

Optimal Unemployment Insurance Financing: Theory and Evidence from Two US States*

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Abstract

Unemployment insurance provides crucial support for unemployed workers but comes with substantial costs. In this paper, I study the optimal approach to financing unemployment benefits, comparing two alternative approaches to assign unemployment tax rates to employers. While employers in the United States are assigned individualized tax rates based on the unemployment benefit spending resulting from their layoffs (experience rating), in all other countries, all employers are assigned the same tax rate irrespective of their individual contributions to unemployment (coinsurance). I derive a formula that defines the optimal financing policy through a tradeoff between the marginal benefit and two marginal costs of coinsurance. The marginal benefit refers to the value of insurance for employers, as coinsurance protects them against the risk of steep tax increases and further financial deterioration following a negative shock. The first marginal cost is a moral hazard from reducing the private cost of layoffs for employers, which imposes a fiscal externality on government budgets in the form of more frequent layoffs and increased spending on benefits. The second marginal cost emerges from the subsidization of high-unemployment risk industries and the resulting reallocation of labor towards these industries. This results in the misallocation of productive skills and generates a further fiscal externality in the form of increased spending on benefits as more workers are subject to a high risk of unemployment. I express the formula for the optimal policy in terms of estimable sufficient statistics for welfare. I then use unemployment tax filing data from two US states and quasi-experimental variation in unemployment taxes from state-level reforms of experience rating policies to estimate the cost of labor reallocation. My results suggest that labor reallocation, an overlooked channel in the literature, is the primary source of inefficiency from coinsurance. Additionally, my finding that the combined marginal cost of moral hazard and labor reallocation exceeds the marginal benefit of coinsurance suggests that, in these states, the current degree of experience rating may be suboptimal.

JEL Codes: D22, H21, H22, H23, H25, H32, H53, J65

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1 Introduction

Unemployment insurance is a fundamental welfare program that helps unemployed workers maintain their consumption levels following job losses. The provision of unemployment benefits, however, comes at a substantial cost, ranging from 0.12% to 2.8% of GDP in Western economies and fluctuating over economic cycles (OECD 2023). For perspective, the United States normally spends approximately 35 billion dollars annually on unemployment benefits, an amount representing 0.18% of its GDP and 0.6% of its total public spending. During the COVID-19 pandemic, unemployment insurance spending reached 160 billion dollars, or 0.8% of GDP and 1.8% of public spending. Since the effectiveness and sustainability of unemployment insurance depend on the ability of governments to secure resources and promptly allocate them to workers as needed, understanding how best to finance the program is of paramount importance.

Typically, unemployment benefits are funded through payroll taxes levied on employers and employees.¹ In this paper, I focus on employer-specific unemployment tax rates and compare the two prevailing approaches to assign these rates to employers. In the United States, employers are assigned personalized and dynamic tax rates, designed to reflect the costs of the unemployment benefits resulting from their layoffs. This financing method, known as “*experience rating*”, holds employers financially responsible for their layoffs. In Europe and Canada, conversely, employers are assigned the same unemployment tax rate regardless of their individual contributions to unemployment. This system, known as “*coinsurance*”, limits employers’ tax liabilities following negative shocks.

It remains unclear which of these two approaches is preferable. The literature highlights three key factors for this evaluation, two against and one in favor of coinsurance. First, coinsurance reduces the private cost of layoffs that employers internalize and, in turn, increases the frequency of layoffs.² The more frequent layoffs then impose a fiscal externality on government budgets in the form of increased spending on unemployment benefits, which must be funded with increased taxation (Fath et al. 2005). Second, coinsurance redistributes the cost of the unemployment benefits generated by employers in high-unemployment risk industries to the broader community of employers, thereby reducing labor costs in these industries and favoring their unwarranted expansion. The reallocation of workers towards high-risk industries results in the misallocation of productive skills and imposes a further fiscal externality in the form of a higher benefit spending since more workers are subject to a high risk of unemployment.³ Third, critics of experience rating argue that the imposition of higher unemployment tax rates on employers in economic distress may reduce their labor demand and, potentially, increase unemployment in the long run. This concern becomes particularly pronounced during recessions, when layoffs are widespread and higher unemployment taxes may slow down economic recovery,

¹In the United States, unemployment taxes are primarily levied on employers, with only three states levying taxes on employees as well. All other countries levy taxes on both employers and employees.

