector, 29.2% in the private informal sector, and 9.2% in the public sector. 27.1% were self-employed. In 2009, these shares were 42.8%, 26.2%, 9.0% and 22.0% respectively.

Figure A3: Macroeconomic context of minimum wage increases (1995-2015), Brazil

(a) GDP growth and unemployment rates



(b) Bolsa Familia expenditures, by region



Sources: Panel (a): World Bank; Panel (b): Authors' database on Bolsa Família expenditures by region.
Notes: Panel (a): GDP per capita normalized to 1 in 1995. Panel (b): Bolsa Família expenditures, as a share of regional GDP.

A.2 History of the minimum wage legislation in Brazil

Introduction in the 1943 Labor code. The minimum wage was first introduced in the 1943 The Brazilian labor code (*Consolidacao das Leis Trabalhistas*, CLT). It stipulates that all employees should accordingly be paid at least the yearly minimum wage. The CLT also establishes that those workers who are paid below the minimum wage have the legal right to request the complement for wages not meeting the minimum value.

Importantly, the minimum wage applies to all workers, whether they have a signed a formal contract or not, as outlined by the following articles extracted from the 1943 Labor code:

- Art. 76: "The minimum wage is the minimum compensation owed and paid directly by the employer to every worker, including rural workers, without distinction of sex, for a normal working day, and must be sufficient to meet, at a given time and in a specific region of the country, the worker's basic needs for food, housing, clothing, hygiene, and transportation."
- Art. 118: "Any worker paid less than the minimum wage is entitled, notwithstanding any contract or agreement to the contrary, to claim from the employer the difference to the minimum wage established in the region, zone, or subzone where the work is performed."
- Art. 120: "Anyone who violates any provision regarding the minimum wage shall be subject to a fine of Cr$50.00 (fifty cruzeiros) to Cr$2,000.00 (two thousand cruzeiros), doubled in case of recurrence."

From its creation to 1984, the minimum wage varied across states.

In the 1988 Brazilian Federal Constitution. The Constitution unifies the minimum wage at the federal level. In particular:

- Art. 7: "The rights of urban and rural workers, in addition to others aimed at improving their social conditions, include: (...)"
- "IV - A minimum wage, established by law, nationally unified, sufficient to meet their basic vital needs and those of their family, including housing, food, education, health, leisure, clothing, hygiene, transportation, and social security, with periodic adjustments to maintain its purchasing power, and its use for any other purpose is prohibited."

State level minimum wages since 2001. Since 2001, states can institute their own state-level minimum wage. Over our period of study (1995-2015), five states have introduced state-level specific wage floors: Rio de Janeiro and Rio Grande do Sul starting in 2001, Paraná since 2006, São Paulo since 2007, and Santa Catarina since 2010. As we are interested in understanding the effect of the minimum wage on both the formal and informal sectors and therefore heavily rely on household survey data, we focus our analysis on the federal minimum wage only. We note that studies that exploit the fine-level matched employer-employee data—and thus focus only on the formal sector—fail to find bindingness of these wage floors. Tepedino (2013) found earnings spikes around the floors in the five states cited above, and Terrell (2009) documented that state minimum wages have increased wages for directly affected workers. However, Corseuil et al. (2013) reported non-compliance with the floor in Paraná and São Paulo. More recently, Saltiel and Urzúa (2022) emphasize that these regional wage floors target mainly workers in the restaurant and accommodation industries. More generally, the enforcement of the regional minimum wage legislation faces some challenges. Although the institution responsible for regional minimum wages inspection is the same as for the national minimum wage, many argue that the enforcement is more complicated at the state level (Moura and Neri, 2007; Corseuil et al., 2013).

Our own analysis of these regional laws led us to conclude that the potential non-compliance with these regional wage floors may come from the fact that the text of the state laws did not cite precisely any industry or occupation official classification codes—leaving firms with leeway when assessing their exposure to the policy.

Indexation of the federal minimum wage on inflation and a measure of growth since 2008. Since 2008, the minimum wage has been determined by a formula that considers past inflation and GDP growth. In the case of inflation, the formula takes into account inflation accumulated during the previous year $(t-1)$, while for GDP, due to lags in data collection, they use the rate of increase of year $t-2$. The law stipulates that the minimum wage is increased each year following the rule:

$$\text{Min wage}_t = \text{Min wage}_{t-1} \cdot \text{inflation}_{t-1} + \max\{0, \text{GDP growth}_{t-2}\}$$

A.3 Minimum wage database (1940-2020)

Content and access. We build a database of minimum wages from 1940—i.e. when the federal minimum wage is introduced in Brazil—to 2020. The database contains the values of

the federal minimum wage at the month-by-year level in nominal terms using information published by the Brazilian Institute of Geography and Statistics (IBGE) website.[3] It also contains nominal values of regional minimum wages. Brazil implemented state-level minimum wages from 1940 to 1984. Since 2001, five states have implemented industry and occupation-specific minimum wages above the federal minimum: Rio Grande do Sul, Santa Catarina, Paraná, Rio de Janeiro and São Paulo.

Sources. *National level.* We report minimum wage rates at the national level since 1940

State level. We provide in Appendix Table A1 the links to the State Assembly laws that implemented regional minimum wages. We constructed two separate databases: i) one with variation by occupation when the minimum wage was defined by occupation; ii) another one by industry.

State-level minimum wage database by occupation. We used two occupation classification systems to construct this database. We constructed the data using five-digit classification codes (CBO94) from 2001 to 2009 and six-digit classification codes (CBO2002) from 2003 to 2020.[4] For Rio de Janeiro (2001-2009), São Paulo (2007-2009), Rio Grande do Sul (2001-2009), and Paraná (2006), both five-digit and six-digit occupational codes are used. In 2007, minimum wage laws in Paraná only referred to six-digit occupation codes.

Using five-digit classification codes. The law, for the most part, designates occupations at the two- or three-digit level. Therefore, we included all of the five-digit occupations contained inside the two- or three-digit level code. In rare cases, we could not match the occupations listed in the law with the five-digit occupation classification codes. This was the case for *trabalhadores em serviços administrativos* (workers in administrative services), *dedetizadores* (fumigators), and *trabalhadores da indústria* (industry workers).

Using six-digit classification codes. Rio de Janeiro started to report the six-digit occupational classification codes (as opposed to the names of the occupations only) in the law in 2017. We proceeded backwards and used the exact match between the text of the law and the six-digit categories in 2017 in Rio de Janeiro and applied this match to all previous years back to 2003.

[3] At this address: https://www.ibge.gov.br/estatisticas/downloads-estatisticas.html.

[4] Although the six-digit classification codes went into effect in 2003, the matched employer-employee data we have access to contain information on the five-digit classification codes until 2009.

Table A1: Links to regional minimum wage laws

Year	Rio de Janeiro	São Paulo	Paraná	Rio Grande do Sul	Santa Catarina
2001	Link	—	—	Link	—
2002	Link	—	—	Link	—
2003	Link	—	—	Link	—
2004	Link	—	—	Link	—
2005	Link	—	—	Link	—
2006	Link	—	Link	Link	—
2007	Link	Link	Link	Link	—
2008	Link	Link	Link	Link	—
2009	Link	Link	Link	Link	—
2010	Link	Link	Link	Link	Link
2011	Link	Link	Link	Link	Link
2012	Link	Link	Link	Link	Link
2013	Link	Link	Link	Link	Link
2014	Link	Link	Link	Link	Link
2015	Link	Link	Link	Link	Link
2016	Link	Link	Link	Link	Link
2017	Link	Link	Link	Link	Link
2018	Link	Link	Link	Link	Link
2019	Link	Link	Link	Link	Link
2020	—	—	Link	Link	Link

Notes: Regional minimum wage laws start to be implemented in Rio de Janeiro and Rio Grande de Sul in 2001, 2006 in Paraná, 2007 in São Paulo, and 2010 in Santa Catarina. For the state of Santa Catarina, the occupations that are covered by the minimum wage law only appear in 2010. In subsequent years, the law lists only the changes relative to this initial law. In 2020, there was no adjustment of the minimum wage law in Rio de Janeiro, São Paulo, and Rio Grande do Sul. Therefore, we assign the 2019 value of the minimum wage in 2020 in these states in our database.

Since minimum wage laws in São Paulo and Paraná were inspired by minimum wage laws in Rio de Janeiro, we use the same matching system for these two states.

For the occupations that were designated in the law and for which we did not have a precise six-digit classification code, we performed a manual matching using the similarity of words between the text of the law and the names used in the six-digit classification codes. This took care of the majority of these cases. However, there were remaining cases in which we could not link the text of the law to a classification code.[5] We were also unable to match

[5]Here is the list: *barboys, teleoperadores nível 1 a 1, operadores de call center, atendentes de cadastro, representantes de serviços empresariais, agentes de marketing, agentes de cobrança, agentes de venda, atendentes de call center, auxiliares técnicos de telecom nível 1 a 3, operadores de suporte CNS, representantes de serviços 103, atendentes de retenção, operadores de atendimento nível 1 a 3, representantes de serviços, assistentes de serviços nível 1 a 3, telemarketing ativos e receptivos, práticos de farmácia, empregados em empresas prestadoras de serviços de brigada de incêndio (nível básico), empregados em empresas prestadoras de serviços de brigada de incêndio (nível médio), bombeiro civil mestre, empregados em empresas*

the four occupations that are included in the law conditional on the worker being registered in their area's council: *trabalhadores de nível técnico devidamente registrados nos conselhos de suas áreas; técnicos de nível médio regularmente inscritos nos Conselhos Regionais de Engenharia; Arquitetura e Agronomia; técnicos industriais inscritos no Conselho Regional de Técnicos Industriais*.

State-level minimum wage database by industry. We used industry classifications to construct this database: the national classification of economic activities 1.0 (CNAE 1.0) to classify industries covered by state minimum wages from 2001 to 2006; and the national classification of economic activities 2.0 (CNAE 2.0) from 2007 to 2020.

Using CNAE 1.0 codes. Because the minimum wage laws did not refer to a specific industry code to define the industries covered by the minimum wage law, we matched the words contained in the law with the names of the industries contained in CNAE 1.0 codes. In rare cases, we were not able to find an exact match.[6]

Using CNAE 2.0 codes. We followed a similar strategy as for the match between the text of the law and CNAE 1.0 codes. In rare cases, we were not able to find an exact match. [7]

prestadoras de serviços de brigada de incêndio (nível superior), empregados não-especializados da indústria, empregados em escritórios de agências de navegação, empregados em terminais de contêineres e mestres e encarregados em estaleiros, trabalhadores marítimos do 1° grupo de Aquaviários que laboram nas secções de Convés, Máquinas, Câmara e Saúde, em todos os níveis (I, II, III, IV, V, VI, VII e superiores).

[6]Here are the categories listed in the law for which we could not find a match in CNAE 1.0: *trabalhadores em estabelecimentos hípicos, empregados de agentes autônomos do comércio, indústria mecânica, indústrias de cristais, espelhos, cerâmica de louça e porcelana and auxiliares em administração escolar (empregados de estabelecimentos de ensino)*. As a result, these are omitted in our database.

[7]Here are the categories listed in the law for which we could not find a match in CNAE 2.0: *trabalhadores em estabelecimentos hípicos, empregados de agentes autônomos do comércio, indústria mecânica, indústrias de cristais, espelhos, cerâmica de louça e porcelana and auxiliares em administração escolar (empregados de estabelecimentos de ensino)*.

A.4 Net pay, gross pay and total labor cost for formal vs. informal employees, at the minimum wage

Monthly earnings in the labor force survey are reported in gross terms—as is the case in the administrative matched employer-employee data in RAIS, and in the ECINF survey data.

Among formal employees. Gross pay is the pay a formal employee receives, net of the employer contribution, and before paying the employee contribution and the income tax.

The gross monthly minimum wage in 1999 amounts to R$477.24 (in 2019 terms). This is the level at which we observe bunching among formal employees (see Appendix Figure A5) for monthly earnings in September in PNAD. In that graph, we "zoom in" around the minimum wage by plotting the monthly earnings distribution around the minimum wage in 1999 by 0.02 log point bins (i.e. five times smaller than in Figure 2.)

On the employer side, social contributions represent 90.28% of the gross pay at the level of the minimum wage in 1999. The total labor cost therefore amounts to R$908.09 (see Appendix Figure A4) in R$2019. Following Pastore (1996) and Souza et al. (2012), the employer contributions include 35.8% of social obligations related to the wage component, 40.8% in non-wage benefits, and 13.68% in related social contributions. We set aside the 13th salary and associated contributions in the total labor cost as we only refer to the total labor cost at the minimum wage for the month of September 1999—the month for which pay is reported in PNAD. Including this element would increase the total labor cost at the level of the minimum wage in 1999 by 102.06% of gross pay. The details of the non-wage benefits and social security contributions are provided in Appendix Table A2.

On the employee side, social contributions represent 7.65% of the gross pay at the level of the minimum wage, in 1999. This means that take-home pay—before income tax—is R$440.73 (in R$2019). The employee contribution is a contribution to the pension system (INSS) (see online tax schedules here).

Because there is no income tax at the level of the minimum wage in 1999, the monthly net pay (net of the income tax) is the monthly take-home pay (gross pay after employee social security contribution) for a formal employee.

Among informal employees. For an informal employee, there is no social security contributions paid on the monthly wage, neither by the employer nor the employee. Understanding the incidence of the employee contribution is key to unveiling the net pay for the informal employee. In Appendix Figure A5 (right panel) we show that there is bunching at the level of

Table A2: Employer social security contributions, 1999

Category	Item	% of Salary
A. Social contributions	INSS (Pension System)	20
	FGTS (Severance Fund)	8
	Education-salary	2.5
	Work accident insurance (average)	2
	Sesi (Social Service for Industry)	1.5
	Senai (Industrial Training Service)	1
	Sebrae (Small Business Support Service)	0.6
	Incra (Land Reform Institute)	0.2
	TOTAL	**35.8%**
B. Non-wage benefits	Weekly rest	18.91
	Paid vacation	9.45
	Holidays	4.36
	Vacation bonus	3.64
	Notice period	1.32
	Sick leave	0.55
	Severance expenses	2.57
	TOTAL	**40.8%**
C. Social contributions on B.	**TOTAL**	**13.68%**
D. All contributions	**TOTAL**	**90.28%**

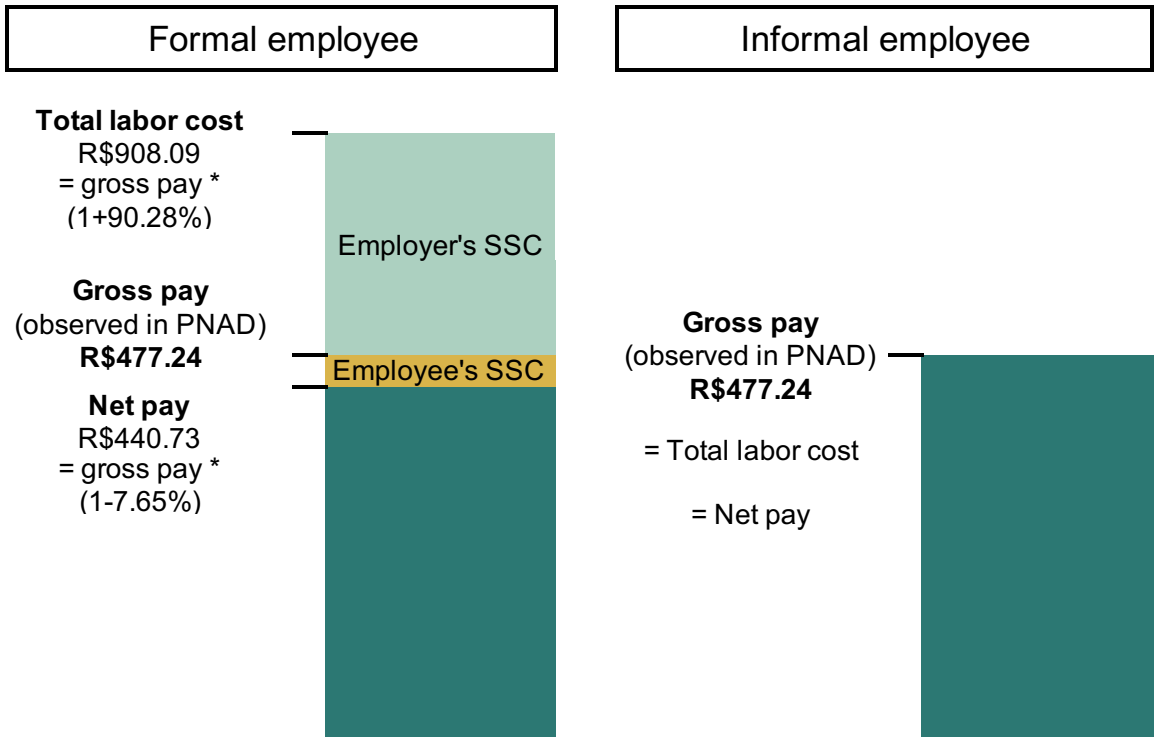
Source: Pastore (1996).

Notes: The legislation is unchanged between Pastore (1996)'s study and 1999. This excludes the 13th month salary (10.91%), and the FGTS incidence over the 13th salary (0.87%).

the gross minimum wage, but not at the level of the gross minimum wage net of the employee contribution of 7.65%. We interpret this as evidence that the informal employee "pockets" the employee contribution.

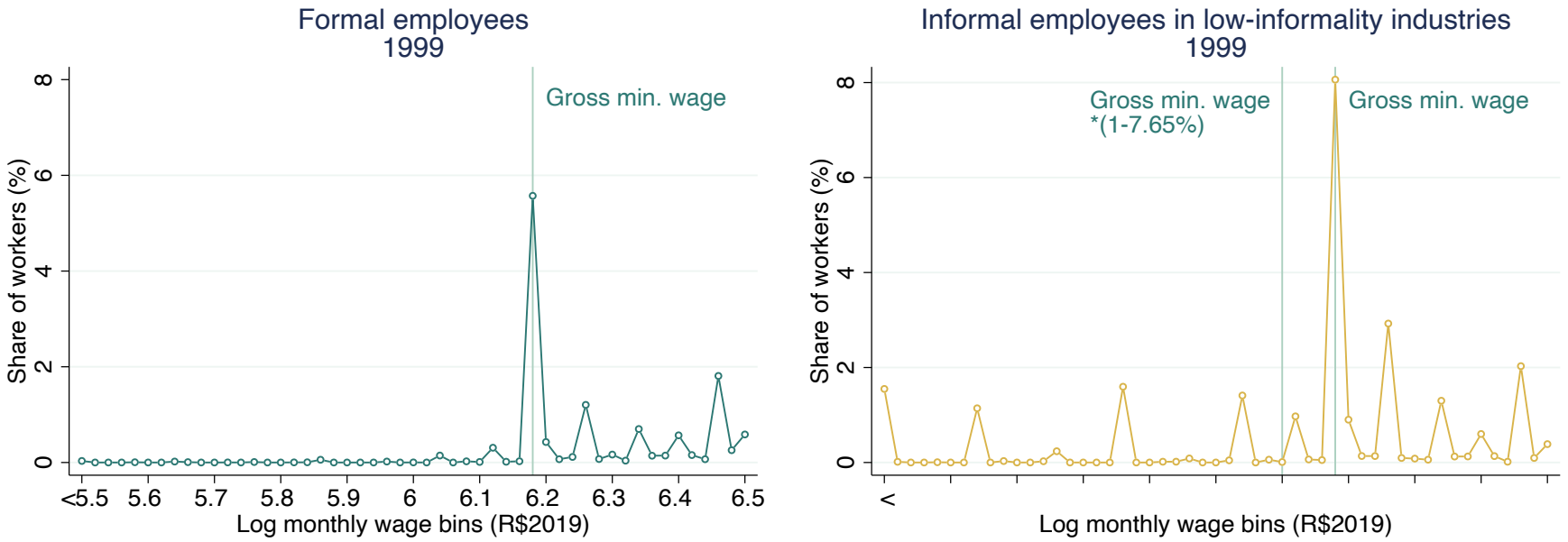
We also conclude that the net pay of the informal employee (after all social security contributions and income taxes) is 7.65% higher than that of a formal employee around the minimum wage in 1999. We note that this number is constant throughout our period of study as there is no change in the income tax schedule or the employee social contribution from 1995 to 2015.

Figure A4: Net pay, gross pay and total labor cost for formal vs. informal employees, at the minimum wage, in 1999



Sources: Authors' calculations based on Pastore (1996) and Souza et al. (2012).
Notes: Values are in R$2019, deflated using the inpc series. Because there is no income tax at the level of the minimum wage in 1999, the monthly net pay displayed above and understood as net of employee contributions is also the net of income tax pay for both formal and informal employees.

Figure A5: Incidence of the employee social security contribution in the informal sector



Sources: PNAD 1999.

Sample: Adults aged 25-54, white or non-white, employed, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Left panel: formal employees. Right panel: informal employees.

Notes: 2 log points monthly wage bins in x-axis. Monthly earnings distribution is truncated on the right hand side (above 6.5 log points in $R2019 terms). Observations are binned together on the left of the distribution (5.5 log points or below). Since there is bunching at the value of the gross minimum wage, and no bunching at the value of the net minimum wage among informal employees in low-informality industries, we conclude that informal employees "pocket" the employee social security contribution.

A.5 Penalties associated with minimum wage violations vs. tax evasion

Penalties associated with minimum wage violations. The 1943 the Brazilian labor code (CLT) establishes a penalty to the employer that is found under non-compliance with the minimum wage.

The penalty varies by firm size (according to a coefficient ρ_s comprised between .08 and .4, see Table A3):

$$\begin{aligned}\text{Penalty}_{\text{mw}} &= (.6 + \rho_s) * \text{fine} \\ &= (.6 + \rho_s) * 1,513.14 \text{ UFIR} \\ &= (.6 + \rho_s) * 11 \times \text{gross monthly minimum wage (in 1999)}\end{aligned}$$

The fine associated with the minimum wage violation corresponds to the maximum fine of all infractions in the labor code (see chapters II and III of Title II of the CLT). The amount of 1,513.14 UFIR is defined in Article 120 of Portaria MTE nº 290/1997 (see here). In 1999, one unit of UFIR is equivalent to R$0.9970.[8] The fine associated with the minimum wage is therefore equivalent to 1,508.60R$ in 1999 terms. Since in September 1999, the nominal value of the minimum wage is 136R$, the fine amounts to 11 times the gross monthly minimum wage.

The value of the penalty depends on a coefficient that comprises three components: (i) a fixed component of 20% that corresponds to the nature of the infraction; (ii) a variable component that depends on the firm size, ρ_s; (iii) a fixed component of 40% that corresponds to the extent of the infraction.

As a result of the variable component, the per-worker penalty varies from 7.5 times the monthly minimum wage for small firms (1-10 workers) to 11 times the monthly minimum wage for large firms (100+ workers).

We view these costs as a lower bound of the cost associated with the minimum wage violation for non-complying firms for four reasons:

1. First, the amount of the fine is doubled in case of recidivism, meaning that the penalty varies from 15 times to 22 times the monthly minimum wage if the firm happens to be caught for such a violation for the second time (or third time, etc.). In practice, Brotherhood et al. (2023) show that there is an increase in the probability of an audit after a firm is caught;

[8] See the conversion between UFIR and reals from 1995 to 2000 at this address.

Table A3: Value of the coefficient ρ_s that enters the calculation of the minimum wage penalty, by firm size

Number of employees	Value of ρ_s
1-10	8%
11-30	16%
31-60	24%
61-100	32%
Above 100	40%

Source: Portaria/MTP Nº 667, de 8 de novembro de 2021, available here.

2. Second, workers can claim the difference between the salary they received and the minimum wage through judicial proceedings. This comes on top of the penalty described above. There is evidence that such claims exist (see here for a recent case).

3. Third, we note the existence of "indirect costs" associated with the minimum wage violation. Firms have an incentive to keep workers happy in order to avoid an inspection (and therefore be less likely to be caught for other violations such as tax evasion on social security contributions), as the evidence suggests that the bulk of labor inspections are triggered after workers' or unions' whistle-blowing (Cardoso and Lage (2005)). Paying the minimum wage to workers, whether they are employed on a formal contract or not, is a good way to do that. We show in particular that informal workers at the minimum wage receive on net a higher wage than formal workers paid at the minimum wage, since it seems that the informal worker pockets the employee social security contribution of 7.65% (see Appendix Section A.4 and Appendix Figure A5). That, plus other advantages informal workers can find in being employed informally in terms e.g. of flexibility in their labor supply (see Breza and Kaur (2025)), might make informal workers in particular less likely to act as whistleblowers when it comes to tax evasion by the firm.

4. Finally, there are non-monetary costs associated with minimum wage violations (e.g. reputational costs).

Penalties associated with tax evasion on social security contributions. Formal firms caught employing informal workers must pay a penalty according to the following formula

(see Brotherhood et al. (2023)):[9]

$$\begin{aligned}\text{Penalty}_{\text{te}} &= \alpha + 3 \times \text{gross monthly salary} \times (1 + \text{employer payroll taxes}) \\ &= 1 \times \text{gross monthly minimum wage} \\ &\qquad + 3 \times \text{gross monthly salary} \times (1 + \text{employer payroll taxes}) \\ &= 6.7 \times \text{gross monthly minimum wage (in 1999 for a min. wage worker)}\end{aligned}$$

The fixed component α is the equivalent of one monthly gross minimum wage. For informal workers around the minimum wage, because the employer social security contributions represent 90.28% of the gross monthly wage, we conclude that the three gross monthly salary and associated contributions amount to $3 \times 1.9028 = 5.7$ gross monthly minimum wage.

The total value of the penalty is therefore 6.7 times the gross monthly minimum wage per informal worker at the level of the minimum wage.

[9] This formula applies in case the informal worker is found to be paid at or above the minimum wage. The firm must pay in addition the specific penalty related to minimum wage violation if the informal worker is paid below the minimum wage.

Appendix B Additional details on data sources

B.1 Census (1960-2010)

The Census is collected every ten years by the Brazilian Institute of Geography and Statistics called *Instituto Brasileiro de Geografia e Estatistica* (IBGE). Microdata are available since 1960. The census has two different questionnaires: one for the universe of households and one for a representative sample. We use the sample one because it contains detailed information about the labor market outcomes of individuals.

Access. The data were accessed through IPUMS International here. Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 7.2 [Census]. Minneapolis, MN: IPUMS, 2019. https://doi.org/10.18128/D020.V7.2. Full documentation available here for harmonized variables, and here for source variables.

The data from the 2000 and 2010 Census were downloaded from the IBGE website (available here). The files were cleaned and prepared for analysis using the Stata ado files as available from Data Zoom (full information here).

B.2 Labor force and establishment surveys

B.2.1 *Pesquisa Nacional por Amostra Domiciliar* (PNAD) (1976 - 2015)

The Pesquisa Nacional por Amostra Domiciliar is a yearly national household survey, similar to the Current Population Survey in the U.S. There are two different questionnaires: one about households' characteristics, one about individuals' characteristics. We only use the questionnaire containing the individual-level characteristics. The sample is drawn from 1,500 municipalities.