²Experience rating reduces layoffs (Feldstein 1976, Brechling 1977, Topel 1977, Topel 1983, Topel 1984, Kaiser 1986, Burgess et al. 1992, Anderson et al. 1994, Card et al. 1994, Blanchard et al. 2008) and stabilizes employment both within the year (Halpin 1979, Card et al. 1994, Anderson 1993, Katz et al. 1998) and over the business cycle (Kaiser 1986, Card et al. 1994, Duggan et al. 2022).

³Becker (1972), Munts et al. (1980), Mortensen (1983), Topel (1984), Anderson et al. (1993a), Anderson et al. (1993b), Laurence (1993), and Leombruni et al. (2003) show that high-unemployment risk industries systematically receive many more dollars in unemployment benefits than they pay in unemployment taxes, with low-unemployment risk industries covering the balance. Topel et al. (1980), Deere (1991), and Anderson et al. (1993a) further demonstrate that the subsidization of high-unemployment risk industries leads to their expansion and discuss the welfare implications of this labor reallocation.

thereby accentuating the business cycle.⁴ By contrast, uniform tax rates act as a safeguard for employers, insuring them against large tax increases and the further deterioration of their net worth following negative shocks.

Until now, these three factors—coinsurance reducing the private cost of layoffs, coinsurance redistributing the cost of the unemployment benefits from high-risk to low-risk industries, and the imposition of higher unemployment tax rates on employers in economic distress—have been studied separately, offering policymakers limited guidance when deciding between experience rating and coinsurance.⁵ In this study, I bring these factors together within a unified theoretical framework, recognize them as the central forces shaping the optimal design of unemployment insurance financing policies, and empirically investigate their relative importance in order to inform the policy debate.

I develop my analysis in three stages. In the first, I derive a formula for the optimal unemployment insurance financing scheme as a function of estimable sufficient statistics. I present a theoretical framework in which employers hire workers and exert costly effort to avoid negative shocks, the probability of which varies across industries. The government levies taxes on employers to fund unemployment benefits for the workers laid off after these shocks. The key choice of the government is the “degree” of experience rating of the unemployment insurance system that maximizes welfare. The degree of experience rating is the share of their benefit costs that employers repay in unemployment taxes, and it indicates the extent to which the financing of the program departs from pure coinsurance (in which all employers pay taxes equally) and from complete experience rating (in which each employer repays its full benefit costs). Consequently, the degree of experience rating does not affect total tax revenue, but, rather, influences the distribution of the tax burden between high- and low-unemployment risk industries.

The formula for the optimal degree of experience rating highlights the key tradeoffs between the sufficient statistics representing the marginal benefits and the marginal costs of coinsurance identified by the literature. On the one hand, decreasing the degree of experience rating insures employers against significant increases in their tax liabilities and further financial deterioration following a negative shock. The sufficient statistic representing the marginal value of this insurance is the loss associated with each dollar of tax increase, which includes factors such as elevated borrowing costs for employers facing economic hardship. This loss, equivalent to the marginal profit gap between the states of the world with and without shock, indicates employers’ willingness to pay for one dollar of insurance against such shock. On the other hand, decreasing the degree of experience rating introduces two costs. First, doing so transfers the financial burden of the unemployment benefits generated by high-unemployment risk industries to low-risk industries, thereby reducing the labor

⁴This theory, advanced in the work of Lester et al. (1939), Burdett et al. (1989), and Johnston (2021), finds further support in the literatures on the incidence of payroll taxes and adjustment costs.

⁵In a review of Becker (1972), one of the earliest studies contrasting experience rating and coinsurance, McCaffree (1975) comments that “*decision makers are not provided with a clear-cut basis for determining trade-offs and making relevant choices.*” Additionally, after establishing that experience rating reduces layoffs, Topel (1984) observes: “*It is tempting to conclude from these findings that subsidies to unemployment should be eliminated via complete experience rating of UI taxes. My analysis does not justify that conclusion, however, since very little is known about the optimal structure of the unemployment insurance financing system.*” Several decades later, this question remains underinvestigated. Guo et al. (2021) stress that “*if the benefits of experience rating are substantial, much of the world would benefit from clear evidence. If its costs outweigh, millions of workers in the U.S. could be spared the consequences*”, and that “*empirical and theoretical work to trace out the implications of these varied costs (...) would be helpful for assessing the tradeoffs of greater experience rating.*”

costs in high-risk industries and increasing their labor demand. The labor demand elasticity with respect to the unemployment tax per worker in high-risk industries is the sufficient statistic representing the marginal cost of this reallocation of labor towards high-risk industries. Intuitively, the more elastic are employers in these industries, the more workers will move into them as unemployment taxes decline. This labor reallocation is inefficient because it results in the misallocation of productive skills and imposes a fiscal externality on government budgets in the form of higher spending on benefits since more workers are exposed to a high risk of unemployment. Second, decreasing the degree of experience rating reduces the private cost of a layoff for employers, thereby leading to more frequent layoffs and imposing a further fiscal externality on government budgets in the form of increased spending on benefits. The sufficient statistic representing this employer moral hazard is the elasticity of layoffs with respect to the degree of experience rating. In summary, the formula for the optimal degree of experience rating compares the marginal benefit of providing insurance to *employers* and the marginal costs from labor reallocation and employer moral hazard. As it mirrors the formula for the optimal unemployment benefit level, comparing the marginal benefit and cost of providing insurance to *workers* (Baily 1978), it can be considered as an employer-Baily-type formula.

In the second part of the paper, I bring the theoretical framework to the data and quantify the cost associated with labor reallocation, which received limited attention compared to employer moral hazard in the existing literature. To estimate the labor demand elasticity with respect to the unemployment tax per worker for employers in high-risk industries, I use restricted unemployment tax filing data covering the universe of employers in South Carolina and Colorado and leverage the quasi-experimental variation in the tax per worker generated by state-level reforms of experience rating policies. My primary focus is on South Carolina, but I provide additional consistent evidence from Colorado. Like those in the rest of the country, employers in South Carolina are “experience-rated;” that is, their experience with unemployment is assessed each year, and higher tax rates are assigned to those with higher experience. In 2011, the state government changed the *measure* of employers’ experiences with unemployment used to assign tax rates, resulting in a sudden change in employers’ measured experiences with unemployment and unemployment tax rates. Before the reform, the tax rates were assigned based on employers’ *reserve ratios*. The reserve ratio is calculated as the normalized difference between the value of all of the unemployment benefits claimed by the workers whom an employer has laid off and the value of all of the unemployment tax payments that the employer has made since the date of establishment. This ratio thus measures the employer’s net position relative to the unemployment insurance system. Following the reform, the unemployment tax rates were determined based on employers’ *benefit ratios*, calculated as the normalized value of the benefits charged to an employer over the rolling seven-year look-back period preceding the calculation date. Consequently, the reform made the unemployment tax payments and the benefits charged to employers beyond this seven-year lookback period irrelevant to the assessment of employers’ experience.

Using a differences-in-differences approach, I compare employers with the same benefit ratios post-reform but different reserve ratios pre-reform. Because of their similar benefit ratios, these employers were on the same track during the seven-year lookback period used to calculate the benefit ratio, that is, the “*recent past*,” coinciding with the reform pre-period. Nevertheless, these employers had different unemployment tax rates

because of the different composition of their “*distant past*” reserves. As the benefit ratio replaced the reserve ratio, the unemployment tax rates were equalized, impacting these two groups differently. The employers with negative reserve ratios saw their tax rates increase because the reform “forgot” their historical tax payments. By contrast, the employers with positive reserve ratios experienced a decrease in their tax rates because the reform “forgot” their distant past benefit charges.