We focus on demographic variables (such as age, gender, education attainment, position in the household, etc.) and labor market outcomes (such as employment, wages, earnings, industry and occupations) that are collected consistently across years.[10]

Regarding earnings, the PNAD questionnaire asks, "How much were your earnings in this job over the last month?" This is a measure of gross monthly earnings, as mentioned on p.2 of the PNAD methodological note here. This measure of earnings must be understood as being after payroll taxes remitted by employers, but before payroll taxes paid by workers. Since social security contributions amount to 7.65% of the gross monthly wage on the worker

[10] In some years, the individual-level questionnaire is complemented by other questionnaires, e.g. on health, migration, or fertility. We do not use this information in this project.

side, and since the income tax is 0% at the level of the minimum wage, take-home pay at the level of the minimum wage for a formal employee is 0.9235 times the gross value of the minimum wage over 1995-2015. By contrast, for informal workers gross monthly pay equals take-home pay (see Appendix A.4 for more details).

We exploit the survey files from 1995 to 2015, i.e. one year after the *Plano Real* stabilized inflation.

In all years, we use the labor market information for the main job of the worker (earnings, weekly hours, etc.)—the most relevant for our study, and the only information that is collected across all years in the survey. It is only in the most recent years that the survey added questions about the other jobs in the reference week and about previous jobs during the year. Finally, we observe monthly earnings (i.e., wages in the main job in the last month), and the number of weeks worked last week, but we do not directly observe the hourly wage variable. Since the minimum wage is set in terms of monthly earnings for full-time workers, we focus on full-time workers in our study, i.e. those who report working 40 hours or more during the week. Close to 90% of workers in the private formal sector are working full-time vs. 61% in the private informal sector in 1999 (see Table 1).

The information on race is collected across all years between 1995 and 2015.

Individuals self select into 5 different racial categories: "Branco" (White), "Preto" (Black), "Amarelo" (Asian), "Indigena" (Indigenous) and "Pardos." This latter category is the most difficult to translate: "Pardos" translates to brown or mixed race with African ancestry. It refers to individuals with Black and white parentage, or Black and indigenous parentage. Following Gerard et al. (2021a), we pool "Pretos" and "Pardos" together to form the "non-white" category. non-white individuals account for about 40-45% of the total population. We restrict our sample to white and non-white individuals, dropping individuals identifying as Amarelos or Indigenas (less than 2% of the population).

Access. Accessed through Data Zoom here starting in 1986.

B.2.2 Monthly Employment Survey, *Pesquisa mensal de emprego* (PME) (1980-2016)

The Monthly Employment Survey is a household survey conducted monthly by IBGE since 1980 in six metropolitan areas: Belo Horizonte, Porto Alegre, Recife, Rio de Janeiro, Salvador and São Paulo. There are two versions of PME: PME-Antiga (1980-2001) and PME-Nova (2002-2016), which has larger questionnaires and a new definition of labor market participation, as well as new rotation schemes of the samples. In March 2014, PME's sample consisted of

33,809 households with 95,122 individuals. PME is a panel survey, in which each household is interviewed 8 times over a 16-months period (the household is surveyed for 4 consecutive months, out for 8, and then returns for another 4 months of interviews).

PME-Nova was discontinued in February 2016 and replaced by PNAD Continuous, a quarterly survey started in the first quarter of 2012. The two surveys coexisted between 2012 and 2016.

Access. Accessed through Data Zoom here.

B.2.3 Urban Informal Economy survey (ECINF)

This establishment survey was conducted by IBGE in 1997 and 2003 to investigate the informal sector in Brazil. It contains information on both the self-employed and informal employees in businesses of 5 employees or fewer. We use this survey only for informal employees, and exploit the information contained to disentangle informal employees working in formal vs. informal firms. More specifically, there are three variables that contain information on the formality status of the employer of informal workers in ECINF: (i) a direct question that asks whether the firm is "an informal sector entreprise" both in 1997 (variable v4901) and 2003 (variable v5901); (ii) a question that asks whether the establishment has a tax identification number, the CNPJ code (variable v4340 in 2003 and variable v4346 in 1997)—this variable is used by Ulyssea (2018); (iii) and a question that asks whether the "company has a legal constitution" (variable v4344) in 1997, and whether the business has a legal entity (variable v4338 in 2003). All three variables lead to exactly the same results. For consistency across ECINF and PNAD, we use the third definition to show that informality shares at the industry level (as measured in PNAD) align well with the formality status of the employer of informal employees in ECINF 1997 and 2003 (see Section 6.2).

Access. Accessed through Data Zoom here.

B.3 Data on labor inspection offices

The enforcement of labor regulations in Brazil—including the minimum wage—is carried out by labor inspectors operating out of regional labor inspection offices (*delegacias* and *subdelegacias do trabalho*) of the Ministry of Labor (*Ministério do Trabalho*). We use data on the location of these inspection offices and on the number of labor inspectors to construct measures of the local intensity of enforcement. The office locations and inspector counts were

collected from the administrative records of the Ministry of Labor by Almeida and Carneiro (2012); we obtain them from the replication files of Ponczek and Ulyssea (2022).

The underlying records from Ponczek and Ulyssea (2022) are organized as the minimum travel time from the seat (*cidade*) of each municipality to the nearest inspection office. We use this travel time as a proxy for the cost to the labor inspector of monitoring employers, and hence for the intensity of enforcement: enforcement is presumably weaker in municipalities that are farther from an inspection office. For our analysis we aggregate this measure to the micro-region level: we take the maximum travel time to the closest office among municipalities within a micro-region and merge it to the Census and PNAD. The data also include the number of labor inspectors, available by state for 2002 which we use in combination with distance as a robustness test (see Table 3, column (4)).

Access. Obtained from the replication package of Ponczek and Ulyssea (2022); the underlying records originate from the Brazilian Ministry of Labor (*Ministério do Trabalho*), as compiled by Almeida and Carneiro (2012).

B.4 Data with restricted access: linked employer-employee data (RAIS) (1995-2017)

Content. We have access to the linked employer-employee data from 1995 to 2017. It contains information on the universe of workers employed in the formal sector in Brazil. The data set contains a worker identifier, and a firm identifier. We have information on three types of earnings: i) earnings in December each year ("December earnings" in what follows); ii) earnings as stipulated in the employment contract at the end of the year or at the end of the relationship for spells that ended during the year ("contracted wage" in what follows), starting in 2002 only; From 2015 to 2017, we also have monthly earnings for each month of the year, not just December ("monthly earnings" in what follows). In some of the graphs, we report the wage distribution for September earnings in 2015, to be as close as possible to the earnings concept used in PNAD.[11]

The dataset also contains a series of workers' characteristics (gender, age, education, tenure, occupation, type of labor contract, contracted hours, hiring date, separation date, type of separation) and firms' characteristics (location, industry, legal status).

Access and documentation. The full documentation can be accessed here. An example dictionary of variables for 2019 is available at this address.

Consistency between RAIS and PNAD. We investigate the consistency between the linked employer-employee data (RAIS) and the labor force surveys (PNAD) for workers in the private formal sector.

We show that the spike at the minimum wage in monthly earnings distributions in PNAD (i.e., earnings reported by workers) is nearly identical to the spike observed using the contracted wage in the universe of the matched employer-employee data (i.e. earnings reported by employers). Appendix Figure B2 compares the share of workers within each wage bin (using the concept of monthly earnings distributions in PNAD and monthly contracted wage distributions in RAIS).[12] We believe these two wage concepts are close. In 2009, at the peak of the minimum wage, both data sources show that 16.5% of workers are paid within 10% of the minimum wage. By contrast, the spike at the minimum wage using the December earnings variable—that takes into account bonuses and overtime pay—is much smaller.

[11] Average monthly earnings over the employment spell in each year is also available in RAIS, which we do not use in our analysis.

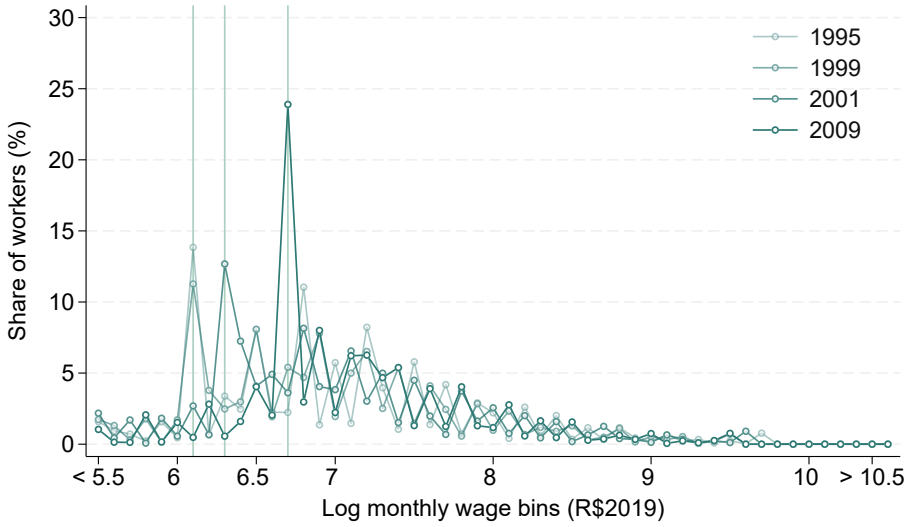
[12] Note that in this series of figures, we've excluded agricultural and domestic services workers from our analysis sample to make the two data sources more comparable.

Virtually no workers report being paid below the minimum wage in the private formal sector. This nearly perfect compliance with the minimum wage is also confirmed in the RAIS data.

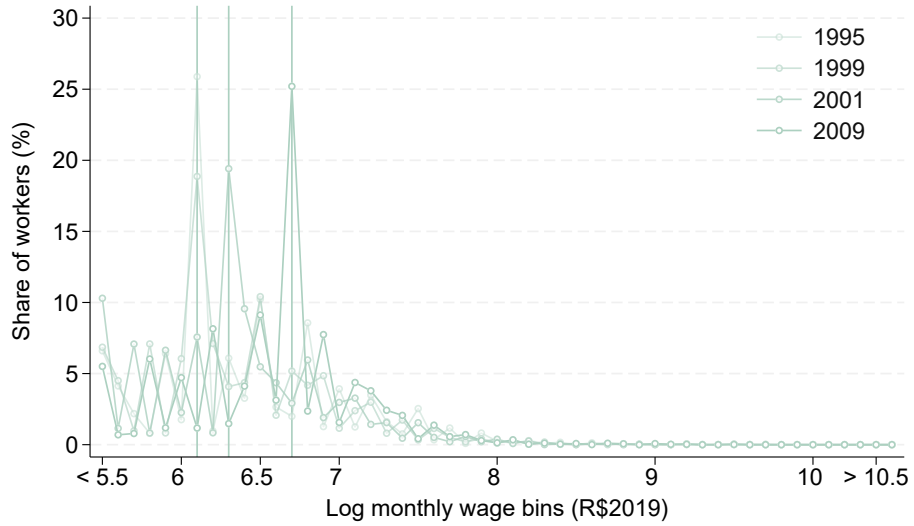
This consistency between RAIS and PNAD is true in terms of share of workers (see Appendix Figure B2), but also in terms of number of workers (see Appendix Figure B3). We show similar consistency across the two data sources by region (see Appendix Figure B4 for the North, Appendix Figure B7 for the South, Appendix Figure B6 for Southeast, Appendix Figure B8 for Central-West), including in the Northeast (Appendix Figure B5), a region where the spike within 10% of the minimum wage is above 35% in 2009.

Figure B1: Monthly earnings distributions among informal employees in low- vs. high-informality industries

(a) Low-informality industries



(b) High-informality industries

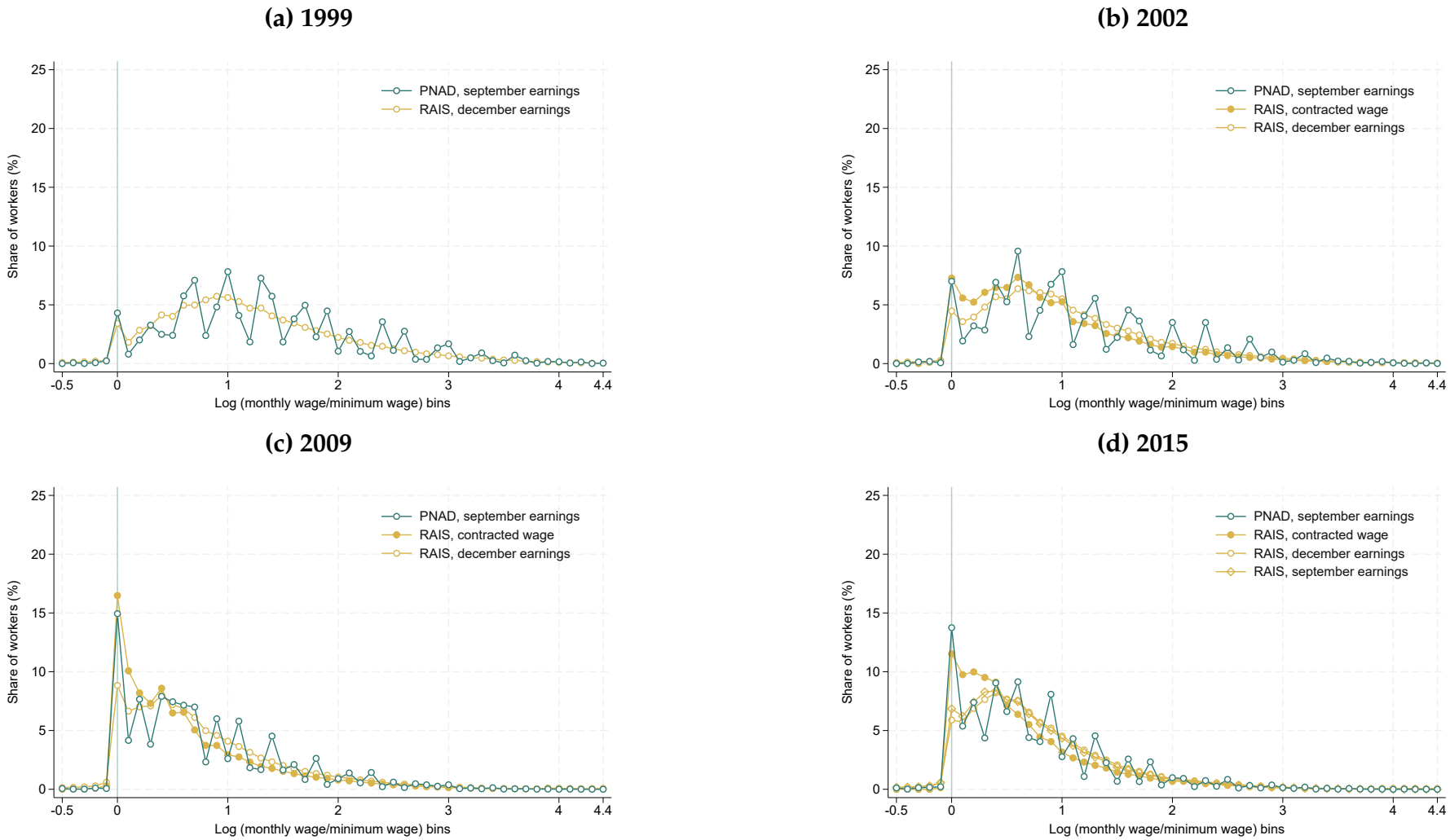


Sources: PNAD 1999-2015.

Sample: Informal employees aged 25-54, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Panel (a): informal employees in "low-informality" industries (i.e. in all industries except agriculture, construction and domestic services). Panel (b): informal employees in "high-informality" industries (i.e. in agriculture, construction and domestic services). See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries.

Notes: The complete series of monthly earnings distributions from 1995 to 2015 is available in our slides here. The wage bin (10 log points wide) in which the minimum wage falls in each year is materialized by a vertical bar. The share of workers in the wage bin where the minimum wage falls and that can be directly read on the y-axis should therefore be understood as the share of workers within 10% of the minimum wage. The exact share of workers at or below the minimum wage are 16.7%, 15.4%, 19.5%, 30.3% among informal employees closer to the formal sector, and 38.2%, 34.5%, 45.1% and 53.2% further away from the formal sector.

Figure B2: Monthly earnings distributions in PNAD vs. RAIS, Brazil (share of workers in y-axis)

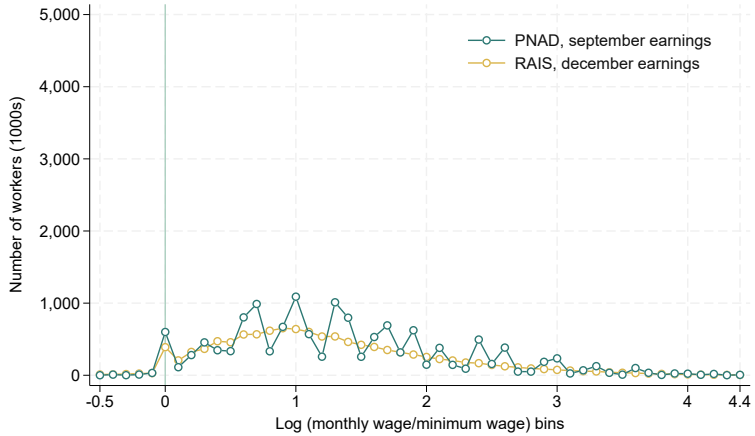


Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

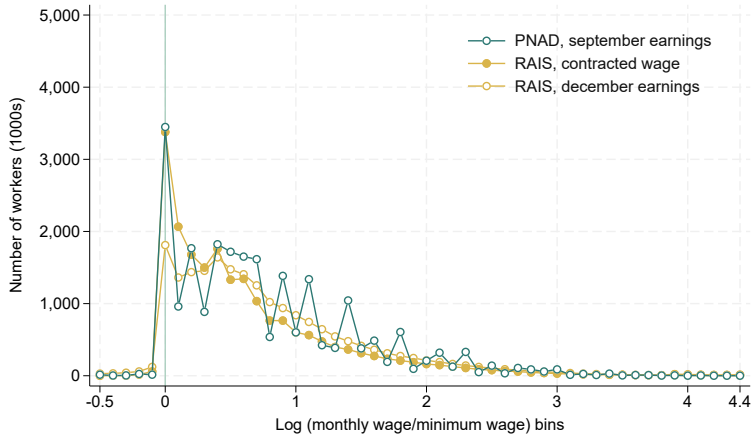
Figure B3: Monthly earnings distributions in PNAD vs. RAIS, Brazil (number of workers in y-axis)

(a) 1999

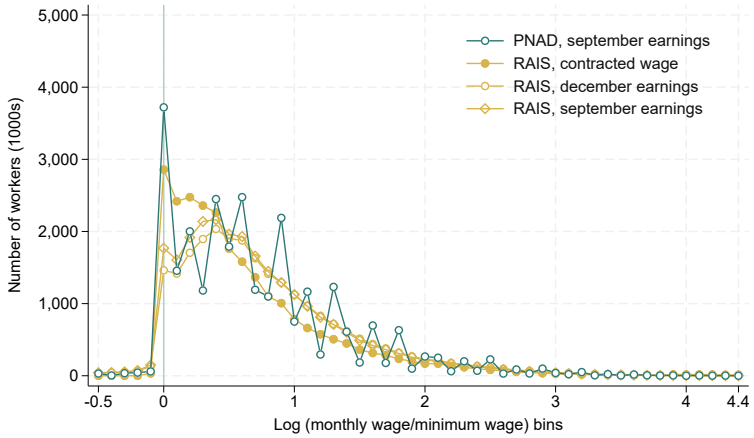


(b) 2002

(c) 2009



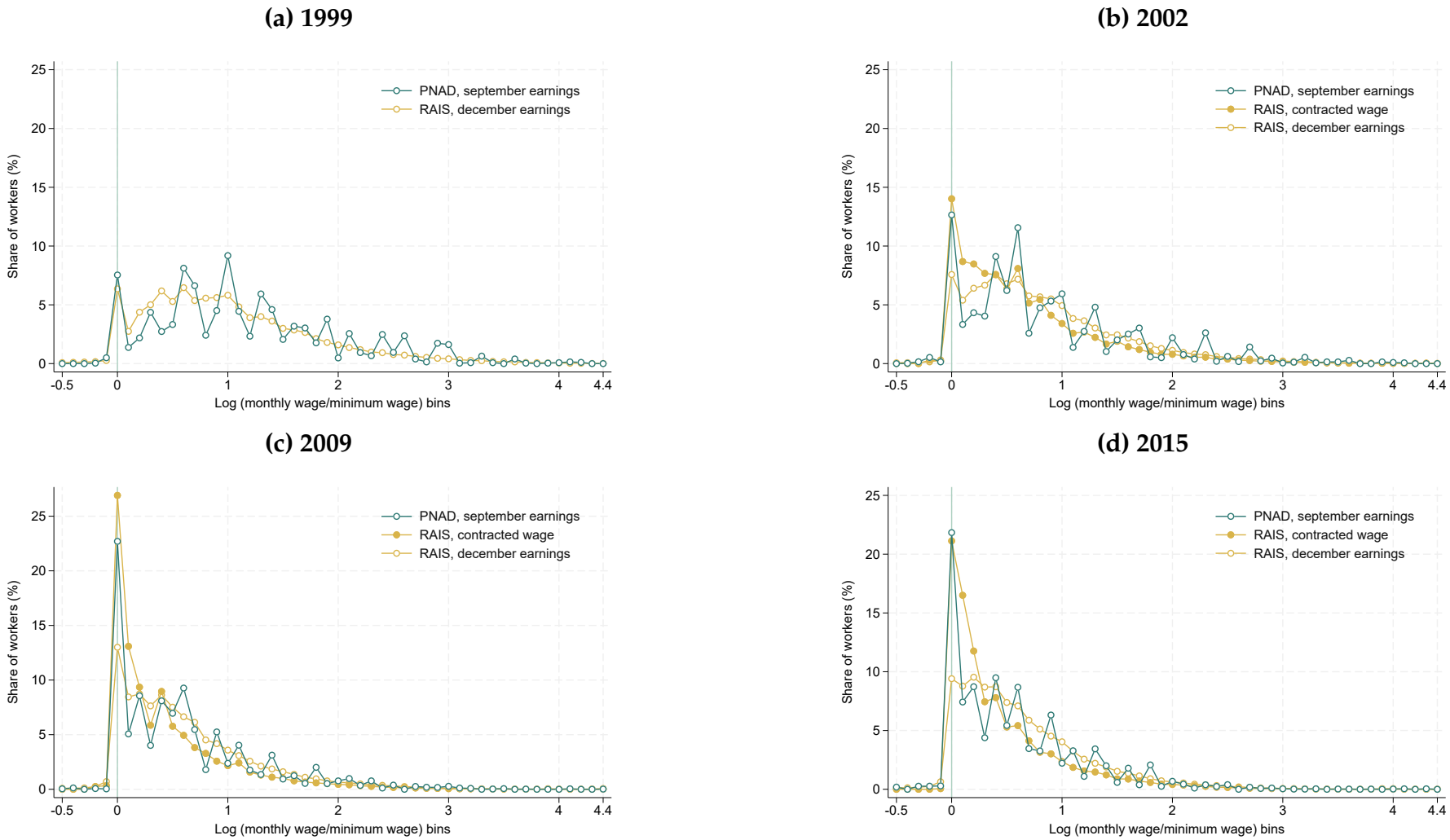
(d) 2015



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

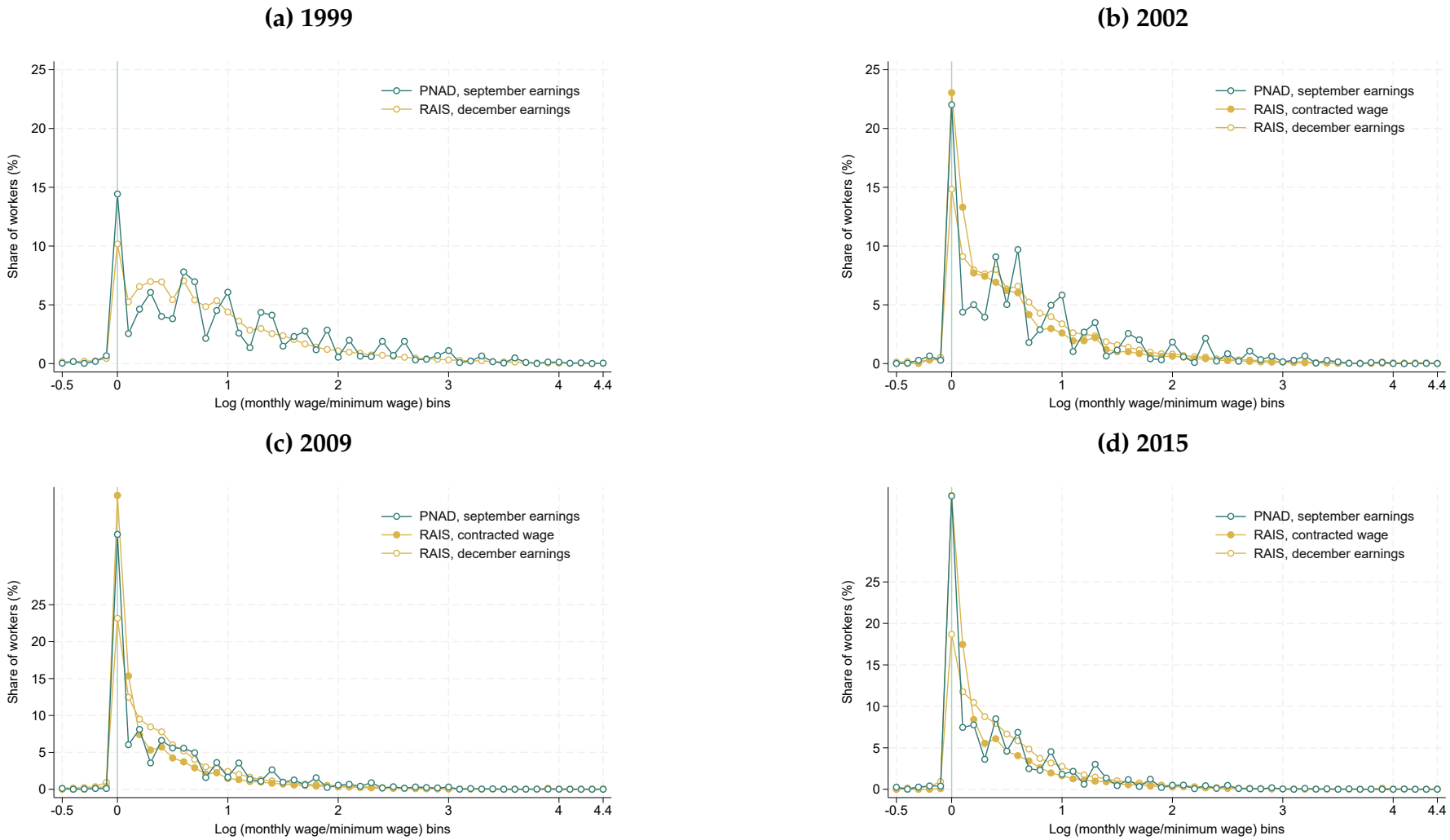
Figure B4: Monthly earnings distributions in PNAD vs. RAIS in the North



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

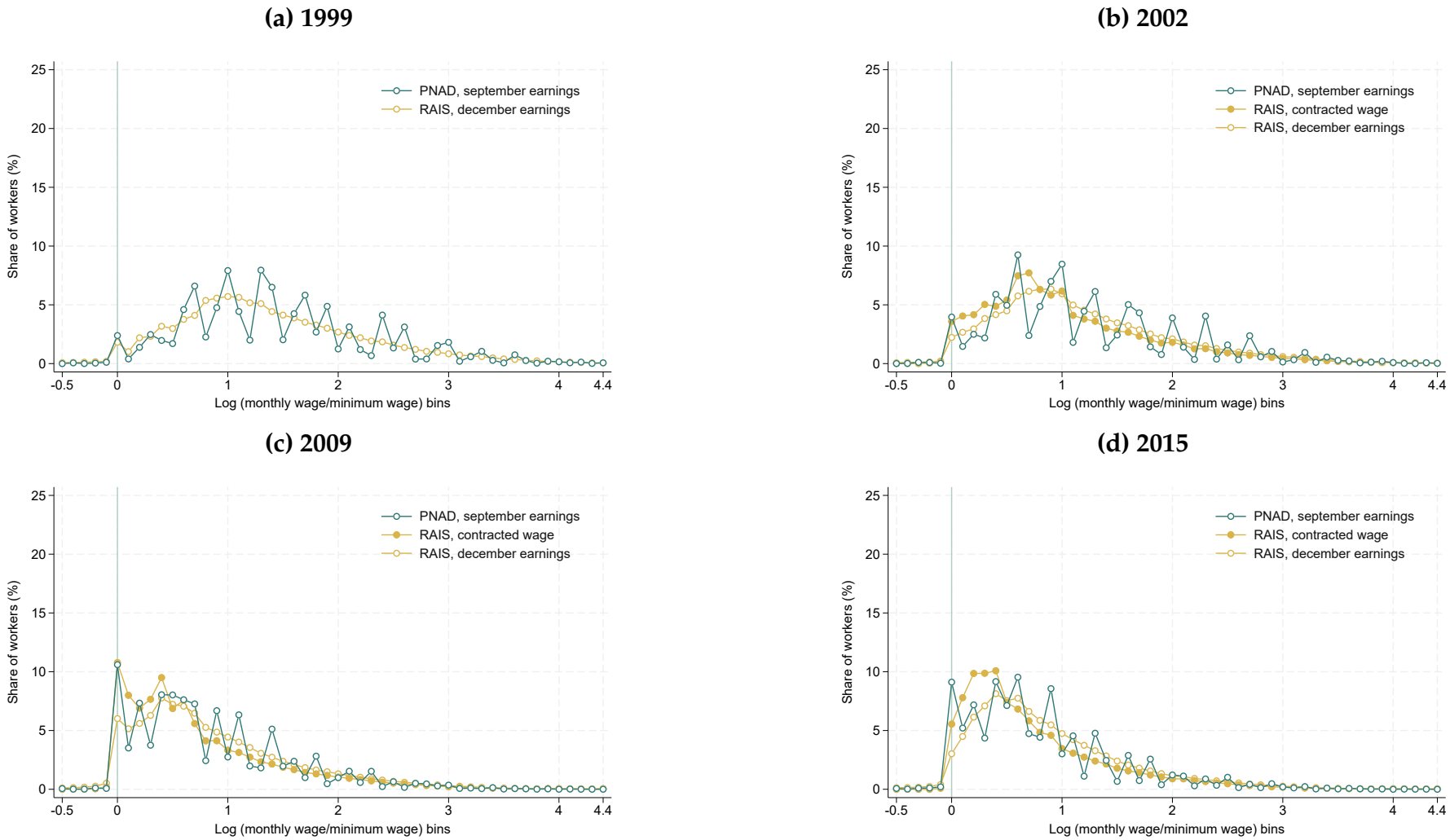
Figure B5: Monthly earnings distributions in PNAD vs. RAIS in Northeast



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

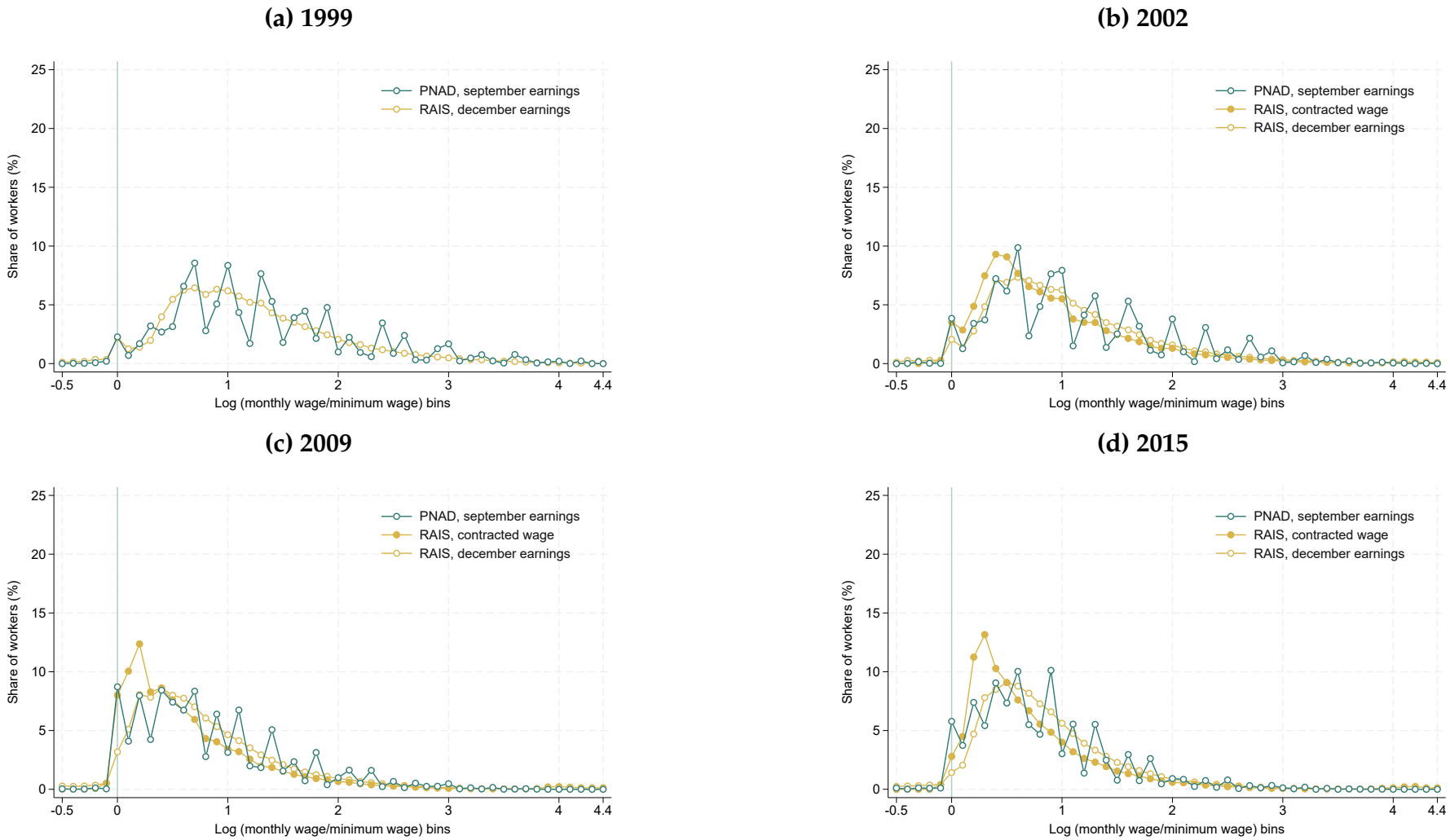
Figure B6: Monthly earnings distributions in PNAD vs. RAIS in Southeast



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

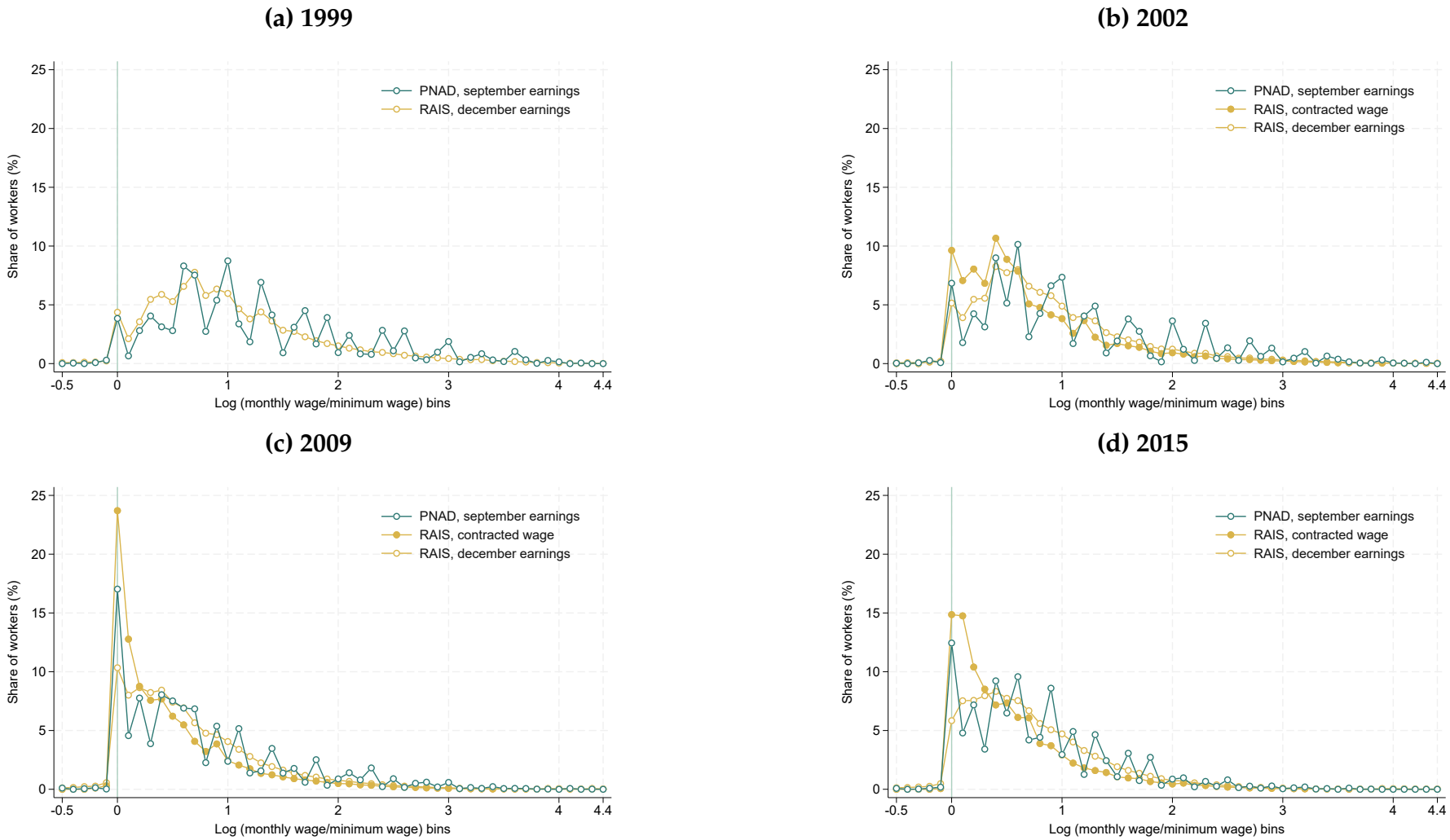
Figure B7: Monthly earnings distributions in PNAD vs. RAIS in the South



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

Figure B8: Monthly earnings distributions in PNAD vs. RAIS in Central-West



Sources: PNAD 1999-2015. RAIS 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Excludes agricultural workers and domestic workers.

Table B1: Transition matrices of minimum wage workers, by employment type

	(1) Formal	(2) Informal	(3) Self-employed
Non-employment	4.3	5.3	2.8
Strictly below the minimum wage	5.8	17.6	23.0
Around the minimum wage or above	89.9	77.2	74.3

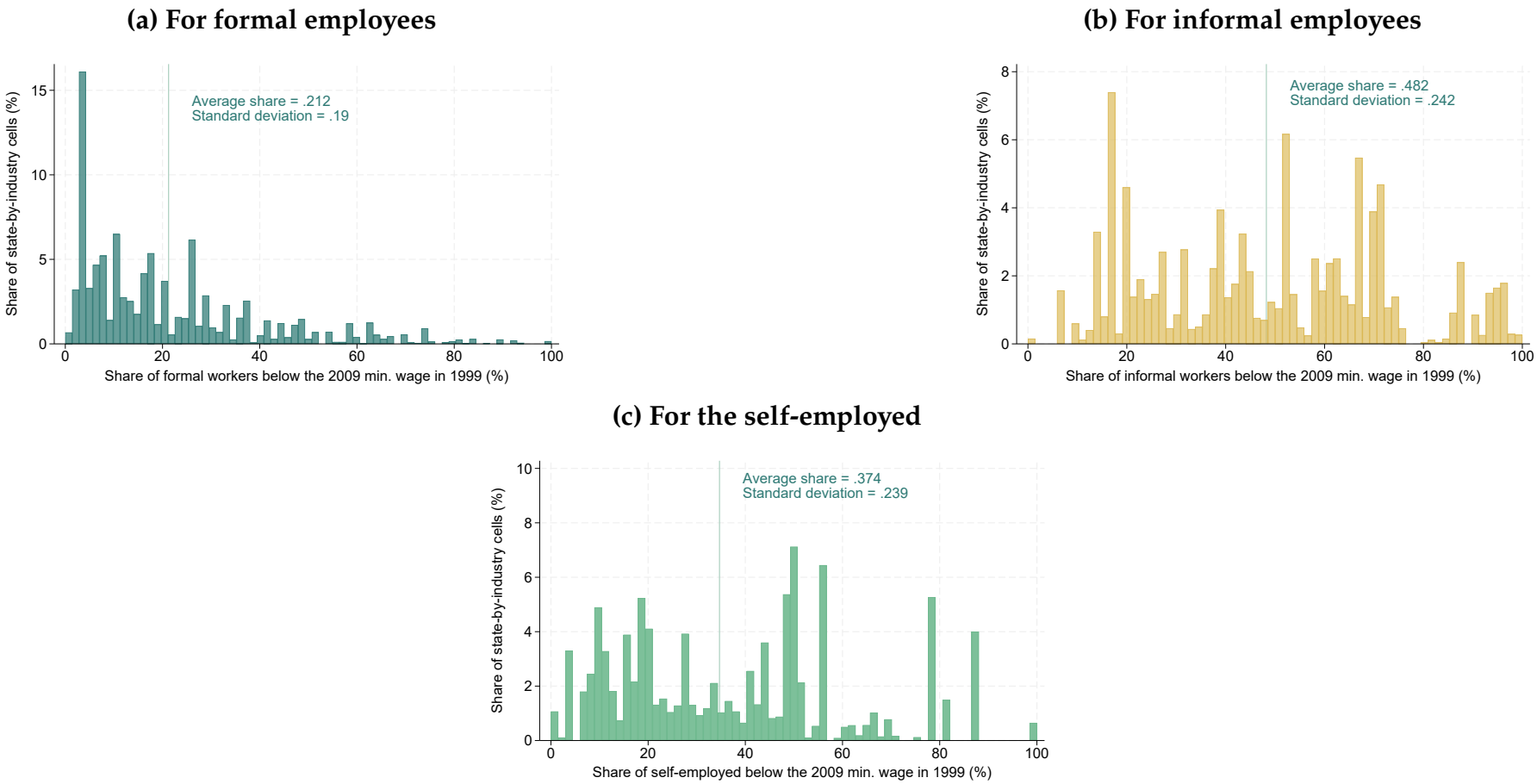
Source: PME 2002-2015.

Sample: Adults aged 25-54, no missing experience variable, white or non-white.

Notes: The table reports transitions of minimum wage workers observed in year t into non-employment, employment below the minimum wage, or employment at or above the minimum wage in year $t+1$. "Strictly below the minimum wage" is defined as strictly below 10 log points below the contemporaneous minimum wage. Outcomes are shown separately by employment type: formal employees, informal employees and the self-employed. For example, among formal minimum wage employees observed in any given year t between 2002 and 2014, 4.3% of them were not employed in the following year, 5.8% were employed strictly below 90% of the contemporaneous minimum wage (in employment of any type), and 89.9% were employed at or above 90% of the contemporaneous minimum wage (in employment of any type).

Appendix C Distribution of share of affected workers

Figure C1: Distribution of share of affected workers



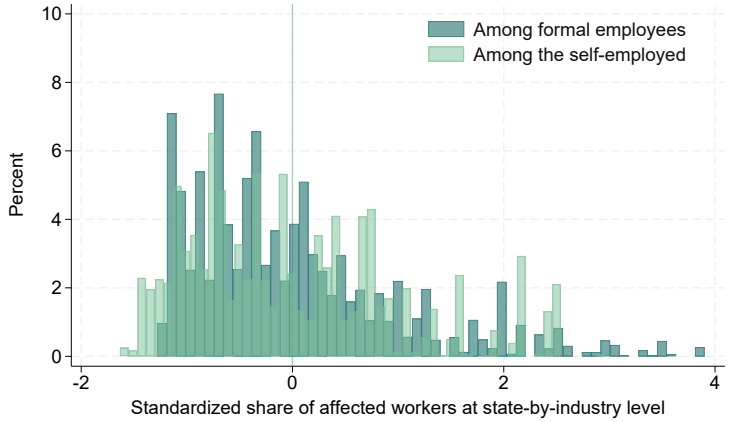
Sources: PNAD 1995-2015.

Sample: Adults aged 25-54 employed full-time. Panel (a): restricted to formal employees in the private sector; panel (b): restricted to informal employees in the private sector; panel (c) restricted to the self-employed. These shares are computed across 279 state-by-industry cells in panel (a), 281 in panel (b), and 230 in panel (c).

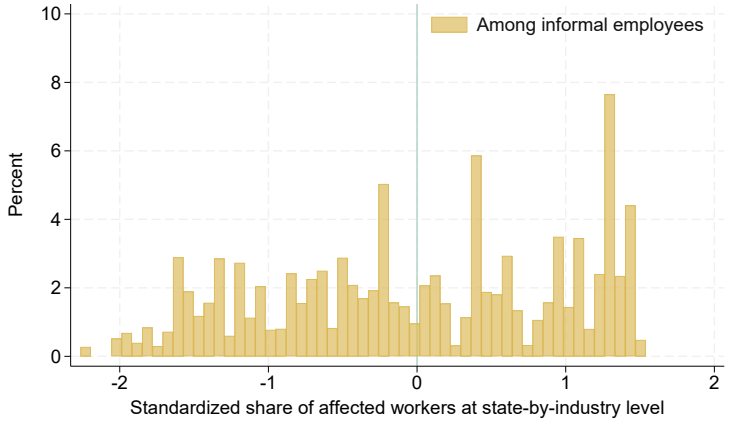
Notes: On average across all state-by-industry cells, the share of affected workers is 21.2% among formal employees, and 48.2 among informal employees. This share is 37.4% among the self-employed. These average shares are weighted by the number of workers in each type of employment in each cell. The standard deviation is 0.21 in the formal sector. It is 0.24 for informal employees, and 0.24 for the self-employed. In the formal sector: p25 is 5.9%, p50 is 15.9%, and p75 is 28.9%. In the informal sector: p25 is 26.3%, p50 is 49.6%, and p75 is 67.2%. Among the self-employed: p25 is 15.3%, p50 is 27.5%, and p75 is 49.3%.

Figure C2: Distribution of standardized treatment variables

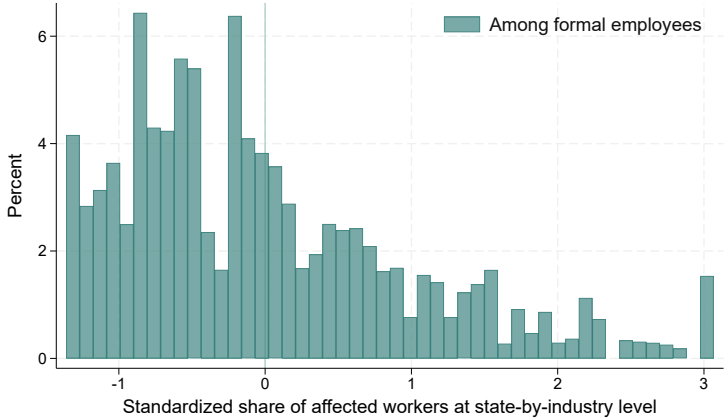
(a) For wage effects, individual-level dataset



(b) For wage effects, individual-level dataset



(c) For employment effects, state-by-industry panel



Sources: PNAD 1995-2015.

Notes: panels (a) and (b) show the distribution of the standardized treatment variable that is used for assessing the effect on wages using the individual-level dataset; the treatment variable is computed separately among formal employees and the self-employed in panel (a); and among informal employees in panel (b). Panel (c) shows the distribution of the standardized treatment variable used to assess the employment effects using the state-by-industry-by wage bin panel. We only use this treatment variable among formal employees in our study.

Appendix D Additional results on wage effects and robustness checks

Table D1: Wage effects of the minimum wage in Census 2010 and across state and microregion by industry designs

	State-by-industry design	Microregion-by-industry design
Strongly treated × 2010		
Formal employees	0.108***	0.120***
	(0.011)	(0.005)
	3,857,316	3,856,627
Informal employees	0.124***	0.136***
	(0.019)	(0.007)
	1,589,202	1,588,462
Self-employed	-0.035	0.051***
	(0.042)	(0.009)
	2,043,143	2,026,776
Individual-level controls	X	X
State GDP controls	X	X
State × industry FEs	X	
Microregion × industry FEs		X
Industry × year FEs	X	X

Sources: Census 2000-2010.

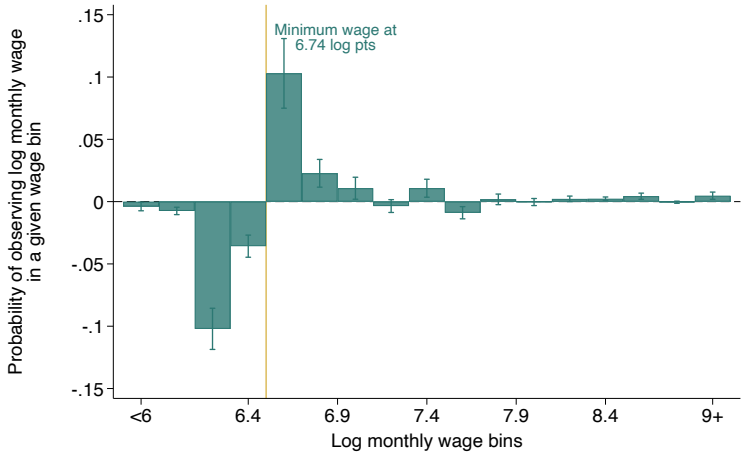
Sample: Adults aged 25-54, white or non-white, employed in the private sector, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The table shows in the first row the average wage effects computed in 2010 using a difference-in-differences design (see Equation 1 in Section 4.1) adapted to census data, in which the omitted year is 2000. Column (1) refers to estimates using variation in the bite at the state-by-industry level; column (2) refers to estimates using variation in the bite at the microregion-by-industry level.

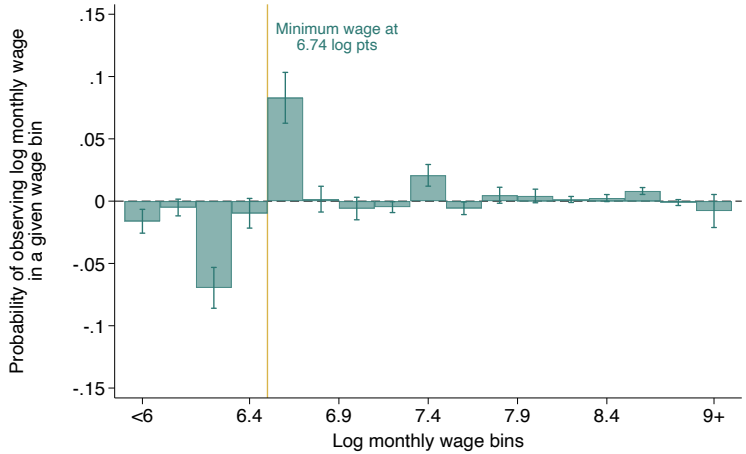
D.1 Consistent wage effects across data sources.

Figure D1: Effect of the min. wage on the probability of being in a specific wage bin in 2010, census data

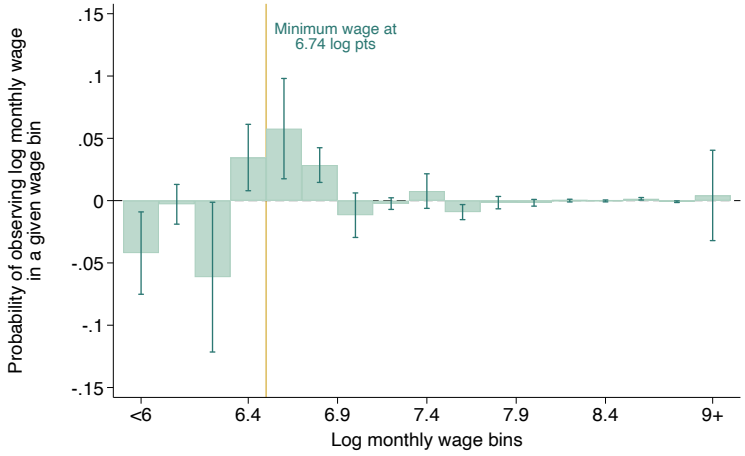
(a) Formal employees



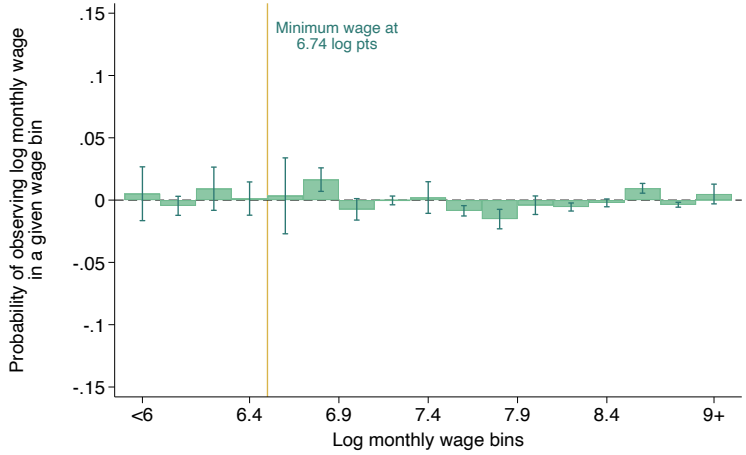
(b) Informal employees in low-informality industries



(c) Informal employees in high-informality industries



(d) Self-employed



Sources: Census 2000-2010.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. Formal employees in panel (a); Informal employees working in low-informality industries in panel (b); Informal employees working in high-informality industries (i.e. agriculture, construction and domestic services; see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries) in panel (c); self-employed workers in panel (d).