I find that, conditional on the benefit ratio, the reform increased the unemployment tax per worker of the negative reserve ratio employers by \$197 per year relative to the positive reserve ratio employers between 2011 and 2014 (equivalent to 144% of the level in 2010). Additionally, the negative reserve ratio employers reduced their workforce by 0.37-0.9 employees (5-11%), and total wages by \$19,000-43,000 (6-14%) per year. Since the average wage didn’t change, the reduction in total wages was entirely driven by the lower employment. The magnitude of the effect is consistent with the missing employees being average-wage employees. Because of the decline in employment, taxable wages and unemployment taxes grew by 20-80% less than they would have without employment responses. These effects are robust to several alternative specifications, including scaling outcomes by their pre-reform level, using alternative definitions of benefit ratio groups to guarantee the comparison of similar employers during the recent past, and using a continuous version of the treatment. Crucially for my ability to back up a labor demand elasticity, these effects are likely driven by fewer hirings since the reform occurred in the aftermath of the Great Recession, when most separations had already taken place.

These reduced form effects imply a full sample elasticity of labor demand with respect to unemployment taxes of -0.1. When I re-estimate the elasticities in the subsamples of employers in low- and high- unemployment risk industries, defined based on their employment standard deviation within the year, I find that the reduction in employment and wages is concentrated in the high-risk industries (high-standard deviation industries), despite the fact that employers in the low- and high-risk industries experience the same increase in the unemployment tax per worker. This result is robust to defining high-risk industries as industries with high average unemployment tax rate. Additionally, the effect is concentrated in high-unemployment tax rate industries even within high-standard deviation industries. This evidence suggests that the largest labor demand responses to unemployment taxes are observed in industries where layoffs result in unemployment benefit claims charged to employers (e.g., construction and food services) rather than in industries with high turnover but short unemployment spells (healthcare). These results imply a labor demand elasticity of -0.26 in high-employment standard deviation industries. This -0.26 is the estimated sufficient statistic representing the marginal cost of labor reallocation.

The analysis based on the Colorado data yields results consistent with those from South Carolina. I leverage the elimination of a surcharge as the source of variation in the unemployment tax per worker and I identify its causal effect on labor demand by comparing various cohorts of employers, only one of which benefitted from the elimination of the surcharge. Using a differences-in-differences approach, I find that the reform reduced the unemployment tax per worker by \$137 (16%) for affected employers, increased employment by 0.46-0.84 employees (3.7-6.7%), and increased wages by \$13,000 and \$23,000 (5.9-10.6%), with no effect on the average wage. These effects are, once again, driven primarily by the employers in the high-unemployment

risk industries.

In the final part of the paper, I use the estimated labor demand elasticity to evaluate the optimal degree of experience rating. Completing my formula with various moments in the unemployment tax filing data, the Quarterly Census of Employment and Wages, and the Employment and Training 394 Report data, I find that the marginal cost of labor reallocation is 2.93. This number indicates that, for every dollar of insurance offered to employers, \$2.93 is lost because of labor reallocation. I then calibrate the marginal cost of moral hazard using an estimate for the layoff elasticity from Topel (1984) and several moments from the data. The resulting marginal cost of 1.97 means that, for every dollar of insurance offered to employers, \$1.97 is lost because of employer moral hazard. The total marginal cost of insurance for employers, calculated by summing the costs from labor reallocation and employer moral hazard, is 4.9. Labor reallocation, accounting for 60% of the total cost, emerges as the primary driver of the inefficiency from incomplete experience rating in South Carolina. The result is robust to alternative estimates for the layoff elasticity and occurs because the fiscal externality associated with a marginal worker in a high-unemployment risk industry is greater than that associated with increased frequency of layoffs. Skill misallocation further increases the cost of labor reallocation. This finding is important both conceptually, given the limited attention that the inefficiencies from labor reallocation receive relative to those from employer moral hazard in the existing literature, and for its policy implications. Acknowledging the costs of labor reallocation implies recognizing the fact that coinsurance remains inefficient even in even those contexts in which employer moral hazard is limited. Such settings include European countries, where layoffs are limited by strong employment protection policies (Saez et al. 2023), and seasonal industries, compelled to downsize their workforces during the low season.