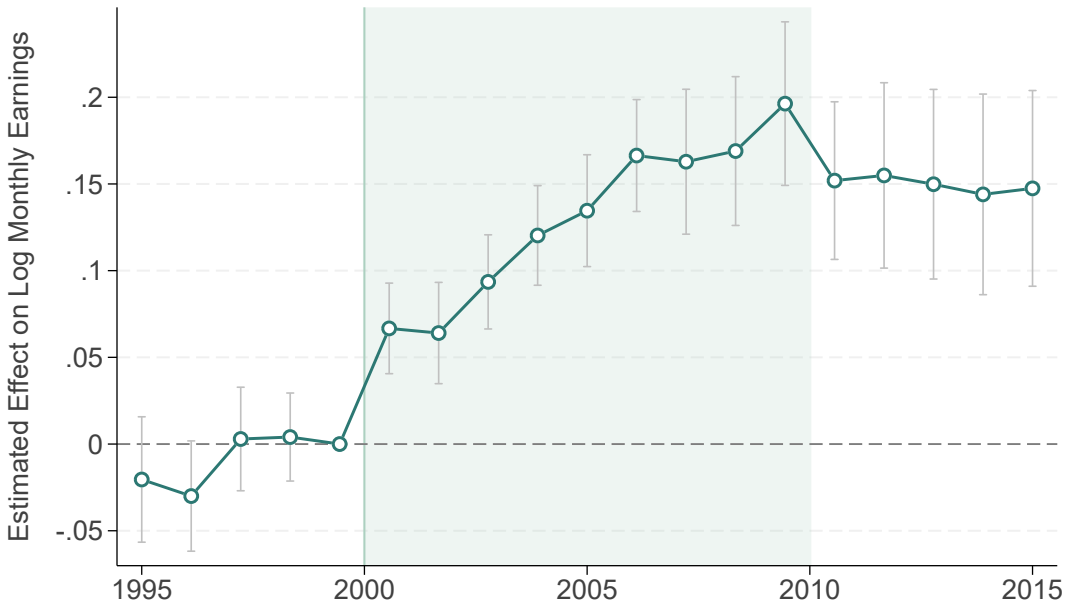
Notes: The figure shows additional results from our bunching difference-in-differences design shown in Figure 6 using census data. The figure assesses the effect of the 2000-2009 minimum wage increases on the change in the probability density of wages between the 2000 and 2010 Census enumerations by levels of informality (see Equation 2 in Section 5.2).

D.2 Robustness to alternative definitions of the treatment variables.

Figure D2: Results on average wages with alternative treatment variables

(a) Q2, Q3, Q4 vs. Q1

(b) Q3, Q4 vs. Q1

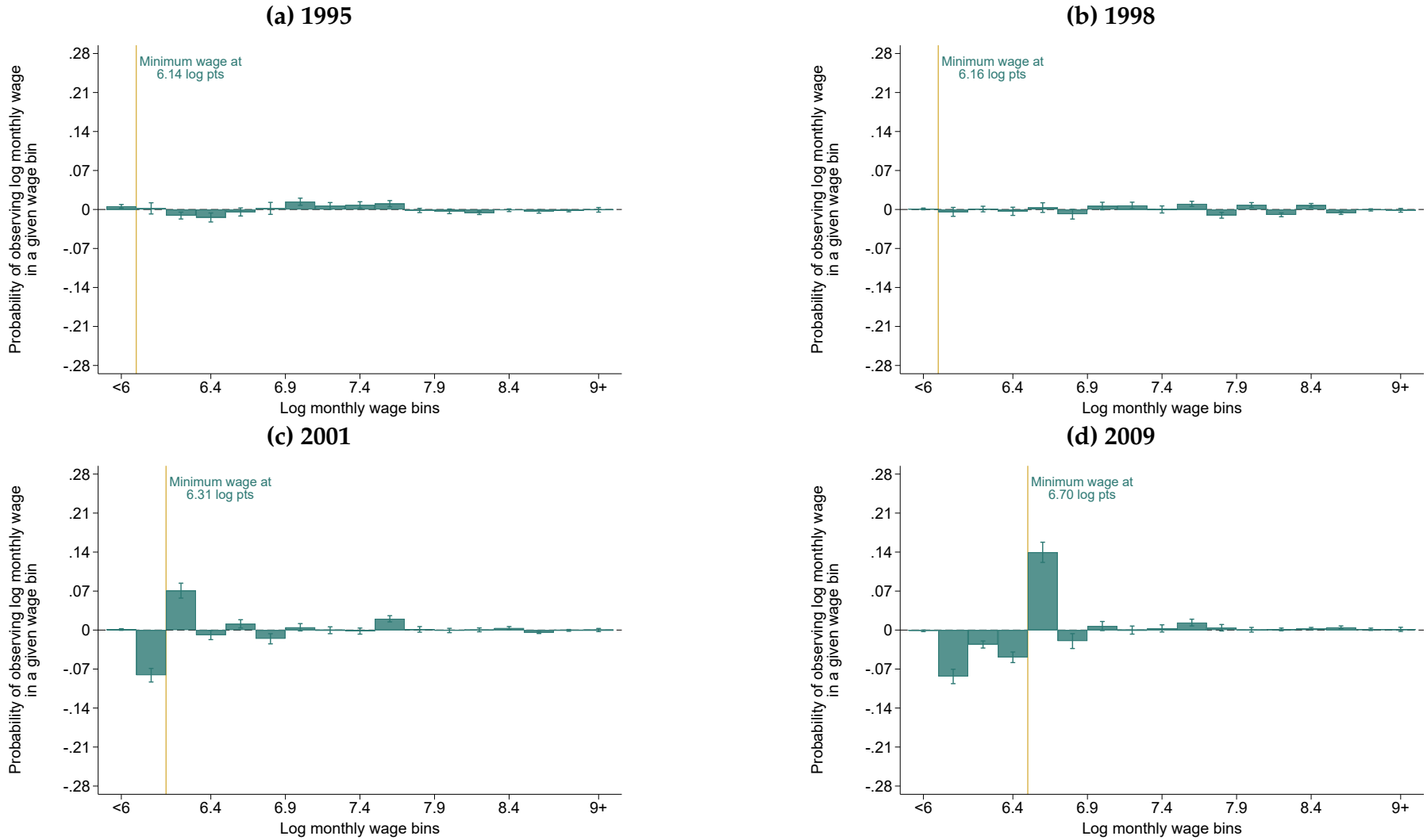


Sources: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector (formal sector only), working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. See Section 5.3 paragraph "Robustness to other treatment variables" for a discussion of the results.

D.3 Robustness to mean reversion.

Figure D3: Evolution of the probabilities to be in a specific wage bin in pre- and post-reform years among formal employees

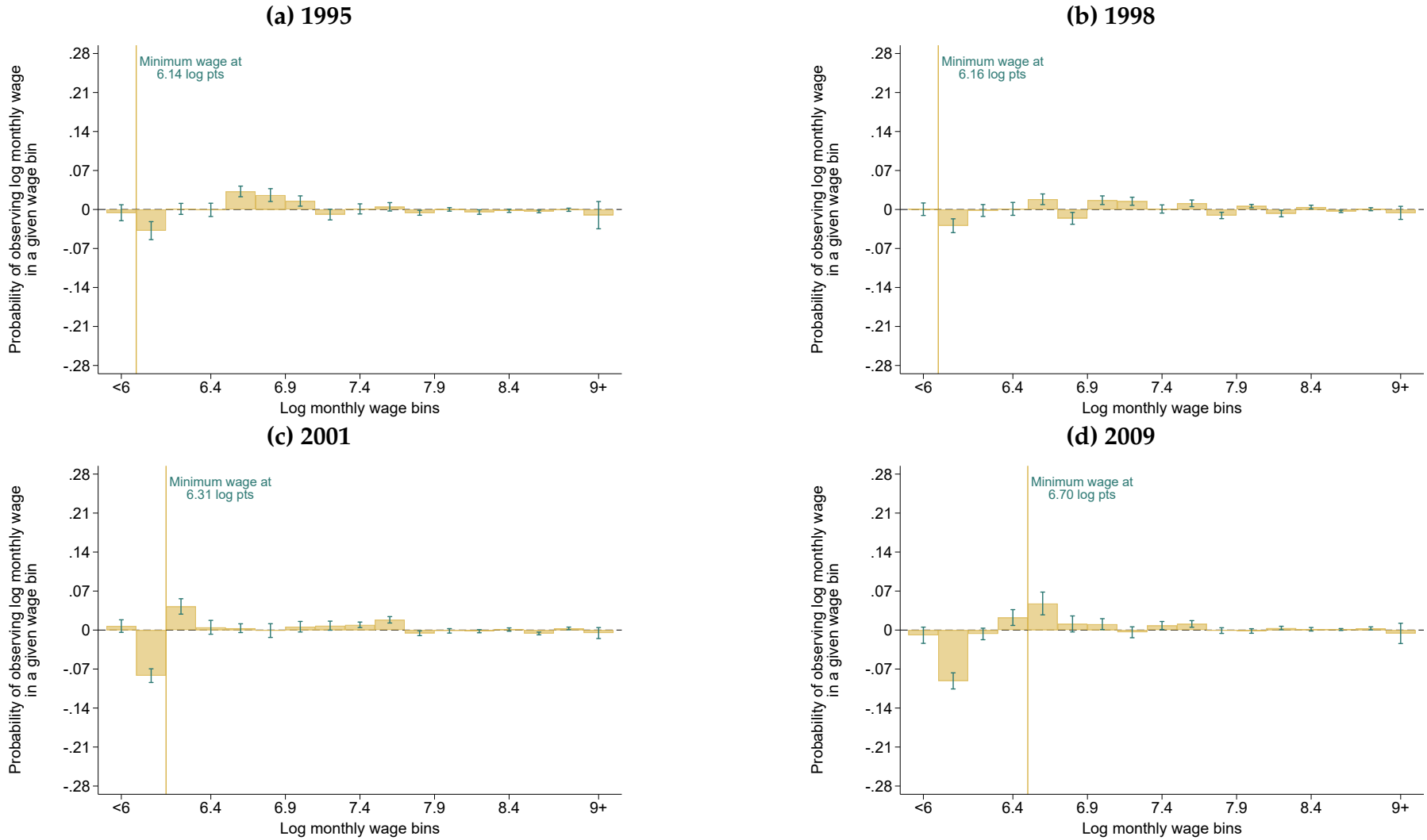


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2). The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D4: Evolution of the probabilities to be in a specific wage bin in pre- and post-reform years among informal employees

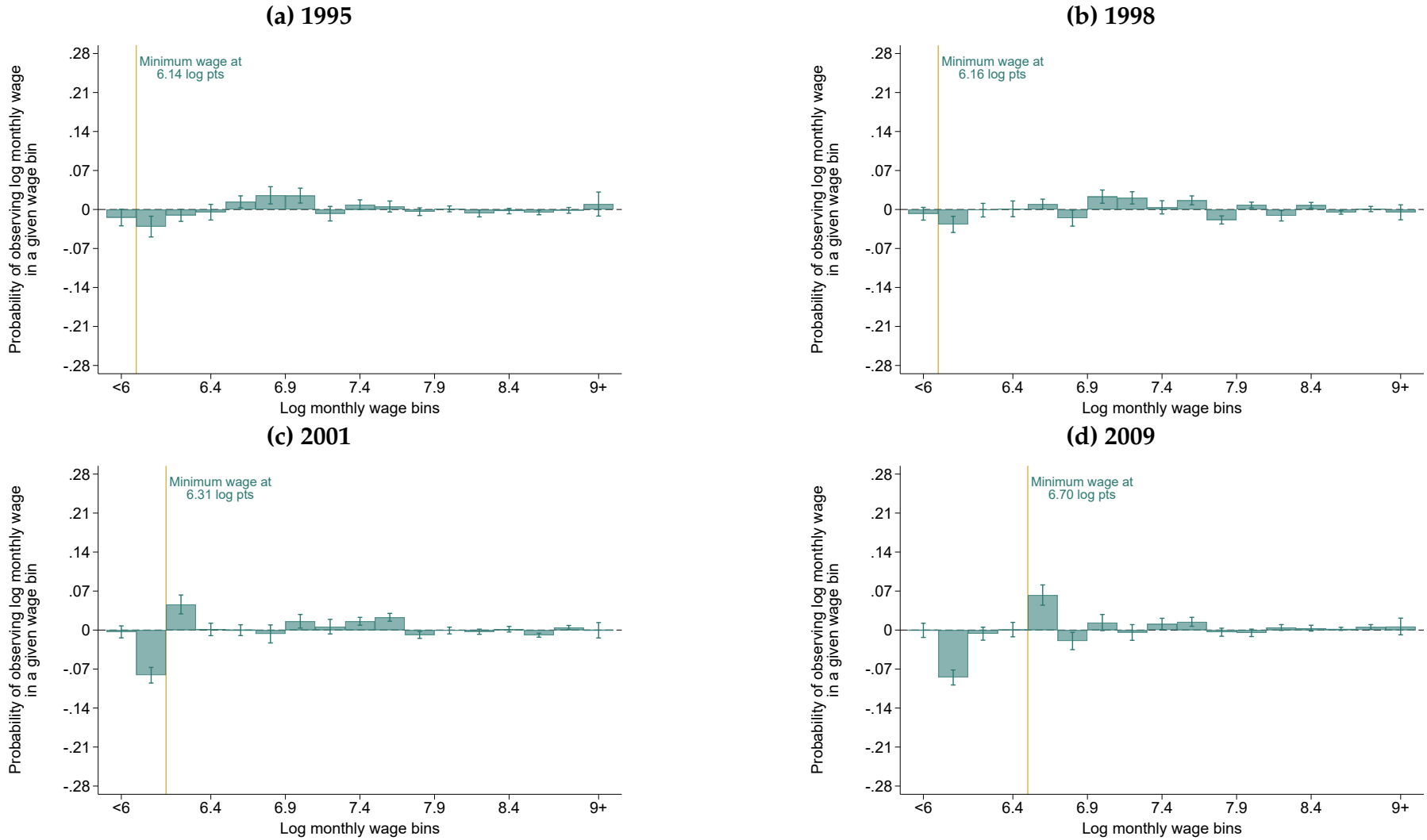


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2). The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D5: Evolution of the probabilities to be in a specific wage bin in pre- and post-reform years among informal employees in low-informality industries

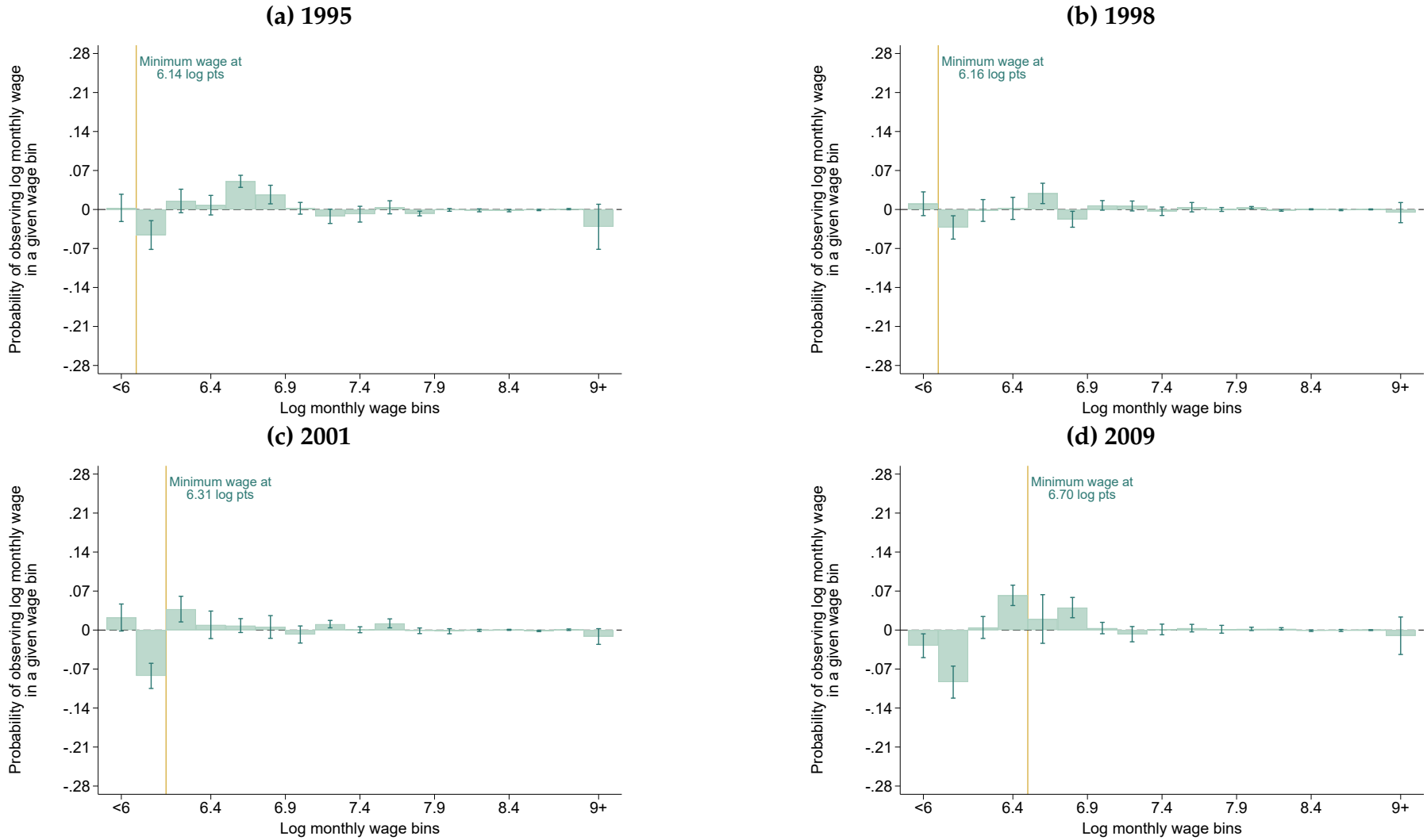


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, informal employees in low-informality industries, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2). The complete 1995-2015 series of graphs is available in our slides here. See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D6: Evolution of the probabilities to be in a specific wage bin in pre- and post-reform years among informal employees in high-informality industries

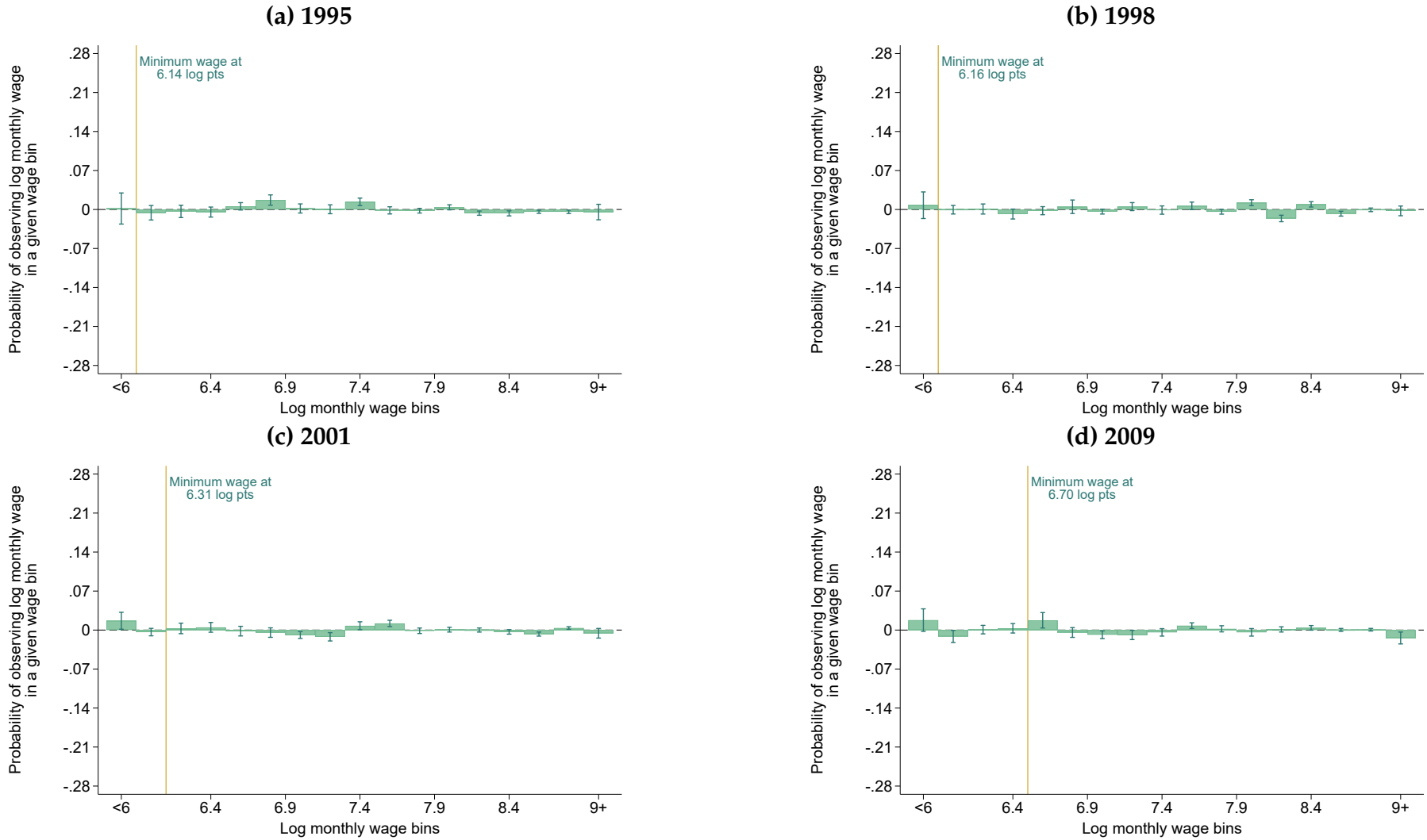


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, informal employees in high-informality industries, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2). The complete 1995-2015 series of graphs is available in our slides here. See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D7: Evolution of the probabilities to be in a specific wage bin in pre- and post-reform years among the self-employed

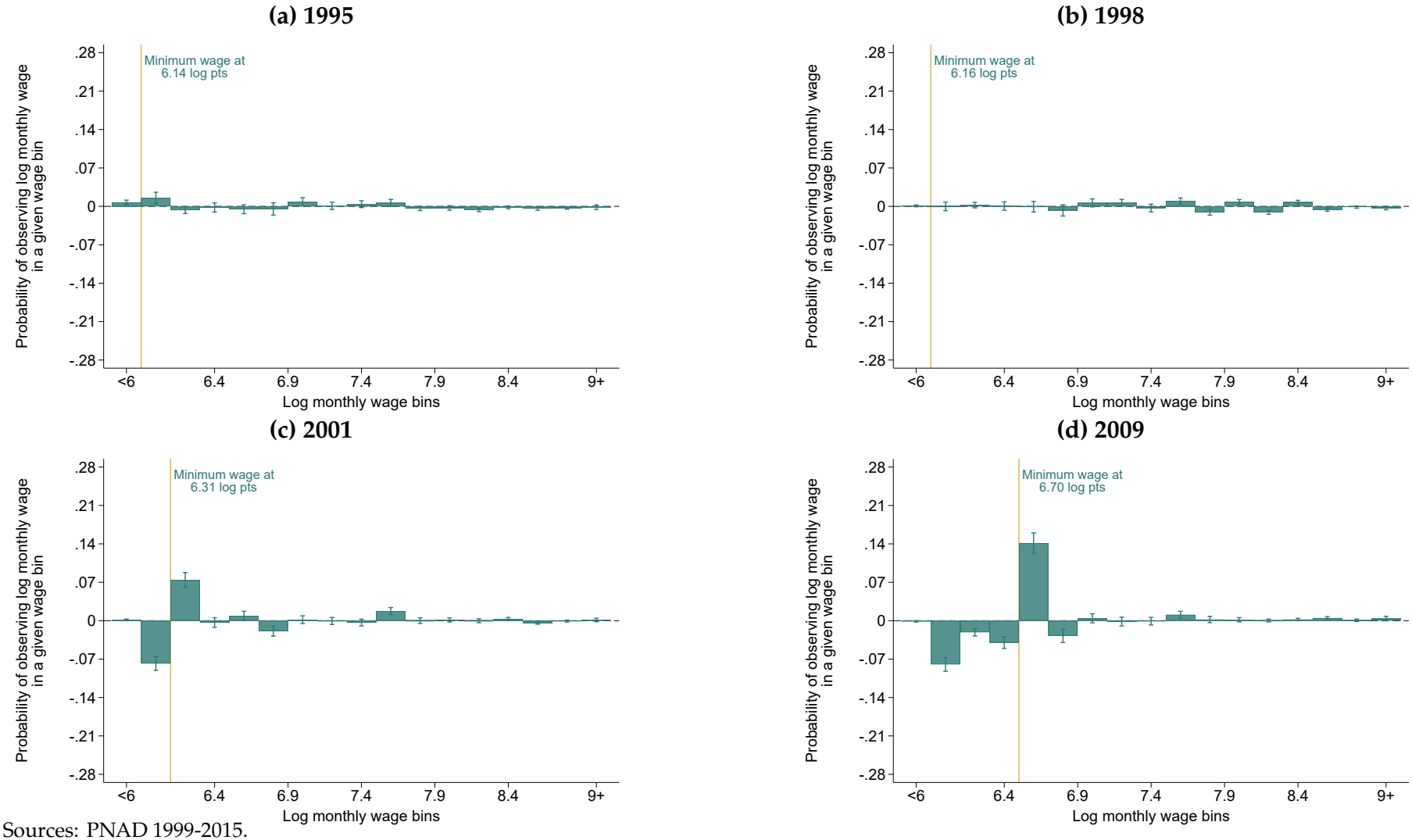


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, self-employed employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2). The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D8: Effect of the minimum wage on the probability of being in a specific wage bin using treatment variable defined in 1995 among formal employees

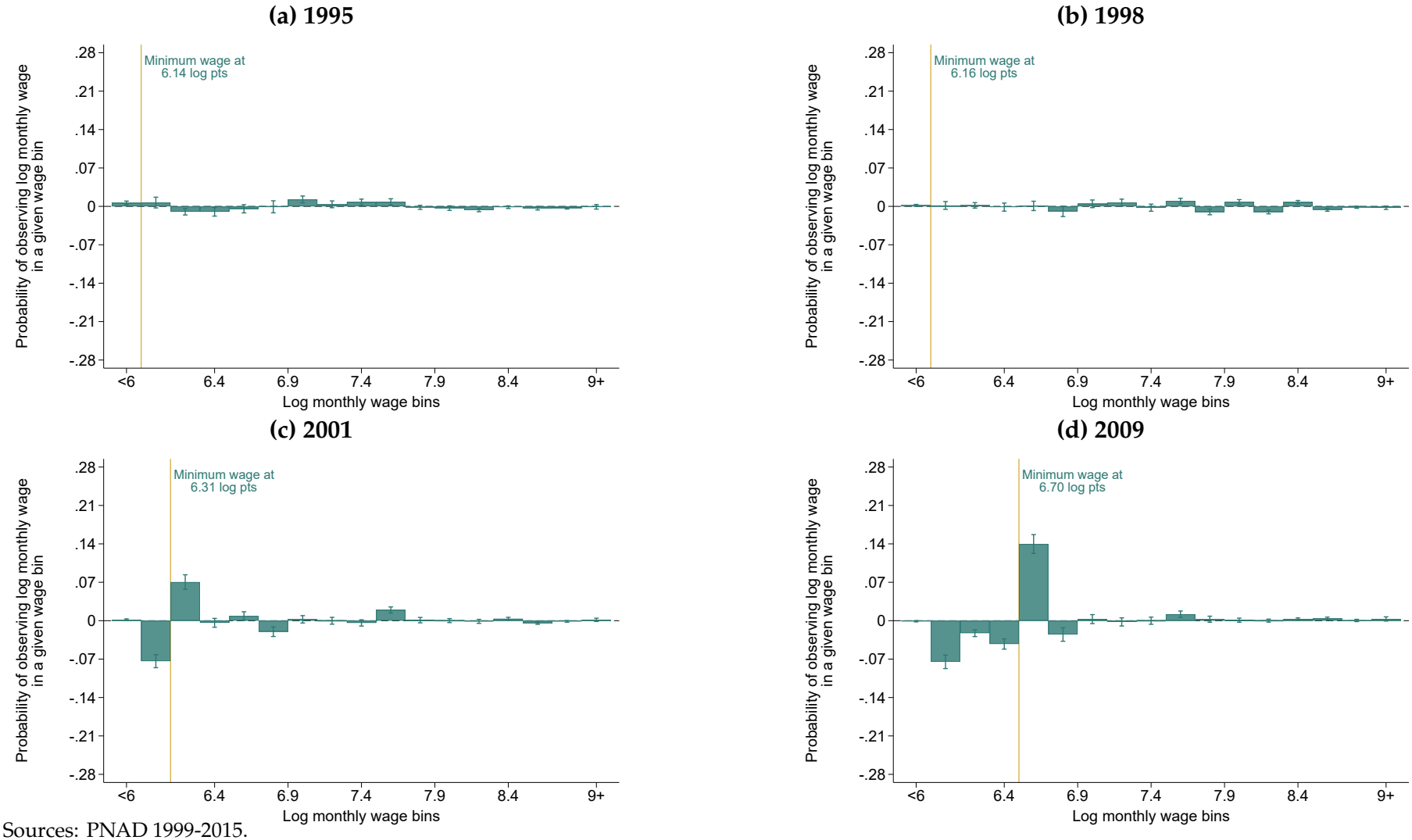


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2) using our treatment variable defined in 1995 instead, i.e. the share of workers below the 2009 minimum wage in 1995. The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D9: Effect of the minimum wage on the probability of being in a specific wage bin using treatment variable defined in 1996

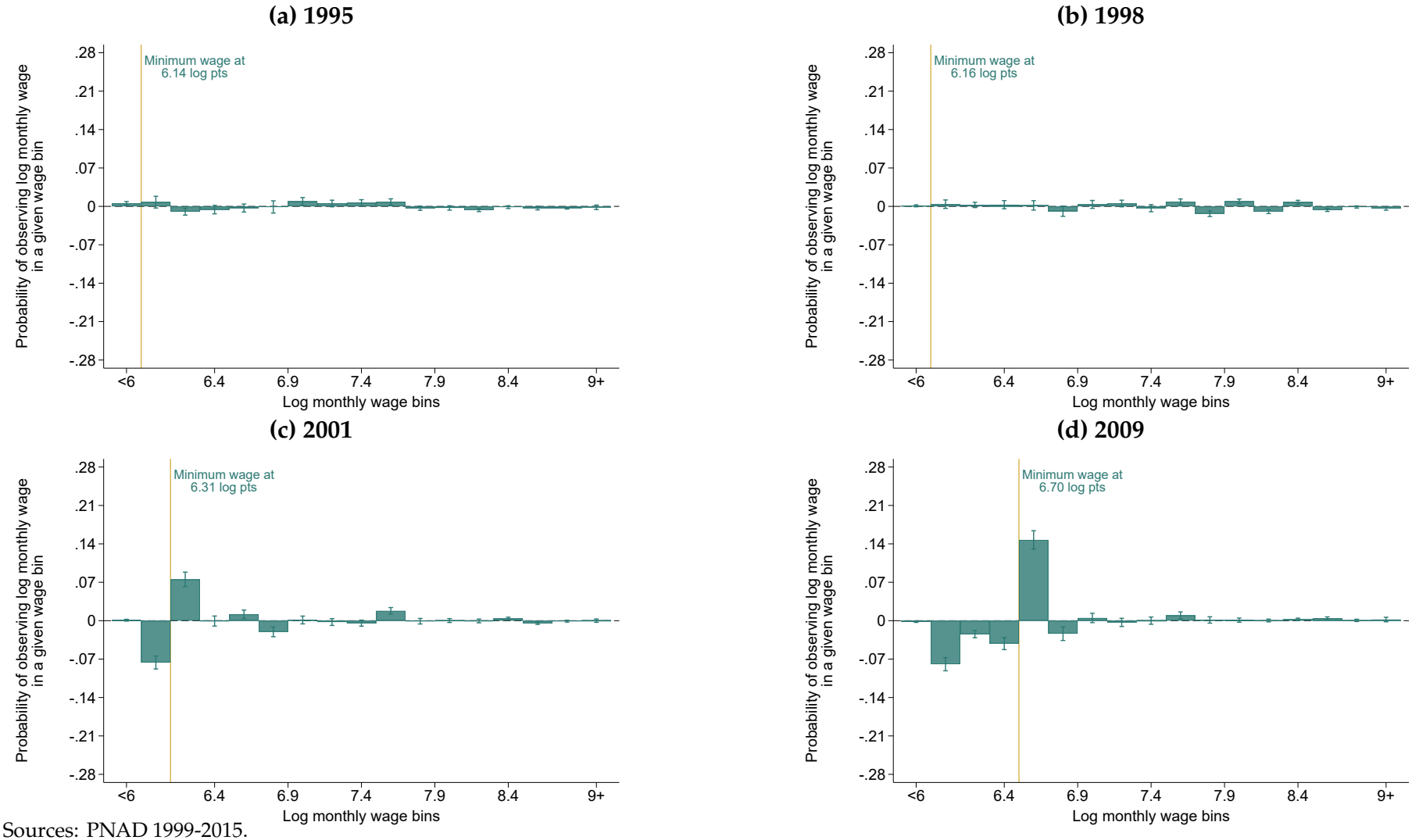


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2) using our treatment variable defined in 1996 instead, i.e. the share of workers below the 2009 minimum wage in 1996. The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D10: Effect of the minimum wage on the probability of being in a specific wage bin using treatment variable defined in 1997

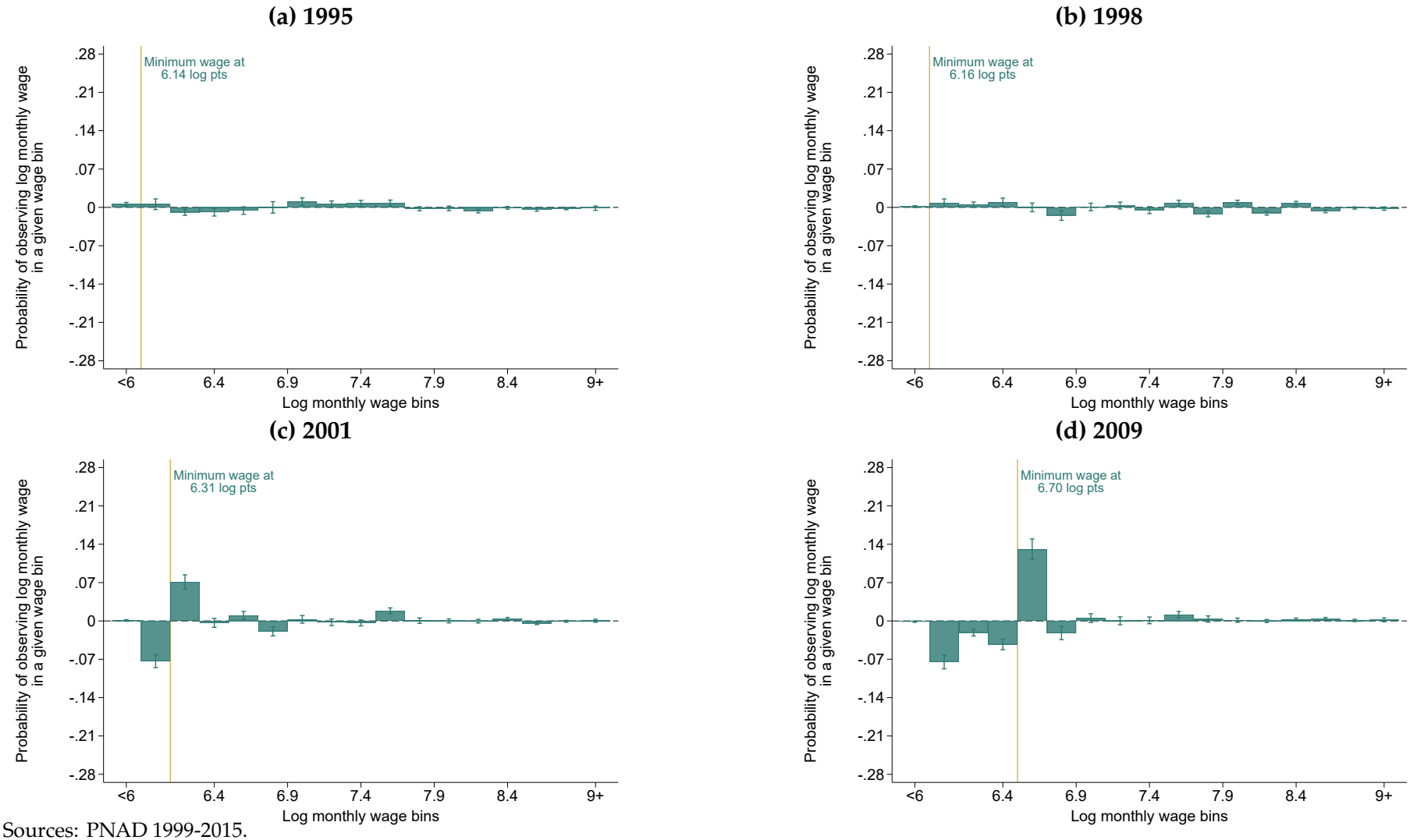


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2) using our treatment variable defined in 1997 instead, i.e. the share of workers below the 2009 minimum wage in 1997. The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Figure D11: Effect of the minimum wage on the probability of being in a specific wage bin using treatment variable defined in 1998



Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, formal employees, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of wages (see Equation 2 in Section 5.2) using our treatment variable defined in 1998 instead, i.e. the share of workers below the 2009 minimum wage in 1998. The complete 1995-2015 series of graphs is available in our slides here. See Section 5.3 paragraph "Robustness to mean reversion" for a discussion of the results.

Appendix E Bunching at multiples of the minimum wage

We evaluate here whether there is bunching at multiples of the minimum wage, as a test for the importance of the minimum wage as a norm in the wage distributions of formal and informal employees, as well as of the self-employed.

Methodology. We use bins of R$10 in nominal values to more easily separate bunching at multiples of the minimum wage and at round numbers (multiples of 50 and 100). In all graphs, red vertical lines indicate values equal to 1, 2, or 3 times the minimum wage; "mist" vertical lines indicate multiples of 100 (solid lines) and multiples of 50 (dashed lines). Using RAIS, we created graphs both for monthly earnings and for the contracted wage in all years from 1995 or 2002 to 2017. Using census data, we created graphs for monthly earnings in the main job in 2000 and 2010, separately for formal employees, informal employees, and the self-employed. Note that in some years, the minimum wage is close to a round number, making it hard to separate bunching at round numbers to bunching at multiples of the minimum wage. This is the case for the 2000 Census, so using the 2010 Census is more useful in this case.

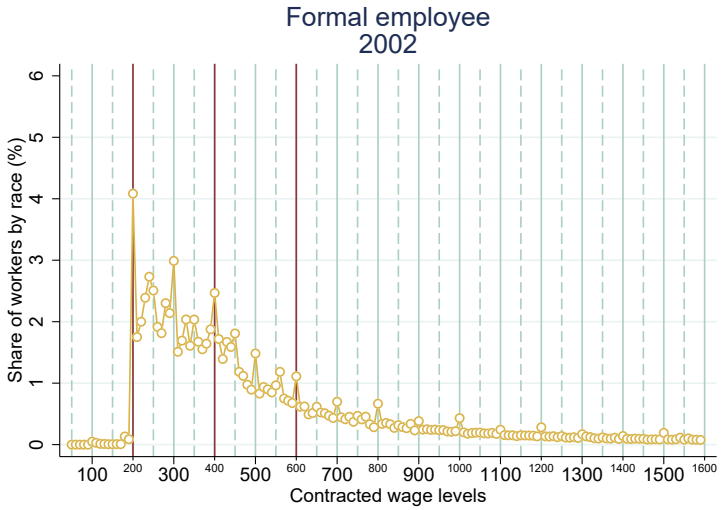
Results. Appendix Figure E1 displays the monthly contracted wage distribution in RAIS in 2002, 2009, 2011 and 2015. There is a small spike at 2 times and 3 times the minimum wage in 2002 among formal employees. However, we note that the magnitude of the spike at multiples of the minimum wage is similar to spikes appearing throughout the distribution at round numbers. We make the same conclusion for 2009, 2011 and 2015 when the minimum wage is much higher. In fact, we note that if anything, the spike at multiples of the minimum wage vanishes over this period of large minimum wage increases.

Appendix Figure E2a displays the monthly earnings distribution in the 2010 Census for formal employees, and confirms the analysis we conducted for formal employees in RAIS over 2002-2015. Using census data, we reach similar conclusions for informal employees (see Appendix Figure E2b) and the self-employed (see Appendix Figure E2c).

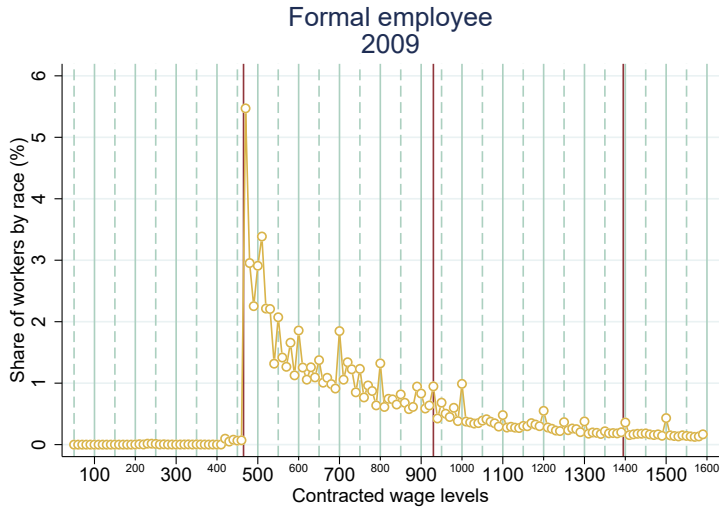
Taken together, our results are not indicative that the minimum acts as a strong social norm shaping the wage distribution during our period of study. This is consistent with the fact that we do not find spillover effects of the minimum wage higher up in the wage distribution (see Figure 6).

Figure E1: Bunching around multiples of the minimum wage in monthly earnings distributions, RAIS

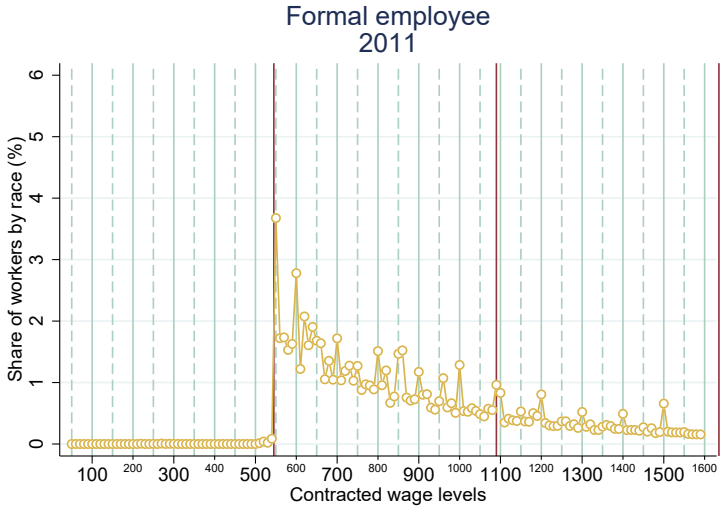
(a) 2002



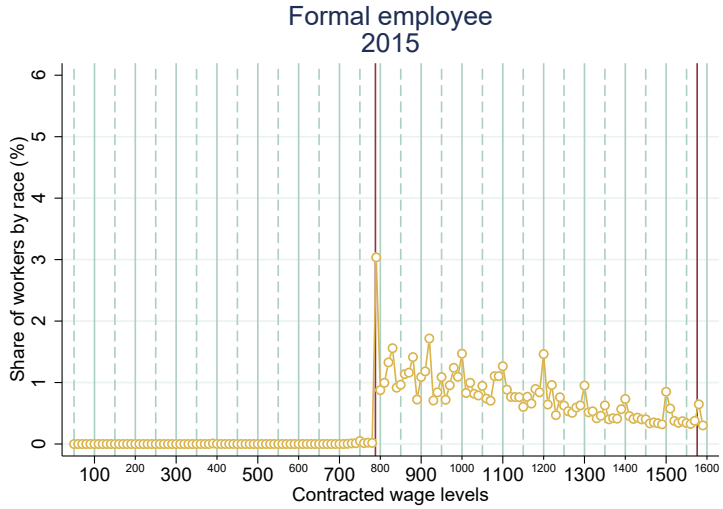
(b) 2009



(c) 2011



(d) 2015

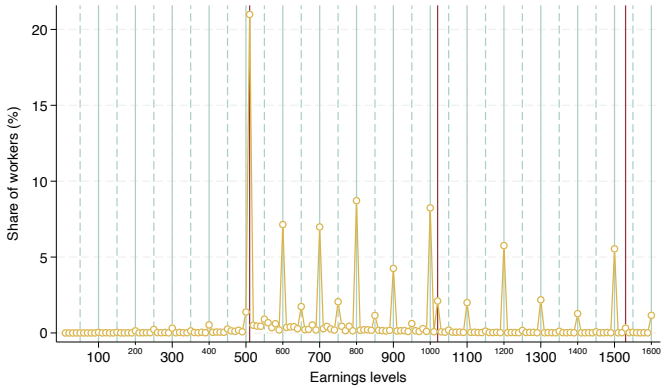


Sources: RAIS 2002, 2009, 2011 and 2015.

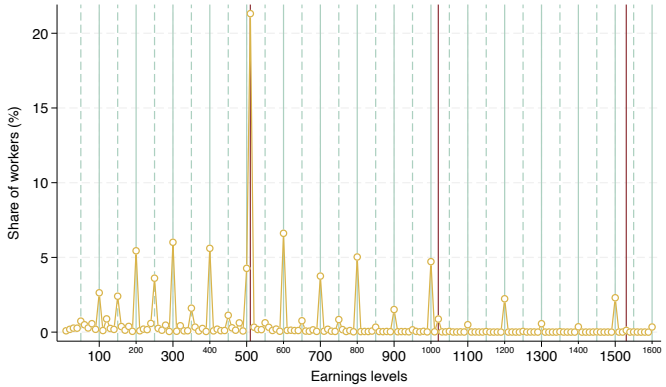
Sample: Adults aged 25-54, employed full-time in private-sector job on December 31st, all race categories. We use bins of R$10 in the nominal value of the monthly contracted wage. 2002 is the first year for which the contracted wage variable is available in RAIS. Red vertical lines indicate values equal to 1, 2, or 3 times the minimum wage; light green vertical lines indicate multiples of 100 (solid lines) and multiples of 50 (dash lines). Distributions are truncated on the right hand side.

Figure E2: Bunching around multiples of the minimum wage in monthly earnings distributions, Census 2010

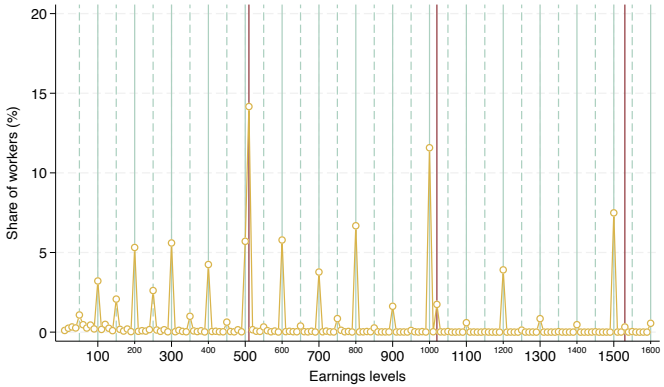
(a) Formal employees



(b) Informal employees



(c) Self-employed



Sources: Census 2010.

Sample: Adults aged 25-54, employed full-time in private-sector job, all race categories. We use bins of R$10 in nominal value of monthly earnings. Red vertical lines indicate values equal to 1, 2, or 3 times the minimum wage; light green vertical lines indicate multiples of 100 (solid lines) and multiples of 50 (dash lines). Distributions are truncated on the right hand side.

Appendix F Additional details on high- vs. low-informality industries and employer formality status

We characterize here the different segments of the informal sector by studying the profiles of informal employees, the types of jobs they hold, and the type of employer by proximity to the formal sector.

Demographic and labor market characteristics. Table 1 reports characteristics of workers in different groups of employment in 1999. Informal employees further away from the formal sector (i.e., those working in agriculture, construction and domestic service workers) typically earn lower wages than workers employed in all other industries; they are predominantly non-white, are more likely to be women, and tend to work in smaller firms than other groups of informal salaried employees. Informal employees employed in agriculture, construction and domestic services are also less likely to work full-time: in 1999, 54% of these informal employees worked full time while 71% of those working in all other industries informal employees did so. Appendix Tables F1 to F4 compare the demographic and economic characteristics of informal workers by industry category and by employer type. They confirm that the profiles of informal employees based on industry category (agriculture, construction, and domestic services vs. all others) are well aligned with the profile of informal employees who work in formal vs. informal firms and help us characterize weaker vs. stronger connections to formal jobs.

Type of jobs. Table 2 documents that the industry and occupation distribution of informal workers closer to the formal sector closely mirrors that of the formal sector before the episode of large minimum wage increases. This pattern is confirmed after the large minimum wage increases, using the employer type and zooming in on workers around the minimum wage (see Appendix Table F5). These descriptive statistics alone underscore possible competition between formal and informal labor in proximity to the formal sector, leaving aside an entire segment of the informal sector that is governed by distinct labor market rules.

Type of employer. For some selected years, we do have the information on whether the informal employee works in a formal vs. an informal firm. More specifically, we have this information in the establishment survey data ECINF 1997 and 2003. This information has been used in seminal work by Ulyssea (2018) that disentangles informal workers on the

intensive margin (i.e. those employed in formal firms) vs. those in the *extensive margin* (i.e. those employed in informal firms); as well as in PNAD starting in 2011 – a source that has not been leveraged in prior studies of the informal sector in Brazil to our knowledge. Starting in 2011, informal workers are asked in PNAD whether they work in a firm that is registered with a tax identification number (the CNPJ code).[13]

Interestingly, we highlight two keypoints. First, the type of employer of the informal worker strongly predicts compliance with the minimum wage. Using PNAD 2011 and 2015, Appendix Figure F1 shows extremely similar patterns of compliance among low- versus high-informality industries and formal vs. informal employers. Using ECINF, Appendix Figures F2 and F3 show that, prior to the large minimum wage hikes, minimum wage compliance is almost perfect among informal employees employed in formal firms, and that non-compliance is concentrated among informal employees in informal firms.[14]

Second, the industry breakdown based on compliance with the minimum wage (agriculture, construction, domestic services vs. all others) serves as a strong indication of employer type. The monthly earnings distributions by industry and employer type overlap well both in ECINF (see Appendix Figure F2 for 1997 and Appendix Figure F3 2003) and in PNAD (see Appendix Figures F1a and F1b for 2011 and Appendix Figures F1c and F1d 2015).

We interpret these sets of results as indicative that compliance with the minimum wage in the informal sector varies by the formality of the employer and the latter is well captured by the industry of the informal employee.

[13]One potential challenge with this question is that among our main sample of interest (prime-age informal employees working full-time) the non-response rate to this question can reach up to 28%. However, because the probability of not responding is uncorrelated with the respondent's wage, we do not believe that this non-response introduces bias for our main outcome of interest. More precisely, non-response on the margin of informality reaches 28.4% in 2011 and 25.5% in 2015. The correlation coefficient between the respondent's non-response status and monthly wage varies between 0.021 at its highest in 2011 to 0.006 at its lowest in 2014.

[14]Note that we adjusted the sample in the PNAD proxied series to match as closely as possible the ECINF sample. In particular the monthly earnings distributions using the industry in PNAD are shown only for firms that employ 5 workers of fewer, and excludes domestic services.

Table F1: Comparison of workers' characteristics among informal employees by distance to the formal sector (Part I), 2011

	Closer to the formal sector		Further away from the formal sector	
	Using employer type	Using industry	Using employer type	Using industry
Median monthly earnings (in R$2019)	2,129	1,910	973	881
Age	36.5	36.3	38.0	38.3
Work experience	21.4	21.1	26.5	26.9
Tenure	4.8	4.4	6.2	8.1
Gender				
Male	0.63	0.60	0.53	0.55
Female	0.37	0.40	0.47	0.45
Race				
White	0.50	0.49	0.34	0.34
Nonwhite	0.50	0.51	0.66	0.66
Education				
Less than high school	0.45	0.46	0.81	0.80
High school completed	0.41	0.42	0.17	0.16
College completed	0.14	0.12	0.02	0.04
Region				
North	0.08	0.08	0.10	0.11
Northeast	0.25	0.25	0.36	0.39
Southeast	0.43	0.44	0.36	0.31
South	0.14	0.13	0.10	0.12
Midwest	0.10	0.09	0.08	0.07
Firm size				
Conditional on non-missing				
Small firm (9 workers or less)	0.55	0.61	0.90	0.90
Large firm (10+ workers)	0.45	0.39	0.10	0.10
Missing	0.23	0.15	0.61	0.76

Source: PNAD 2011.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Informal employees are closer to the formal sector if they are employed in a formal firm; and further away from the formal sector if employed in an informal firm. Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e.,in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries). Median monthly earnings in R$2019 winsorized at 1% and 99% levels, deflated using the inpc series.

Table F2: Comparison of workers' characteristics among informal employees by distance to the formal sector (Part II), 2011

	Closer to the formal sector		Further away from the formal sector	
	Using employer type	Using industry	Using employer type	Using industry
Workers near the minimum wage				
Strictly below 100% of the mw (%)	0.09	0.13	0.38	0.29
Strictly below 115% of the mw (%)	0.70	0.74	0.93	0.74
Between 105% and 115% of the mw (%)	0.30	0.29	0.19	0.16
Between 90% and 105% of the mw (%)	0.38	0.42	0.62	0.49
Strictly below 90% of the mw (%)	0.02	0.03	0.12	0.09
Industry				
Agriculture, forestry and fishing	0.05	0.00	0.23	0.37
Mining and extractive industries	0.00	0.01	0.00	0.00
Manufacturing	0.12	0.15	0.04	0.03
Construction	0.06	0.03	0.17	0.17
Wholesale and retail trade	0.20	0.22	0.03	0.02
Hotels and restaurants	0.07	0.09	0.02	0.02
Transportation, communication and electricity, gas, water	0.06	0.08	0.03	0.02
Finance, insurance, real estate and repair services	0.13	0.15	0.04	0.01
Public administration	0.19	0.15	0.00	0.00
Education, health and social work	0.04	0.04	0.00	0.07
Domestic services	0.00	0.00	0.42	0.29
Entertainment, recreation and other services	0.07	0.08	0.02	0.01
Occupation				
Managerial	0.05	0.04	0.00	0.01
Scientific and artistic	0.08	0.08	0.01	0.03
Mid-level technicians	0.08	0.08	0.01	0.02
Administrative service workers	0.10	0.10	0.01	0.01
Service workers	0.18	0.22	0.46	0.32
Retail service workers	0.14	0.16	0.03	0.02
Agriculture workers	0.05	0.00	0.22	0.37
Manufacturing, construction and repair workers	0.26	0.29	0.26	0.21
Armed forces and other occupations	0.05	0.04	0.00	0.00

Source: PNAD 2011.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Informal employees are closer to the formal sector if they are employed in a formal firm; and further away from the formal sector if employed in an informal firm. Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e., in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries).

Table F3: Comparison of workers' characteristics among informal employees by distance to the formal sector (Part I), 2015

	Closer to the formal sector		Further away from the formal sector	
	Using employer type	Using industry	Using employer type	Using industry
Median monthly earnings (in R$2019)	2,184	2,028	1,095	1,045
Age	36.9	36.7	38.7	38.8
Work experience	21.3	20.9	26.5	26.5
Tenure	4.7	4.5	6.4	7.8
Gender				
Male	0.65	0.62	0.57	0.58
Female	0.35	0.38	0.43	0.42
Race				
White	0.46	0.46	0.31	0.33
Nonwhite	0.54	0.54	0.69	0.67
Education				
Less than high school	0.42	0.40	0.76	0.74
High school completed	0.42	0.45	0.22	0.20
College completed	0.16	0.15	0.02	0.06
Region				
North	0.09	0.09	0.12	0.12
Northeast	0.26	0.27	0.36	0.39
Southeast	0.43	0.43	0.36	0.31
South	0.13	0.12	0.09	0.11
Midwest	0.09	0.09	0.07	0.07
Firm size				
Conditional on non-missing				
Small firm (9 workers or less)	0.58	0.63	0.90	0.92
Large firm (10+ workers)	0.42	0.37	0.10	0.08
Missing	0.26	0.17	0.59	0.76

Source: PNAD 2015.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Informal employees are closer to the formal sector if they are employed in a formal firm; and further away from the formal sector if employed in an informal firm. Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e.,in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries). Median monthly earnings in R$2019 winsorized at 1% and 99% levels, deflated using the inpc series.

Table F4: Comparison of workers' characteristics among informal employees by distance to the formal sector (Part II), 2015

	Closer to the formal sector		Further away from the formal sector	
	Using employer type	Using industry	Using employer type	Using industry
Workers near the minimum wage				
Strictly below 100% of the mw (%)	0.09	0.12	0.36	0.26
Strictly below 115% of the mw (%)	0.78	0.80	0.96	0.78
Between 105% and 115% of the mw (%)	0.31	0.29	0.20	0.19
Between 90% and 105% of the mw (%)	0.45	0.49	0.65	0.52
Strictly below 90% of the mw (%)	0.01	0.02	0.11	0.07
Industry				
Agriculture, forestry and fishing	0.06	0.00	0.22	0.36
Mining and extractive industries	0.00	0.00	0.00	0.00
Manufacturing	0.11	0.13	0.03	0.03
Construction	0.06	0.03	0.21	0.19
Wholesale and retail trade	0.19	0.22	0.04	0.02
Hotels and restaurants	0.08	0.10	0.03	0.01
Transportation, communication and electricity, gas, water	0.06	0.07	0.03	0.02
Finance, insurance, real estate and repair services	0.13	0.15	0.04	0.01
Public administration	0.20	0.17	0.00	0.00
Education, health and social work	0.05	0.05	0.01	0.10
Domestic services	0.00	0.00	0.37	0.25
Entertainment, recreation and other services	0.06	0.08	0.02	0.01
Occupation				
Managerial	0.06	0.05	0.00	0.01
Scientific and artistic	0.09	0.09	0.01	0.05
Mid-level technicians	0.08	0.08	0.01	0.03
Administrative service workers	0.11	0.11	0.01	0.02
Service workers	0.19	0.24	0.43	0.29
Retail service workers	0.11	0.13	0.03	0.02
Agriculture workers	0.07	0.00	0.22	0.35
Manufacturing, construction and repair workers	0.26	0.27	0.29	0.23
Armed forces and other occupations	0.04	0.04	0.00	0.00

Source: PNAD 2015.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

Notes: Informal employees are closer to the formal sector if they are employed in a formal firm; and further away from the formal sector if employed in an informal firm. Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e.,in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries).

Table F5: Comparison of workers' characteristics around the minimum wage in the formal vs. informal sector, 2015

	Formal employees	Informal employees	
		Low-informality industries	High-informality industries
Industry			
Agriculture, forestry and fishing	0.06	0.08	0.31
Mining and extractive industries	0.00	0.00	0.00
Manufacturing	0.20	0.13	0.06
Construction	0.08	0.06	0.36
Wholesale and retail trade	0.24	0.22	0.07
Hotels and restaurants	0.07	0.10	0.05
Transportation, communication and electricity, gas, water	0.08	0.06	0.05
Finance, insurance, real estate and repair services	0.14	0.10	0.06
Public administration	0.01	0.15	0.00
Education, health and social work	0.09	0.04	0.01
Entertainment, recreation and other services	0.03	0.06	0.04
Occupation			
Managerial	0.02	0.02	0.01
Scientific and artistic	0.02	0.04	0.01
Mid-level technicians	0.06	0.06	0.01
Administrative service workers	0.17	0.13	0.02
Service workers	0.23	0.25	0.10
Retail service workers	0.13	0.13	0.05
Agriculture workers	0.06	0.08	0.31
Manufacturing, construction and repair workers	0.31	0.29	0.50
Armed forces and other occupations	0.00	0.00	0.00

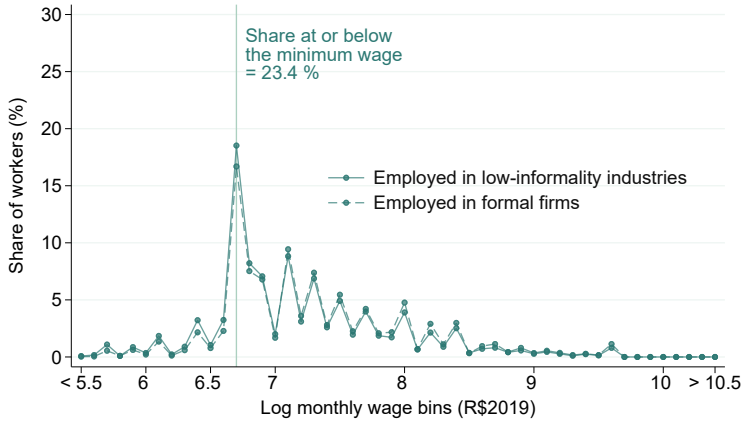
Source: PNAD 2015.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more) between 95% and 110% of the minimum wage, no missing monthly earnings variable, no missing experience variable; excludes domestic services.

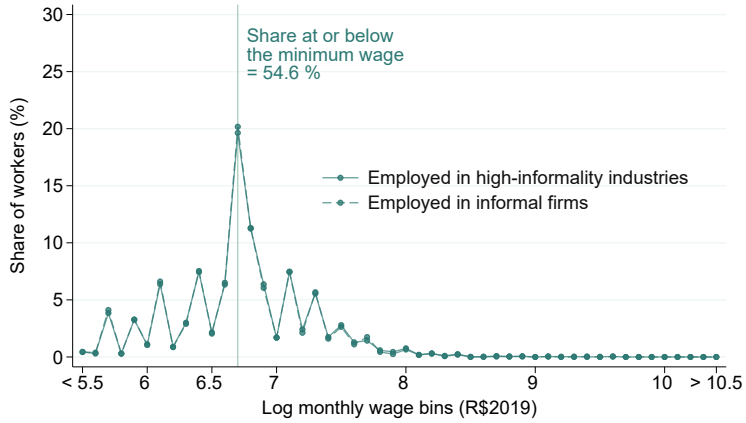
Notes: Informal employees are further away from the formal labor market if they work in "high-informality industries," i.e.,in agriculture, construction, or domestic services. They are closer to the formal labor market if they work in all other industries (see Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries).

Figure F1: Comparison of monthly wage distributions among informal employees in low- vs. high-informality industries with distributions by employer type (formal vs. informal) for the years in which we observe both in PNAD (2011-2015)

(a) In low-informality industries, 2011

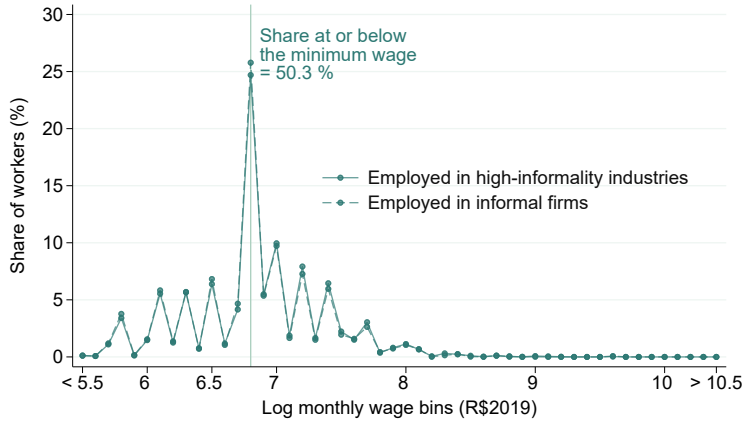


(b) In high-informality industries, 2011



(c) In low-informality industries, 2015

(d) In high-informality industries, 2015



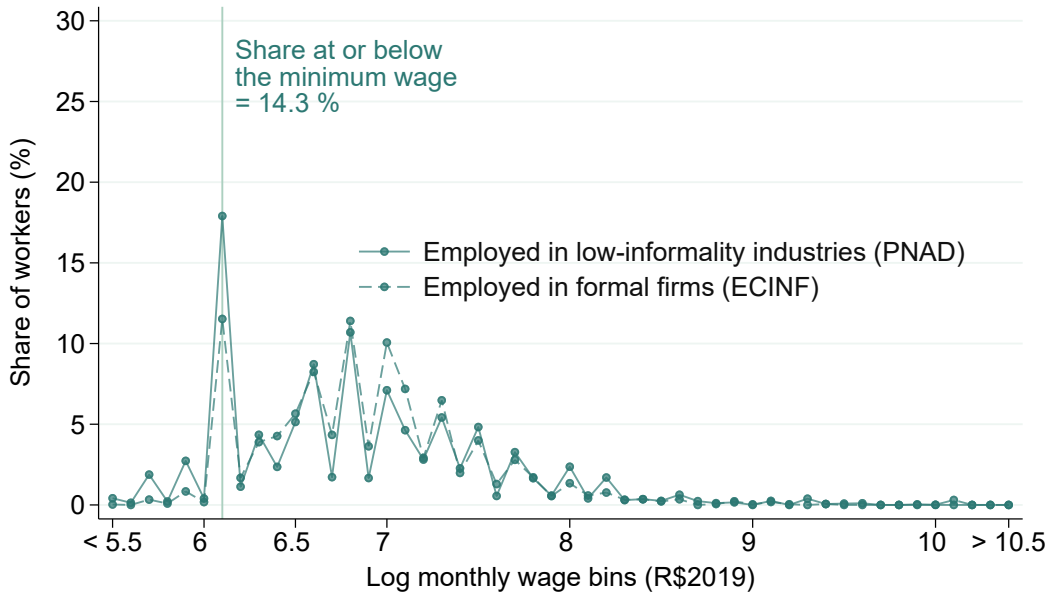
Source: PNAD 2011 & 2015.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable.

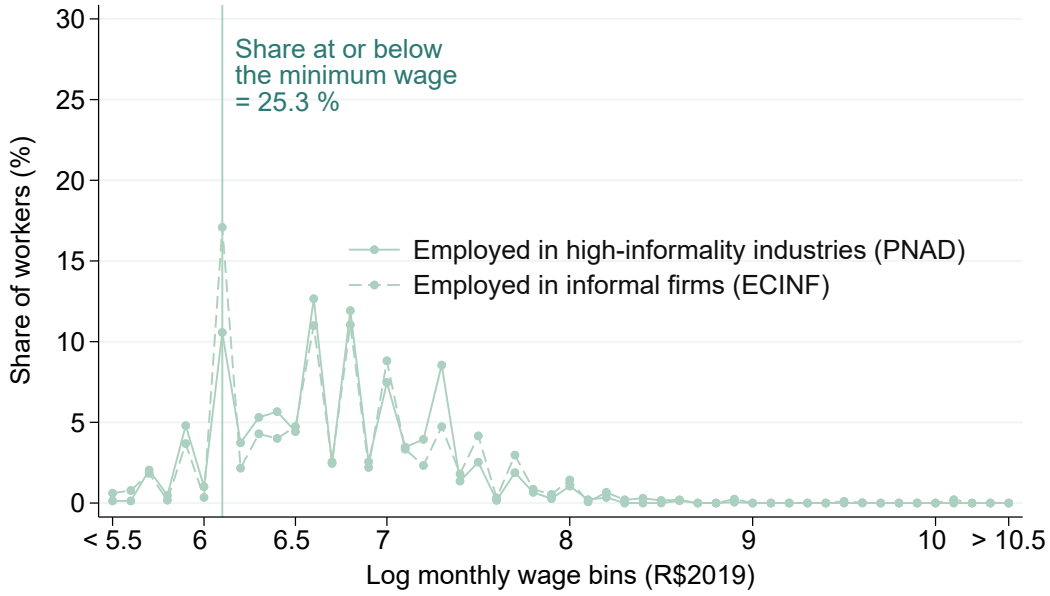
Notes: All four panels report the shares of workers at exactly the minimum wage or below among informal employees employed in low or high-informality industries. The Figure shows that the wage distributions of informal employees employed in low-informality industries and in formal firms are well aligned in 2011 and 2015. It is also true when comparing informal employees employed in high-informality industries and in informal firms. The results are similar for all the other years for which we observe the employer type of informal employees, i.e. in 2012, 2013 and 2014, as shown in our slides here. See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries.

Figure F2: Comparison of monthly wage distributions among informal employees in low- vs. high- informality industries in PNAD 1997 with distributions by employer type (formal vs. informal) in ECINF 1997

(a) In low-informality industries, 1997



(b) In high-informality industries, 1997



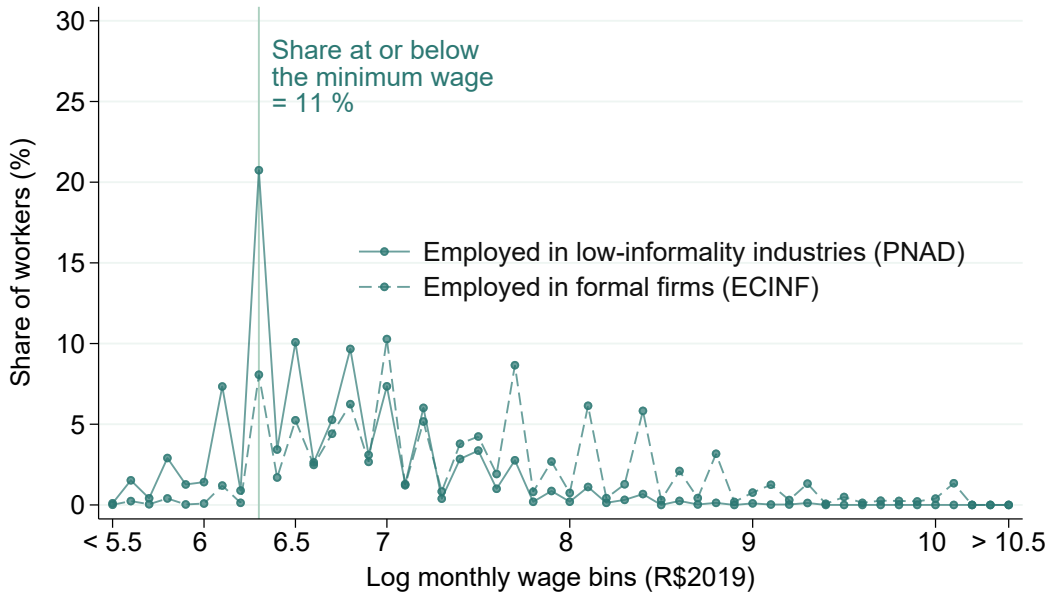
Sources: PNAD 1997 and ECINF 1997.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. The PNAD sample is further restricted to workers employed in firms of size 5 workers or fewer, and excludes domestic workers from the sample—so that the PNAD and ECINF samples are made closest to each other.

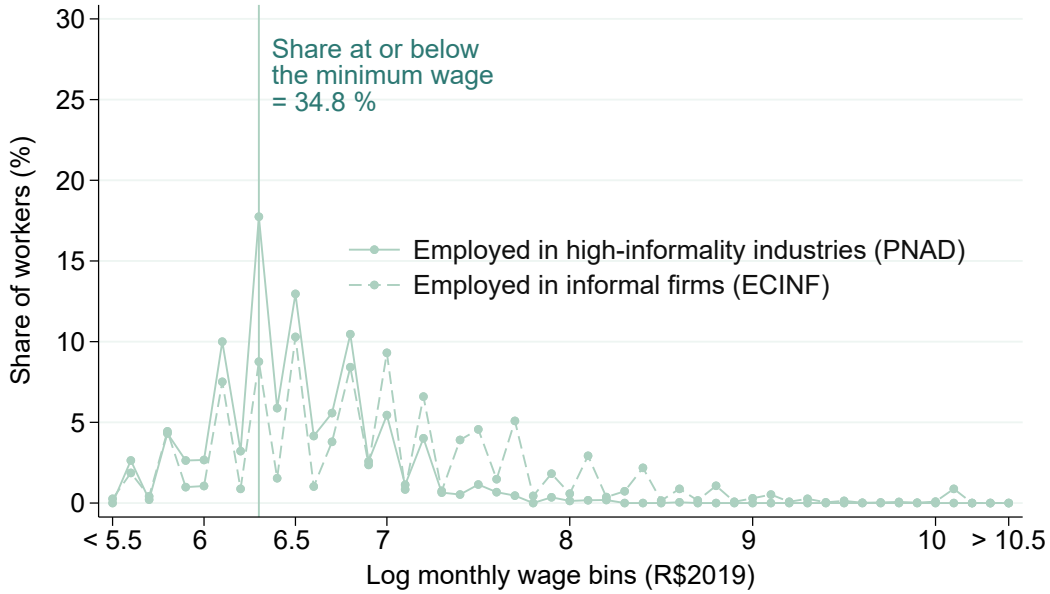
Notes: The two panels report the shares of workers at exactly the minimum wage or below in the observed series in ECINF. See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries.

Figure F3: Comparison of monthly wage distributions among informal employees in low- vs. high- informality industries in PNAD 2003 with distributions by employer type (formal vs. informal) in ECINF 2003

(a) In low-informality industries, 2003



(b) In high-informality industries, 2003



Sources: PNAD 2003 and ECINF 2003.

Sample: Adults aged 25-54, informal employees, white or non-white, working full-time (i.e. 40 hours a week or more), with no missing monthly earnings variable, and with no missing experience variable. The PNAD sample is further restricted to workers employed in firms of size 5 workers or fewer, and excludes domestic workers from the sample—so that the PNAD and ECINF samples are made closest to each other.

Notes: The two panels report the shares of workers at exactly the minimum wage or below in the observed series in ECINF. See Section 6.1, paragraph "Employer compliance practices" for our definition of high- vs. low-informality industries.

Appendix G Outside Option Index

G.1 Construction of the Outside Options Index

The Outside Options Index (OOI) is a measure of labor market concentration developed in Caldwell and Danieli (2024). Each worker i with observed characteristics x_i is assigned an OOI defined as

$$OOI_i \;=\; -\int f_{Z|X}(z_j \mid x_i)\,\log\!\left(\frac{f_{Z|X}(z_j \mid x_i)}{g(z_j)}\right) dz_j, \tag{G1}$$

where z_j indexes observed job characteristics, $f_{Z|X}(z_j \mid x_i)$ is the conditional density of the job characteristics held by workers of type x_i, and $g(z_j)$ is the unconditional density of those characteristics across all jobs. This expression is (minus) the relative entropy of the type-x_i job distribution from the economy-wide job distribution. Higher (less negative) values of OOI_i indicate that workers of type x_i are distributed more like the economy-wide mix of jobs while lower (more negative) values reflect excess concentration of that worker type in particular job cells.

Because the integrand in Equation (G1) is additive over z_j, the OOI decomposes across any partition of the job-characteristic space. We exploit this property to separate the contributions of formal and informal jobs to a worker's relative labor market concentration. Letting $\mathcal{Z}_F$ and $\mathcal{Z}_I$ partition the job-characteristic space $\mathcal{Z}$ into formal and informal jobs, the OOI decomposes into:

$$OOI_i \;=\; OOI_i^F + OOI_i^I, \qquad OOI_i^F \;=\; -\int_{\mathcal{Z}_F} f_{Z|X}(z_j \mid x_i)\,\log\!\left(\frac{f_{Z|X}(z_j \mid x_i)}{g(z_j)}\right) dz_j, \tag{G2a}$$

with OOI_i^I defined analogously, and

$$\text{FormalShare}_i \;=\; \frac{OOI_i^F}{OOI_i} \;=\; \frac{\int_{\mathcal{Z}_F} f_{Z|X}(z_j \mid x_i)\,\log\big(f_{Z|X}(z_j \mid x_i)/g(z_j)\big)\,dz_j}{\int_{\mathcal{Z}} f_{Z|X}(z_j \mid x_i)\,\log\big(f_{Z|X}(z_j \mid x_i)/g(z_j)\big)\,dz_j}. \tag{G2b}$$

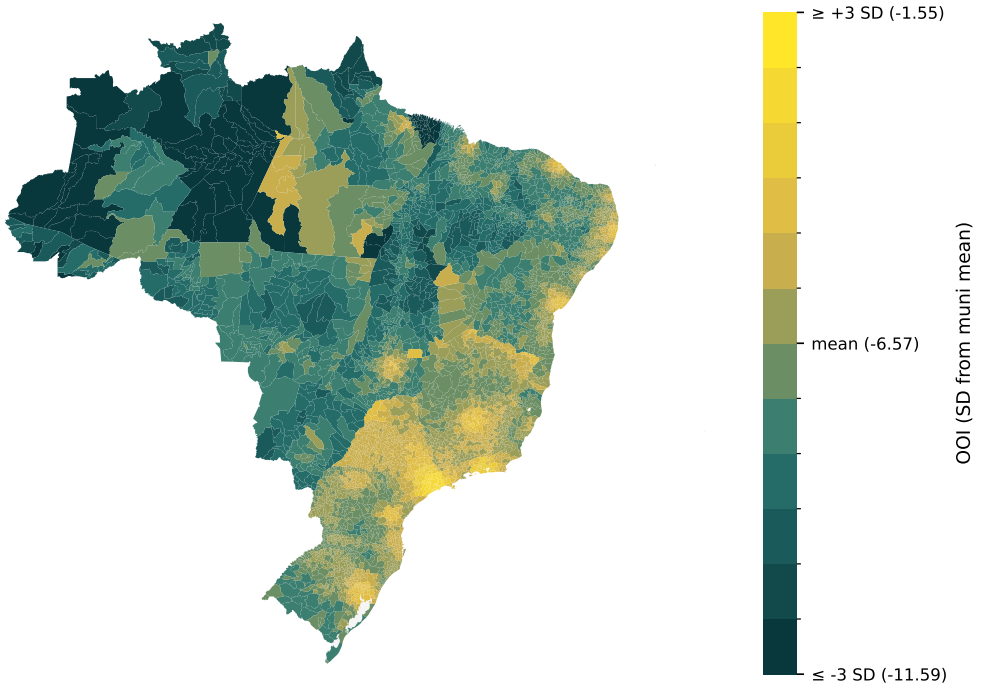
OOI_i^F captures the excess concentration of worker i in formal-sector jobs, and FormalShare_i is the share of a worker's labor market concentration attributable to the formal sector. FormalShare_i is bounded between zero and one.

We compute the OOI using the 2000 Census within our working sample of prime-age, private-sector workers. Worker types are defined by race, gender, age, education, and municipality of residence. Job types are defined by occupation, industry, formality, and municipality of work.

G.2 Empirical Properties of the Outside Options Index

Figure G1 maps the resulting OOI across Brazilian municipalities. Table G1 reports its population-weighted mean and the formal/informal components by gender, race, education tier, and municipality-size quintile. Total OOI is higher on average for men and for white workers, and rises with education; the decomposition reveals that the education gradient is driven by lower concentration in the informal sector, with a moderate countervailing increase in the formal sector.

Figure G1: OOI across Brazil



Source: 2000 Brazilian Census (IBGE).
Sample: Prime-age (25–54) private-sector workers.
Notes: Each municipality is shaded by the sample-weighted mean of the total OOI among its resident workers. Legend tick marks denote the across-municipality mean (-7.42) and ± 3 standard deviations; this mean differs from the worker-level mean in Table G1 because municipalities are equally weighted in the choropleth.

Table G1: Mean OOI components by worker characteristics

	OOI total	OOI(F)	OOI(I)	OOI(F)/OOI	N
All workers	-5.385	-2.196	-3.189	0.436	113,605,975
Sex					
Men	-5.370	-2.194	-3.176	0.437	68,783,155
Women	-5.408	-2.200	-3.208	0.434	44,822,819
Race					
White	-5.185	-2.280	-2.905	0.465	60,883,196
Non-white	-5.616	-2.100	-3.516	0.401	52,722,779
Education					
Less than high school	-6.090	-1.587	-4.503	0.281	39,623,500
Some or all high school	-5.168	-2.118	-3.050	0.426	34,187,652
At least some higher education	-4.869	-2.871	-1.998	0.598	39,794,823
Municipality-size quintile					
Q1 (smallest)	-6.727	-1.892	-4.835	0.303	18,560,361
Q2	-6.402	-2.202	-4.199	0.372	20,639,859
Q3	-5.403	-2.425	-2.978	0.478	23,606,343
Q4	-4.739	-2.247	-2.492	0.491	25,254,898
Q5 (largest)	-4.211	-2.152	-2.058	0.490	25,544,513

Source: 2000 Brazilian Census (IBGE).
Sample: Prime-age (25–54) private-sector workers.
Notes: The table reports the population-weighted mean of total OOI (OOI), its formal-sector component ($OOI(F)$), its informal-sector component ($OOI(I)$), and the formal share $OOI(F)/OOI$, by worker characteristics. N is the sum of population weights within each cell. Education tiers correspond to (i) less than high school, (ii) some or all of high school, and (iii) at least some higher education. Municipality-size quintiles are constructed on the sample-weighted population of the worker's municipality of residence, with breakpoints at populations of 15,668, 55,687, 193,779, and 876,897.

Table G2 reports the population-weighted mean OOI and its components by coarse industry and occupation categories. Within each block, rows are ordered from most concentrated (most negative OOI) to least concentrated.

G.3 Validation against Informal-to-Formal Transitions in the PME

Table G3 validates our measure using the Pesquisa Mensal de Emprego (PME), Brazil's monthly metropolitan labor force survey. We estimate the association between the OOI formal share and informal-to-formal transitions, both unconditional (Column 1) and conditional on having made a job-to-job transition (Column 2). Across both, a one-standard-deviation increase in the formal share of outside options raises the likelihood of transitioning from informal to formal employment by 40–66% of the baseline mean.

Table G2: Mean OOI components by industry and occupation

	OOI total	OOI(F)	OOI(I)	OOI(F)/OOI	N
Industry					
Agriculture, forestry & fishing	-7.862	-2.100	-5.762	0.236	11,620,175
Mining and extraction	-6.962	-3.130	-3.832	0.427	220,193
Private household services	-6.259	-2.317	-3.942	0.355	4,904,089
Teachers & Nurses	-6.128	-2.813	-3.316	0.454	1,652,614
Wholesale & retail trade	-5.801	-2.797	-3.004	0.465	9,144,689
Hotels and restaurants	-5.781	-2.551	-3.230	0.428	2,995,924
Construction	-5.742	-2.463	-3.279	0.421	4,336,920
Education, health & social work	-5.673	-2.858	-2.816	0.496	4,344,144
Entertainment & recreation	-5.559	-2.617	-2.942	0.459	5,597,998
Manufacturing	-5.472	-2.608	-2.864	0.475	8,318,989
Logistics	-5.325	-2.592	-2.733	0.485	795,636
Financial, business, & real estate	-5.140	-2.572	-2.568	0.491	5,833,149
Occupation					
Agriculture workers	-7.893	-2.068	-5.825	0.230	11,166,884
Retail service workers	-5.975	-2.775	-3.200	0.444	6,227,404
Service workers	-5.907	-2.373	-3.533	0.393	12,191,340
Manufacturing & construction	-5.754	-2.567	-3.187	0.438	15,466,751
Managerial	-5.417	-2.761	-2.656	0.504	2,615,217
Mid-level technicians	-5.406	-2.907	-2.499	0.527	4,124,892
Teachers & Nurses	-5.339	-3.111	-2.228	0.561	83,745
Scientific and artistic	-5.273	-2.792	-2.481	0.515	3,103,319
Administrative service workers	-5.197	-2.860	-2.337	0.540	4,784,967

Source: 2000 Brazilian Census (IBGE).
Sample: Prime-age (25–54) private-sector workers.
Notes: The table reports the population-weighted mean of total OOI (OOI), its formal-sector component ($OOI(F)$), its informal-sector component ($OOI(I)$), and the formal share $OOI(F)/OOI$, separately by 1-digit industry (CNAE) and 1-digit occupation (CBO-Dom). N is the sum of population weights within each row.

Table G3: PME Informal-to-Formal Transitions

	Share of informal transitions to formal	Any new formal job
Std. OOI(F)/OOI(All)	0.0716***	0.00406***
	(0.0206)	(0.000366)
N	5,479	290,116
Mean of DV	0.2229	0.0034

Source: PME 2002–2016 (IBGE); OOI from the 2000 Brazilian Census.
Sample: Adults aged 25–54, white or non-white, observed in PME's six metropolitan regions and informally employed (informal salaried) in month t.
Notes: The table reports linear-probability estimates of two month-over-month transition outcomes on the standardized formal share of outside options and the standardized total OOI. Column 1 reports estimates for the share of transitions out of informal salaried employment that lead to a formal job, conditional on having made a job-to-job transition or exited employment between month t and $t+1$; Column 2 reports estimates of indicator for holding a new formal job in $t+1$ given informal salaried employment in t, not conditioned on making any transition. Both OOI measures are merged from the 2000 Census at the level of detail offered by PME (state $\times$ race $\times$ sex $\times$ age $\times$ education $\times$ occupation $\times$ industry $\times$ formality status), and then standardized to unit variance on the analysis sample. All regressions include education fixed effects, race, sex, a quadratic in age, and occupation, industry, state, and year fixed effects. "Mean of DV" reports the mean of the dependent variable on the estimation sample. Standard errors clustered at the individual level are in parentheses.

Table G4: OOI and wage effects of the minimum wage on informal workers

	Baseline	+ OOI_{all}
Strongly treated	0.080***	0.054**
	(0.023)	(0.022)
$\times$ high share OOI_F	0.068***	0.046***
	(0.011)	(0.010)
$\times$ high OOI_{all}		0.043***
		(0.010)
Mean dep. var.	6.785	6.785
$\text{OOI}_{all} \times$ treat $\times$ post	No	Yes
Individual-level controls	Yes	Yes
N	1,302,500	1,302,500

Source: Census, 2000-2010. OOI constructed on Census 2000.
Sample: Full time private informal employees, age 25-54, white or non-white.
Notes: The table reports two estimates of our triple difference model. Column (1) replicates the specification shown in table 4 column (4) where the coefficient reports the triple interaction of our state-by-industry exposure variable, OOI_F, by the effect of having above the median share of a workers' outside options in the formal sector. Column (2) reports the same regression, but adding in a triple interaction between exposure, year, and overall outside options as constructed in Caldwell and Danieli (2024).

Appendix H Additional results on employment effects

Table H1: Mediators of own-wage reallocation elasticities out of the formal labor force, including non-employment

	(1) Enforcement	(2) Industry informality	(3) Share OOI_F	(4) Estab. LM concentration	(5) All mediators
Panel B. Working-age population					
Strongly treated × *Post*	-0.006	-0.003	-0.019***	-0.005	-0.014***
	(0.006)	(0.002)	(0.007)	(0.003)	(0.005)
× weaker enforcement	-0.016***				-0.008*
	(0.004)				(0.005)
× high-informality industry		0.003			-0.011
		(0.003)			(0.012)
× high share OOI_F			0.015***		0.010***
			(0.004)		(0.003)
× high estab. concentration				0.010***	0.003
				(0.003)	(0.006)
Mean dep. var.	0.284	0.118	0.303	0.118	0.308
N	14,443,958	34,326,721	11,761,774	34,326,721	11,276,881

Source: Census 2000-2010.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed; workers working either part-time or full-time and no missing monthly earnings variable, no missing experience variable; unemployed individuals and labor force non-participants.

Notes: The table shows the relationship between our four wage effect mediators and formal employment vs. other forms of employment or non-employment. The first four columns report each effect separately, the final column reports the effect of all four in a single regression, as in Table 4.

Table H2: Percent change in the share of employees among the total private workforce, by employment category, 2009

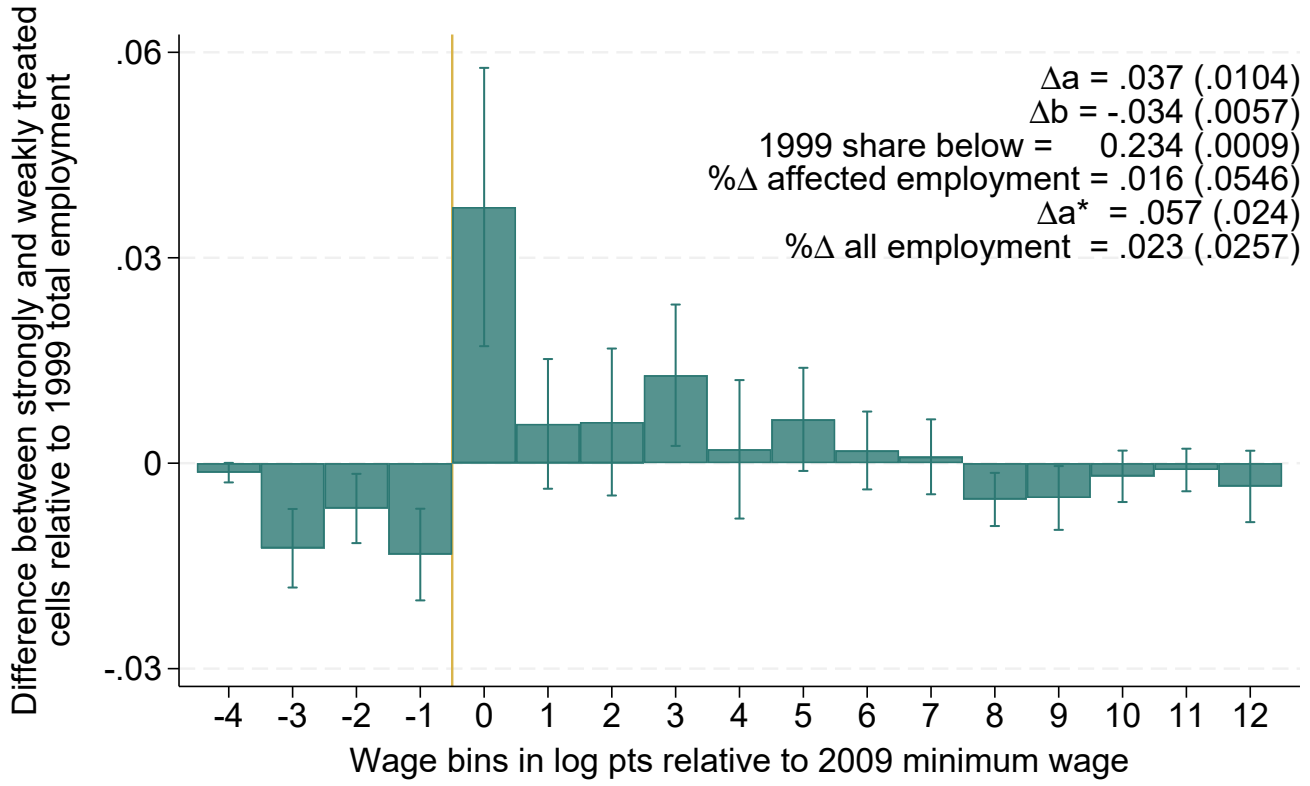
	%Δ emp.
Formal employees	-0.033**
	(0.016)
	1,851,404
Informal employees	
Low-informality industries	0.045*
	(0.027)
	1,851,404
High-informality industries	-0.024
	(0.048)
	1,851,404
Self-employed	-0.046**
	(0.022)
	1,650,515

Source: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed; workers working either part-time or full-time and no missing monthly earnings variable, no missing experience variable.

Notes: The table shows the percent change in the share of formal employees (respectively informal employees and self-employed) among the total private workforce as estimated using equation 4 in Section 7.1 separately for each category of worker. A one standard deviation in the share of affected workers as defined in our treatment variable is associated with a 3.3% decline in the share of formal employees in the private workforce.

Figure H1: Effect of the minimum wage on total share of formal employment, 2009 – without Northeast



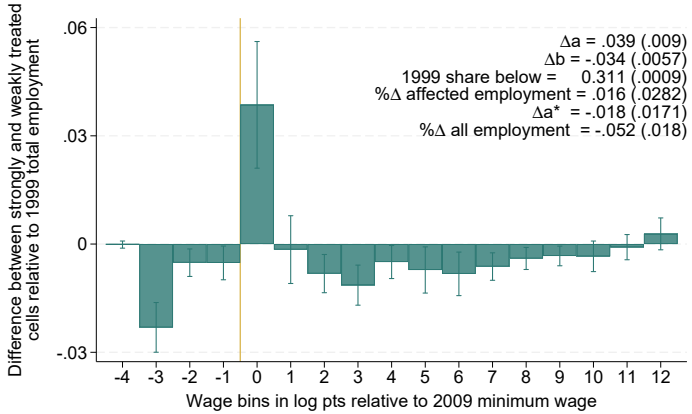
Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, with no missing monthly earnings variable, and with no missing experience variable. Excludes adults from Northeast.

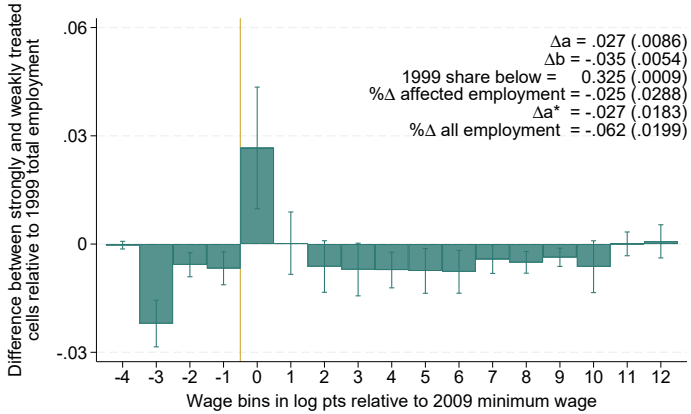
Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of jobs (see Equation 3 in Section 7.1). The outcome variable is the number of formal employees in each state-by-industry-by wage bin in 2009 over the total number of workers in 1999 in that state-by-industry cell, across all sectors of employment (formal or informal employees, or self-employed). The figure documents the effect of the 2000-2009 increases on the reallocation of employment away from formal employment.

Figure H2: Effect of the minimum wage on total share of formal employment, 2009 – excluding one region

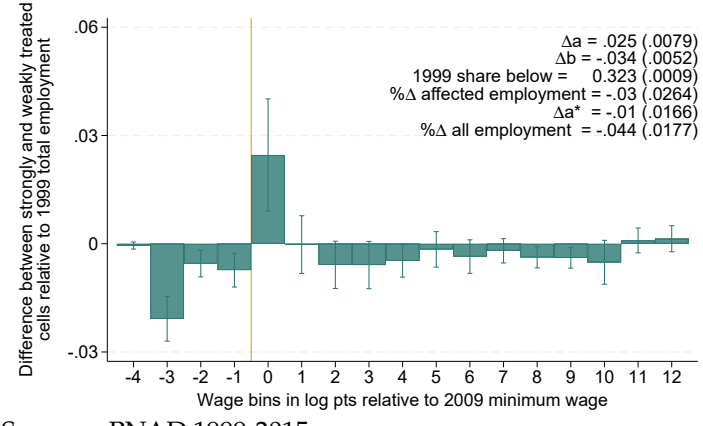
(a) Without North



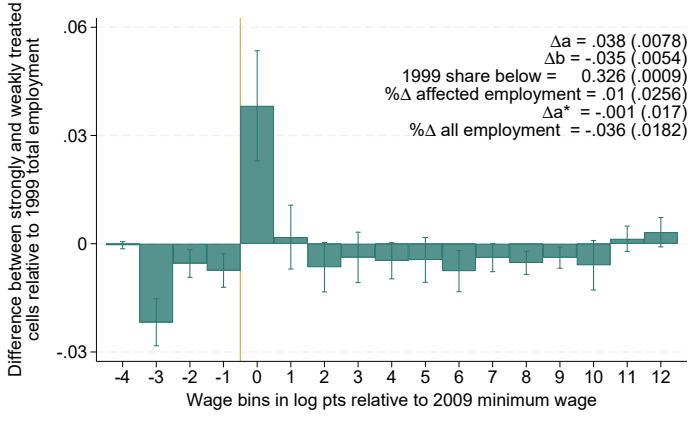
(b) Without Southeast



(c) Without South



(d) Without Central-West

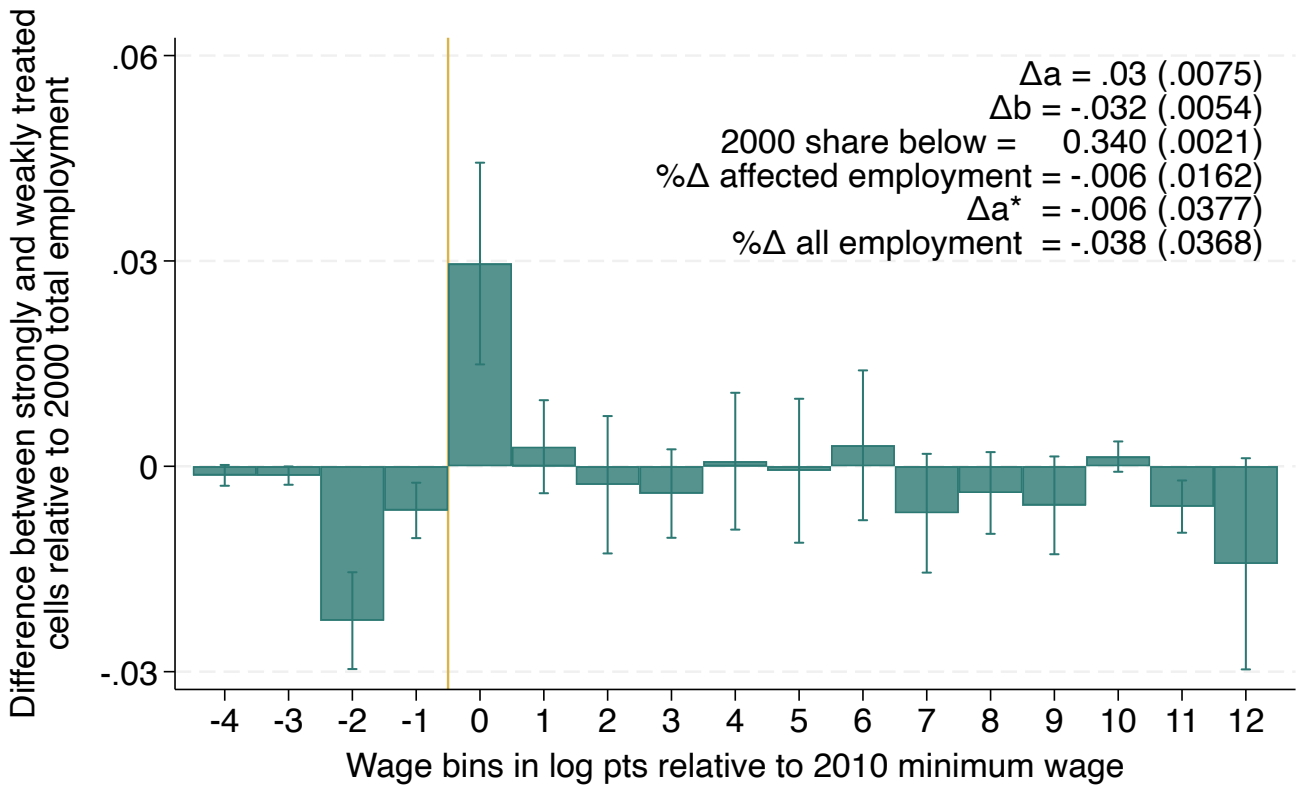


Sources: PNAD 1999-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, with no missing monthly earnings variable, and with no missing experience variable. Excluding adults from the region mentioned in the caption of each subfigure.

Notes: The figure shows the main results from our bunching difference-in-differences design assessing the effect of the 2000-2009 minimum wage increases on the distribution of jobs (see Equation 3 in Section 7.1). The outcome variable is the number of formal employees in each state-by-industry-by wage bin in 2009 over the total number of workers in 1999 in that state-by-industry cell, across all sectors of employment (formal or informal employees, or self-employed). The figure documents the effect of the 2000-2009 increases on the reallocation of employment away from formal employment.

Figure H3: Effect of the minimum wage on total share of formal employment in 2010, using census data

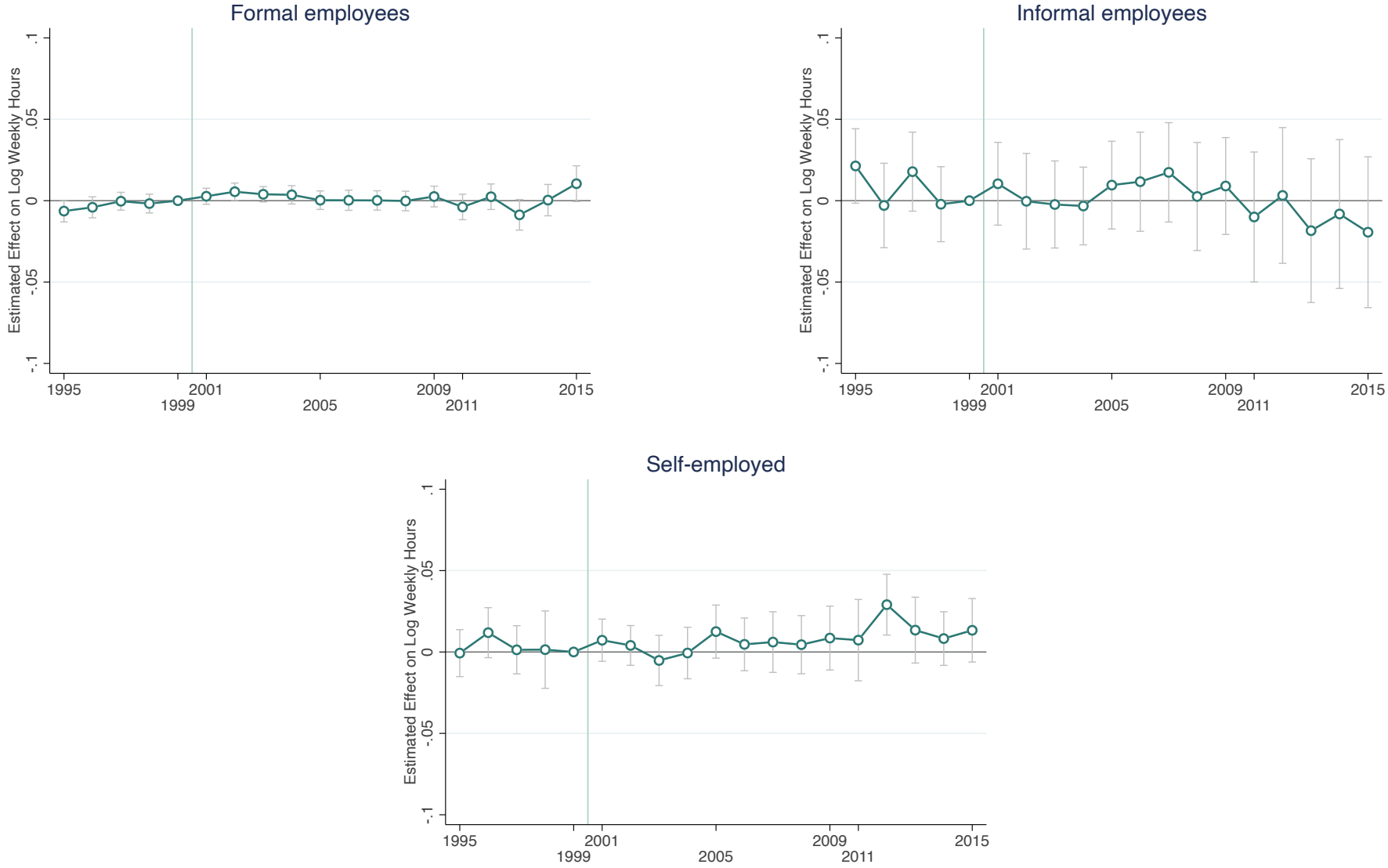


Sources: Census 2000-2010.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure shows results from our bunching difference-in-differences design assessing the effect of the 2010 minimum wage increase on the distribution of jobs (see Equation 3 in Section 7.1) with region-by-year fixed effects. The outcome variable is the number of formal employees in each state-by-industry-by-wage bin in 2010 over the total number of workers in 2000 in that state-by-industry cell. The figure documents the effect of the 2010 increase on the reallocation of employment across the formal wage distribution while controlling for potential confounding regional shocks.

Figure H4: Effect of the minimum wage on the log of weekly hours



Source: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed, with no missing monthly earnings variable, and with no missing experience variable.

Notes: The figure plots the coefficient of main interest for each year from 1995-2015 using our baseline specification from Equation 1 in Section 4.1, except that the outcome is log weekly hours (bottom and top winsorized at the 1.5% level).

Table H3: Weekly hours elasticities, 2009

	%Δ hours	%Δ wage	Hours elasticity
Formal employees	0.003	0.128***	0.020
	(0.003)	(0.011)	(0.025)
Informal employees	0.009	0.119***	0.076
	(0.015)	(0.019)	(0.125)
Self-employed	0.009	-0.017	-0.506
	(0.010)	(0.022)	(0.813)

Source: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed, with no missing monthly earnings variable, and with no missing experience variable.

Notes: The table shows in column (1) the main results from our baseline specification from Equation 1 in Section 4.1, except that the outcome is log weekly hours (bottom and top winsorized at the 1.5% level). We show in Appendix Figure H4 that there are no pre-trends in the pre-period, and that the effects on weekly hours are centered around zero from 1999-2009 for all types of workers.

Table H4: Own-wage reallocation elasticities out of the formal labor force, by year (2001-2015)

	%Δ emp.	%Δ wage	Reallocation elast.
2001	-0.000	0.037***	-0.008
	(0.009)	(0.007)	(0.256)
2002	-0.005	0.044***	-0.123
	(0.009)	(0.006)	(0.216)
2003	-0.007	0.060***	-0.122
	(0.010)	(0.005)	(0.162)
2004	-0.015	0.073***	-0.212
	(0.011)	(0.007)	(0.148)
2005	-0.020*	0.086***	-0.238*
	(0.011)	(0.008)	(0.136)
2006	-0.028**	0.105***	-0.265**
	(0.012)	(0.009)	(0.121)
2007	-0.022	0.105***	-0.214
	(0.014)	(0.010)	(0.145)
2008	-0.035**	0.109***	-0.317**
	(0.015)	(0.011)	(0.155)
2009	-0.036**	0.128***	-0.282**
	(0.015)	(0.011)	(0.123)
2011	-0.037**	0.108***	-0.340*
	(0.018)	(0.013)	(0.183)
2012	-0.031	0.120***	-0.258
	(0.021)	(0.015)	(0.181)
2013	-0.044**	0.117***	-0.379**
	(0.020)	(0.014)	(0.193)
2014	-0.029	0.112***	-0.256
	(0.021)	(0.015)	(0.200)
2015	-0.038*	0.112***	-0.341*
	(0.021)	(0.015)	(0.205)

Source: PNAD 1995-2015.

Sample: Adults aged 25-54, white or non-white, employed in the private sector, either formal employee, informal employee or self-employed; workers working either part-time or full-time and no missing monthly earnings variable, no missing experience variable.

Notes: The table shows yearly results from our estimation of the linear probability model version of the total reallocation effect in PNAD (see panel A, columns 1-3, and notes for Table 5)).

Appendix I Implications for models of informality and wage determination

I.1 Comparing recent calibrated model counterfactuals to our empirical estimates

Two recent papers, Haanwinckel and Soares (2021) and Machado Parente et al. (2025), provide structural estimates isolating the effect of minimum wage increases on various moments of the Brazilian economy. We use the estimates from these models to calculate statistics that can be compared to our empirical results on the effect of the minimum wage on informal wages and the percent of formal workers reallocated out of formal employment.

Using either the moments generated by the replication files (in the case of Haanwinckel and Soares (2021)) or based on the moments published in the paper (Machado Parente et al. (2025)), we calculate the implied informal wage increase and the implied reallocation from formal to informal employment (and from formal to informal employment or unemployment/nonemployment).

Calculations from Haanwinckel and Soares (2021) Haanwinckel and Soares (2021) provided replication code for their model of informality. To extract our statistics of interest, we first follow their methodology to load in baseline model estimates and counterfactual estimates of a 61.2% minimum wage increase. These estimates include statistics such as formality rates, mean wages (by formality status), and unemployment. They are also initially grouped by regions within Brazil and further stratified into "skilled" and "unskilled" categories. We follow Haanwinckel and Soares (2021) methodology to aggregate these estimates to the national level.

This is done by first pooling the unskilled and skilled statistics together, using within-region skill weights. This produces a pooled statistic for each region. To aggregate the region statistics to the national level, each region-level statistic is weighted by the relative size of the region, following the approach in Haanwinckel and Soares (2021). The national-level statistics yielded a mean formal wage increase of 16.84%, a mean informal wage decrease of 17.92%, a formal reallocation of 13.09% to informality, and a formal reallocation of 6.62% to unemployment. To rescale these computed statistics to be in terms of a 10% increase in mean formal wages, we multiply each value by $\frac{10}{16.84}$. The scaled mean informal wage decrease becomes 10.6%, the formal reallocation to informality becomes 7.8%, and the formal reallocation to unemployment becomes 3.9%. Thus, the total percent of formal workers

reallocated to either informality or unemployment is 11.7% for a 10% increase in mean formal wages.

Calculations from Machado Parente et al. (2025) Machado Parente et al. (2025) include two models of informality in their paper. The primary model includes an informal margin of adjustment, whereas the secondary model includes both an informal and unemployment margin of adjustment. Both models report three key statistics which aid our calculations: the formal wage premium ($\frac{\text{mean formal earnings}}{\text{mean informal earnings}}$), the ratio of minimum to mean formal wages, and the informal share of labor. These statistics can be found in the counterfactual exercises of the 2024 working paper version of Machado Parente et al. (2025) (Machado Parente, 2024), which are omitted from the 2025 version. We use statistics from the 2024 working paper version for this reason. The 2025 version has an updated calibration scheme which targets different moments in the Brazilian microdata. Our approach will likely still give qualitatively similar results to that of the 2025 version, as the underlying model is the same. Furthermore, we assume that "wage" and "earnings" are identical, given that in the model, labor supply is inelastic, and each worker supplies one unit of time regardless of sector or firm. Consequently, there's no intensive margin of adjustment that could differentiate earnings and wages. Thus, we refer to any use of "earnings" as "wages".

We start with the primary model. Machado Parente et al. (2025) simulate a minimum wage increase from 1996 to a counterfactual with only the minimum wage parameter altered. The model-calibrated log minimum wage is 4.04 and the counterfactual minimum wage is 6.6, so the implied minimum wage increase is 63.37%. To find the formal wage increase, we utilize the minimum to mean formal wage ratio, which is 0.26 in 1996 and 0.33 in the counterfactual. We thus have the following relations:

$$0.26 = \frac{4.04}{\text{1996 mean formal wage}}, \quad 0.33 = \frac{6.6}{\text{CF mean formal wage}},$$

which both rearrange to:

$$\text{1996 mean formal wage} = \frac{4.04}{0.26} = 15.54, \quad \text{CF mean formal wage} = \frac{6.6}{0.33} = 20.$$

The implied percent increase is then:

$$\text{formal wage increase} = \frac{20 - 15.54}{15.54} \cdot 100 = 28.7\%.$$

To find the informal wage increase, we use the previous results along with the formal wage premium statistic, which is 2.11 in 1996 and 1.70 in the counterfactual. By the definition

of the formal wage premium:

$$2.11 = \frac{\text{1996 mean formal wage}}{\text{1996 mean informal wage}}, \quad 1.70 = \frac{\text{CF mean formal wage}}{\text{CF mean informal wage}}.$$

Next, the formal wage increase implies:

$$\text{CF mean formal wage} = (1.287)(\text{1996 mean formal wage}).$$

Additionally, let CF mean informal wage $= (1+r)$(1996 mean informal wage), where r is the rate of increase. Upon substitution, we obtain the following equation:

$$1.70 = \frac{(1.287)\text{1996 mean formal wage}}{(1+r)\text{1996 mean informal wage}},$$

which implies:

$$\frac{1.70(1+r)}{1.287} = \frac{\text{1996 mean formal wage}}{\text{1996 mean informal wage}} = 2.11.$$

Solving for the rate of increase yields:

$$r = \frac{2.11 \cdot 1.287}{1.70} - 1 = 0.598.$$

Therefore, the informal wage percent increase is 59.8%.

To find the formal reallocation, we use the informal share statistic, which is 0.39 in 1996 and 0.73 in the counterfactual. Accordingly, the 1996 and counterfactual formal shares are 0.61 and 0.27, respectively. Computing the percent decrease in formal share between the two periods yields:

$$\text{formal reallocation} = \left|\frac{0.27 - 0.61}{0.61}\right| \cdot 100 = 55.75\%.$$

Notably, this does not consider the unemployment margin of adjustment.

To find the formal reallocation that includes the unemployment margin of adjustment, we turn to the appendix extension of the model, which simulates a 120% minimum wage increase and reports the actual and simulated unemployment rate of 0.065 and 0.071, respectively. When taking the unemployment rate into account, we assume that the total population remains fixed between 1996 and the counterfactual. This model also has different values for the informal share of labor, which is 0.39 in 1996 and 0.871 in the counterfactual. Equivalently, the 1996 and counterfactual formal shares of labor are 0.61 and 0.129, respectively. Since the unemployment rates are 0.065 and 0.071, the employment rates are 0.935 for 1996 and 0.929 for the counterfactual. Multiplying these rates by the formal shares of labor yields the share of formal workers:

$$\text{1996 formal worker share} = 0.935 \cdot 0.61 = 0.57, \quad \text{CF formal worker share} = 0.929 \cdot 0.129 = 0.12.$$

The implied percent change then yields the formal reallocation percentage:

$$\text{formal reallocation (with unemployment margin)} = \left|\frac{0.12 - 0.57}{0.57}\right| = 78.99\%.$$

Because this result is from the appendix extension of the model, we cannot directly use it alongside the primary model calculations. Instead, we use the result to calculate a simulated statistic of formal reallocation with the unemployment margin for the main model. We do this by considering the ratio of formal reallocation with the unemployment margin to formal reallocation without the unemployment margin. To obtain the measure of formal reallocation without the unemployment margin, we neglect unemployment and only consider the formal shares of labor. So, since the 1996 and counterfactual formal shares are 0.61 and 0.129, solving for the percent change yields:

$$\text{formal reallocation (no unemployment margin)} = \left|\frac{0.129 - 0.61}{0.61}\right| \cdot 100 = 78.85\%.$$

Multiplying the main model's formal reallocation of 55.75% (which does not consider unemployment by construction) by this extended model's reallocation ratio produces a simulated reallocation value if the model had included the unemployment margin of adjustment:

$$\text{formal reallocation (simulated unemployment margin)} = 55.75 \cdot \frac{78.99}{78.85} = 55.84\%.$$

Lastly, we rescale all the computed statistics for the primary model to be in terms of a 10% increase in mean formal wages. In other words, we multiply each value by $\frac{10}{28.72}$. Thus, in terms of a 10% increase in formal wages, informal wages increase by 20.81%, the formal reallocation to informality is 19.41%, and the simulated formal reallocation to informality and unemployment is 19.45%.

I.2 Three views of labor markets with informality

Over the last decade or so, the literature on labor market informality in Brazil has shifted away from the traditional view that labor markets with informality can be well characterized by perfect competition and complete segmentation. Ulyssea (2018) offers a model with perfectly competitive labor markets where firms offer both types of contracts—formal and informal—to workers. The model helps explain observed "gradients" of informality in the labor market, where informal workers work at registered, and thus "formal," firms. The model also helps explain the lack of a conditional wage gap between formal and informal workers within firms. Meghir et al. (2015) develop a model with on-the-job search, where workers search in either sector, thus helping to explain the large overlap in productivity between formal and informal workers. However, neither paper evaluates how a minimum wage might affect informal workers' wages or the share of formal employment.

Two recent studies directly evaluate the impact of the minimum wage on the wage structure and formality using structural models of the Brazilian labor market. Haanwinckel (2024) provides a search model where workers search in either sector from unemployment, and wages are determined via Nash bargaining. Machado Parente et al. (2025) uses a static monopsony model with homogeneous workers and firms that vary by productivity. Both models incorporate search frictions and both are integrated in the sense that informality is an endogenous choice on the part of workers or firms, respectively. Nevertheless, each model's predictions on the effect of minimum wages on the informal sector can be summarized by more simplified frameworks presented in Sections I.2.1 and I.2.2.

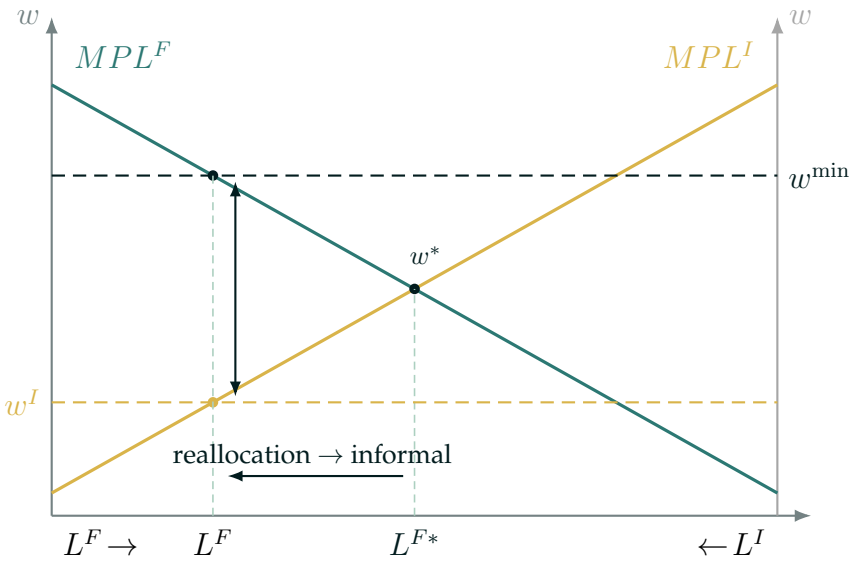
As an alternative that can capture our empirical finding of a positive wage effect on informal workers and limited reallocation, we present a simple framework in I.2.3. As a frictional model with formal jobs forming a real outside option for informal workers, the model is similar in spirit to Meghir et al. (2015) though we model this through a static framework here.

I.2.1 Competitive, segmented: minimum wage decreases informal wage by increasing informal supply

In the classic dual sector view of labor markets with informality represented below, a minimum wage set above the competitive wage (w^* that makes workers indifferent between the two sectors) reduces formal labor demand. Formal labor falls from L^{F*} to L^F, reallocating those workers to the informal sector. The increase in the number of informal workers drives

the informal wage down to w^I while the formal wage cannot fall below $w^{\min}$.

Figure I1: Segmented and competitive labor market model of informality



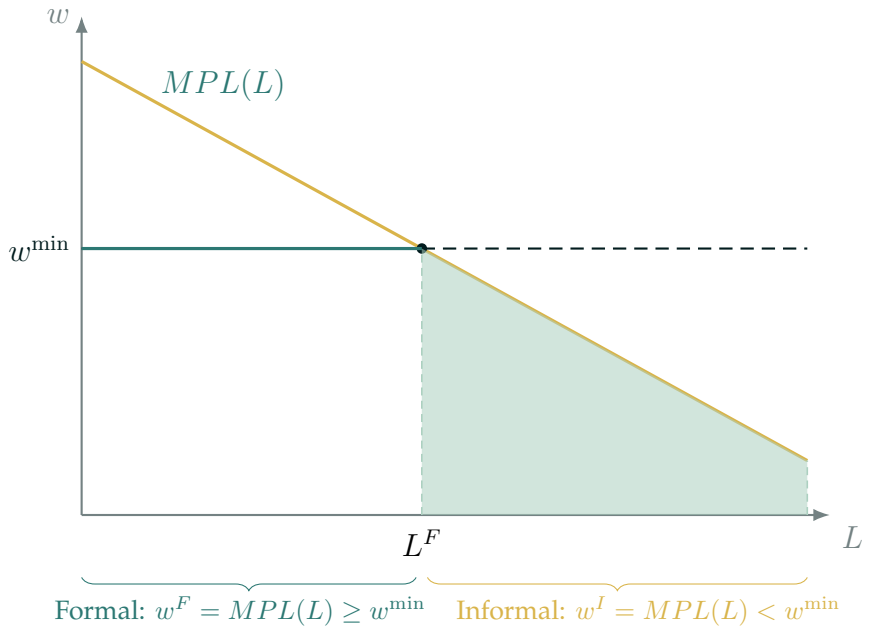
Notes: The figure illustrates Case 1, with the formal and informal demand curves drawn back-to-back. Formal employment is measured from the left origin and informal employment from the right. The sectors have separate technologies and clear competitively, so absent a floor they meet at L^{F*} with common wage w^*. A binding floor $w^{\min} > w^*$ sets formal employment where $MPL^F = w^{\min}$; the displaced $\Delta L^F = L^{F*} - L^F$ workers crowd into the informal sector and push its wage down to $w^I < w^*$.

I.2.2 Competitive, integrated: minimum wage changes informal wage through composition

In a model where workers are homogeneous, but firms vary by productivity such that the minimum wage makes it unprofitable for some of them to operate formally (as in Machado Parente et al. (2025)), increases in the minimum wage will result in the reallocation from the bottom of the formal firm productivity distribution to the informal sector. These firms fall at the top of the informal sector firm productivity distribution, thus bringing average wages up in this sector.

This mechanism can be illustrated by a simple competitive, integrated model like the one below. Workers are homogeneous, but their marginal productivity depends on their firm, and the minimum wage ($w^{\min}$) determines the threshold between the formal and informal sectors (firms where marginal productivity falls below the minimum wage operate informally). As the minimum wage moves up, the average informal wage ($\bar{w}^I = \frac{1}{L^I}\int_{L^F}^{L^F+L^I} MPL(L)$) increases.

Figure I2: Integrated and competitive labor market model of informality



Notes: The figure illustrates Case 2, in which the two sectors share a single demand curve $MPL(L)$. Workers whose marginal product exceeds the floor are employed formally; the remainder work informally. A higher $w^{\min}$ shifts the cutoff point L^F to the left, so the newly reallocated informal workers enter just below the old floor and above the pre-existing informal average: the average informal wage rises through composition alone.

I.2.3 Frictional and integrated: the minimum wage raises informal wages through the distribution of formal outside options

Suppose instead that the informal sector is monopsonistic, and formal jobs constitute real outside options for informal workers. Informal workers accept an informal wage offer only if it exceeds their formal outside option:

$$w_i^I \geq b_i = p^F \cdot w_i^F,$$

where p^F is the probability of a formal job offer, and w_i^F is the worker i's expected wage in the formal sector.[15]

We illustrate this case in a simplified manner in Appendix Figure I3. MPL^F traces out the distribution of marginal products across formal jobs. Let $F(\cdot)$ denote the c.d.f. of formal marginal products among the $\bar{L}$ workers in the market and $G(\cdot)$ the c.d.f. of their formal outside options. Formal labor demand counts the jobs whose marginal product covers the wage,

$$L^F(w) \;=\; \bar{L}\left[1 - F(w)\right], \qquad \varepsilon^F \;\equiv\; -\frac{\partial \ln L^F}{\partial \ln w}, \tag{I3}$$

[15]Implicitly, the value of not receiving a formal job offer is zero ($(1-p^F)\cdot b_0$ where $b_0 = 0$).

with ε^F being the elasticity of formal labor demand. Informal labor supply counts the workers whose outside option falls short of the informal offer,

$$S^I(w) \;=\; \bar{L}\, G(w). \tag{I4}$$

Without a minimum wage, let $p^F = 1$ (formal jobs are not rationed), so a worker's outside option is simply her own formal product. With $p^F = 1$ the two distributions coincide, $G \equiv F$, and informal labor supply and formal labor demand can be traced on one line read from opposite ends—the c.d.f. and its complement for a single distribution. This equivalence allows us to draw the two labor markets back-to-back, as in Case 1, with $MPL^F = S^I$, and informal and formal employment given as follows:

$$L^I = \bar{L}G(w) \text{ and } L^F = \bar{L}(1 - G(w)).$$

There is a single cutoff wage w_0 such that workers with $MPL^F > w_0$ are employed formally and workers with $MPL^F \leq w_0$ are employed informally, with w_0 being the marked-down wage at the cutoff in the informal sector.

Now suppose a minimum wage is imposed in the formal sector that compresses the distribution at the bottom of the formal sector, thus reducing dispersion in formal outside options.[16] This compression of the outside option distribution flattens the informal supply (and thus the marginal cost) curve, making labor supply to the informal sector more elastic.[17]

If the minimum wage destroys formal jobs, and formal labor falls to $L^{F'}$, following the formal labor demand curve, the probability of a formal offer falls to $p^F = L^{F'}/L^F$. If formal job loss is very large, even with $w^{\min} > w_0$, the net effect on the outside option could be negative due to the decline in p^F. In this case, informal wages fall and informal employment rises, following the informal demand curve. Thus, the framework nests the predictions of the segmented model presented in Case 1.

If, on the other hand, formal job destruction is not too large, the outside option improves ($b_i = p^F \cdot w_i^F > w_0$), the informal wage increases to w^I (where $w_0 < w^I < w^{\min}$), and the informal supply curve (and the marginal cost curve along with it) shifts up. With the

[16] A large body of empirical evidence, including ours, on the bunching at the minimum wage in Brazil in the formal sector is consistent with such compression.

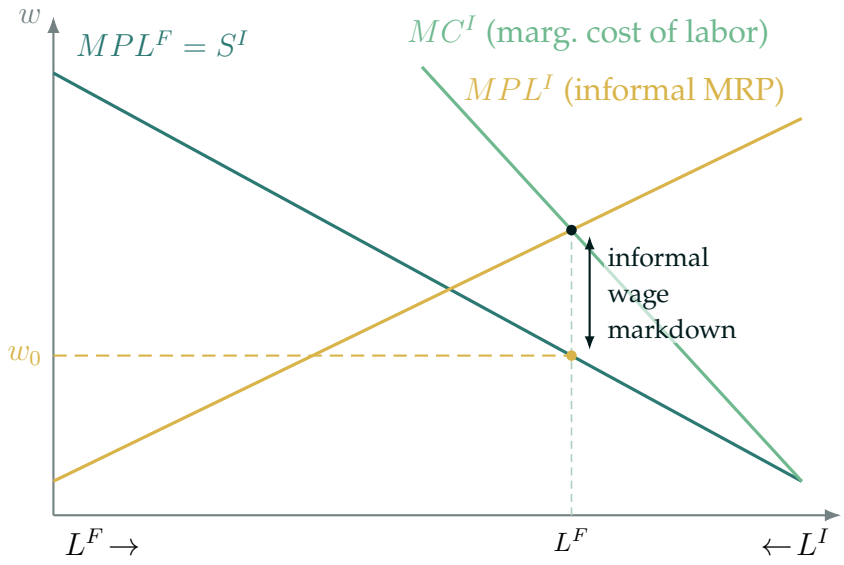
[17] The flattening of the informal supply curve can be microfounded using a monopsony framework adapted from Caldwell et al. (2026) and Card et al. (2018). Specifically, consider a shifted-power informal supply function: $S^I(w) = A\,(w - b)^e$, where b is the lowest formal outside option, e is the shape parameter, and A is a positive constant. The residual supply elasticity facing an informal employer is $\varepsilon^I = ew/(w - b)$, with e the inverse dispersion of outside options. Compressing the distribution raises e, flattening informal supply and shrinking the monopsony markdown $\varepsilon^I/(1 + \varepsilon^I)$.

increased wage, informal employment moves back down along the marginal revenue product of labor curve, thus dampening the employment response.

Our results are thus consistent with the minimum wage not only compressing the outside option distribution, but also shifting the distribution up such that informal workers' wages increase in response. This impact of the minimum wage on informal wages through the outside option channel is represented in Appendix Figure I4.

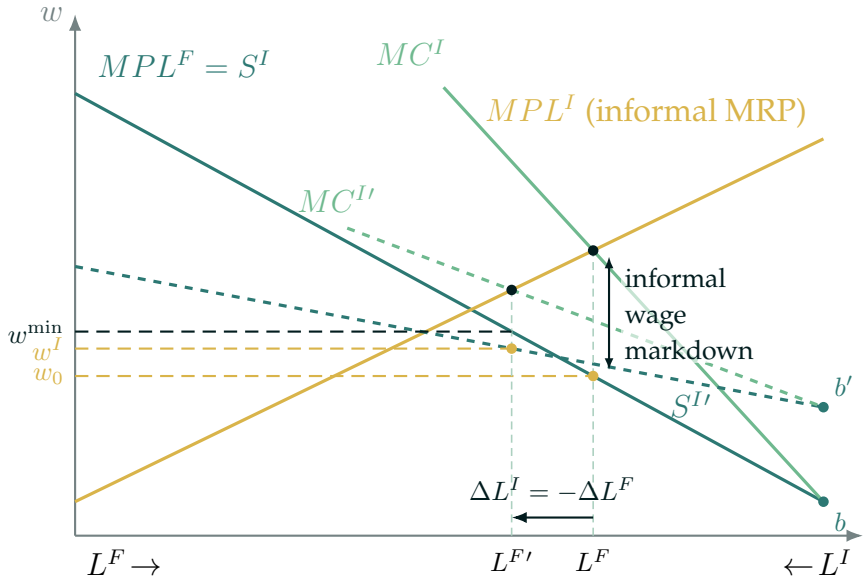
Finally, we note that the elasticity of formal labor demand determines whether the outside option for informal workers improves or declines (see Appendix Figure I5). With highly elastic formal labor demand, informal workers may not see wage gains from the minimum wage. With highly inelastic formal labor demand, the outside option on net improves and informal workers see higher wage gains.

Figure I3: Integrated and frictional labor market model of informality



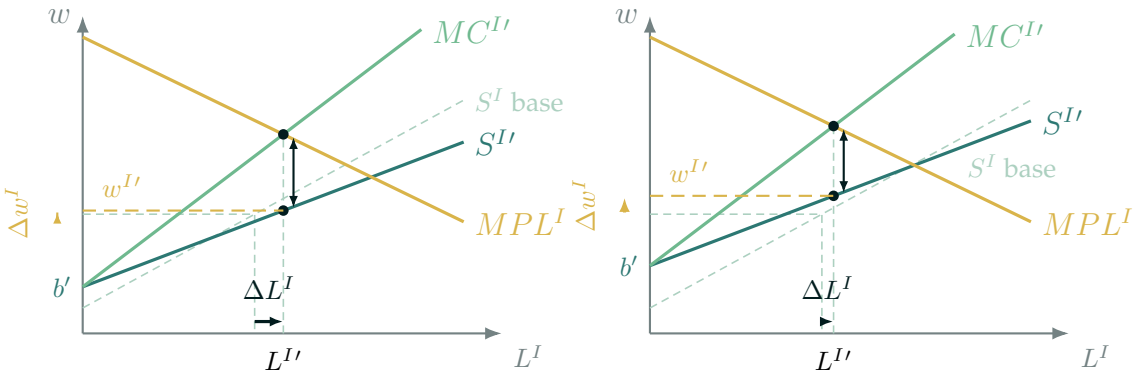
Notes: The figure shows the baseline (no minimum wage) equilibrium of Case 3, in the back-to-back format of Case 1. Every worker's outside option equals her own formal marginal product, so the distribution of formal products and the distribution of outside options coincide. The curve describing that common distribution can be read as formal labor demand from the left and informal labor supply $S^I = MPL^F$ from the right. The informal sector is a monopsonist, hiring where its marginal cost of labor meets the informal marginal revenue product MPL^I and paying a marked-down wage. The market splits at L^F with a cutoff wage equal to w_0.

Figure I4: Minimum wage in a frictional, integrated labor market



Notes: The figure shows the effect of a minimum wage imposed in the formal sector. After a minimum wage is introduced, the formal demand curve and informal supply curve separate. A binding minimum wage $w^{\min}$ in the formal sector leads to compression in the formal wage distribution and reduces formal employment to $L^{F\prime}$. The lower support of the formal outside option rises from b to b^{mw} (level) and the distribution also correspondingly compresses, so informal supply $S^{I\prime}$ and its marginal cost $MC^{I\prime}$ rotate flatter. The figure illustrates a case where the net outside option improves ($p^F \cdot w^{\min} > w_0$), shifting informal supply and marginal cost up. The new equilibrium reallocates labor toward the informal sector (L^I rises by $-\Delta L^F$) and raises the informal wage to $w^I > w_0$.

Figure I5: Elasticity of formal labor demand mediates minimum wage effect on informal sector



(a) Highly elastic formal labor demand

(b) Inelastic formal labor demand

Notes: The figure illustrates two responses of informal wages and employment to the minimum wage from the viewpoint of the informal sector (L^I reads in the standard left-to-right direction). Dashed lines reproduce the baseline supply S^I and wage w_0 from the previous figure; both panels can be read off the same informal demand MPL^I. The panels differ in the size of the level shift $b \to b^{\text{mw}}$, which is governed by the elasticity of formal labor demand ε^F to the minimum wage. In panel (a), formal labor demand is more elastic; job destruction limits the rise in b, MC^I falls, informal employment rises appreciably, and the informal wage rises only slightly. In panel (b), formal labor demand is more inelastic; job destruction is limited, so b rises substantially. MC^I still falls with the flattening of the supply curve, so informal employment still rises.