I then indirectly calibrate the marginal value of insurance using two alternative approaches. First, I assume that workers value their employers' survival because a shock to their employers could result in their unemployment. This allows me to calibrate the value of insurance for employers with the value of insurance for workers from the literature (Gruber 1997a, Hendren 2017 Landais et al. 2021). Second, I assume that the provision of insurance to employers that cannot optimally adjust following a shock is valuable in itself in the presence of liquidity constraints or wage rigidities. I thus calibrate the value of insurance for employers with the elasticity of employment with respect to the number of hours subsidized with short-time work for illiquid employers from Giupponi et al. (2022). The upper value for the marginal value of insurance of 3.13 indicates that employers are willing to pay up to \$3.13 to shift one dollar from the good to the bad state.

In summary, I find that the calibrated marginal value of insurance for employers is smaller than the combined marginal cost of labor reallocation and employer moral hazard. This observation suggests that in South Carolina employers were overinsured and the degree of experience rating was suboptimal. Increasing the degree of experience rating would not only enhance welfare but also reduce unemployment without sacrificing the generosity of unemployment benefits for workers. These conclusions, however, should be interpreted with caution. The current calibrations of the value of insurance for employers, based on estimates from other countries and historical periods, may not fully capture the magnified value of insurance for employers during the Great Recession. Therefore, refining the characterization of the value of insurance for employers and understanding its variations over economic cycles is essential before making definitive policy recommendations.

A potential metric for assessing the value of insurance for employers is an employer's share of temporary layoffs, serving as a proxy for an employer's forecast regarding the future of the business (Nekoei et al. 2020). Depending on the findings, the optimal policy may involve less experience rating during recessions and more experience rating during periods of economic stability, reflecting changes in the underlying value of insurance for employers.

This paper contributes to four strands of literature. First, within the literature on the optimal design of social insurance programs, it complements research on the optimal provision of unemployment benefits (Baily 1978, Kiley 2003, Shimer et al. 2007, Gruber 1997a, Chetty 2006, and J. F. Schmieder et al. 2016) by providing a framework for characterizing the optimal approach to funding the targeted benefit level. The optimal design of unemployment insurance taxes had previously been analyzed by Fath et al. (2005) and Blanchard et al. (2008), respectively contending that experience rating eliminates fiscal externalities and achieves productive efficiency by minimizing layoffs. Blanchard et al. (2008) further acknowledges the existence of a tradeoff between the goals of reducing layoffs and of limiting tax payments following layoffs for “risk-averse” or liquidity-constrained firms. I build on this research by formalizing in a unified sufficient statistics framework the joint contribution of employer moral hazard, labor reallocation, and the value of insurance for employers to the determination of the optimal policy, and by providing its first empirical assessment. Additionally, while numerous studies have estimated the costs of moral hazard, the only estimate of the costs of labor reallocation is that by Anderson et al. (1993a). My estimate differs from that estimate in two ways. First, my model suggests that the relevant parameter to estimate is the labor demand elasticity for employers in high-unemployment risk industries. My finding of heterogeneous labor demand elasticities by unemployment risk suggests that generic labor demand elasticities underestimate the cost of labor reallocation. Additionally, my estimates capture both the fiscal externality and the skill misallocation induced by labor reallocation.

Second, this paper contributes to the literature on experience rating. Most studies focus on the effect of the presence of minimum and maximum tax rates on the degree of experience rating in a state. I highlight here a critical but underexplored policy parameter: the measure of “experience with unemployment” used for tax rate assignments. Twenty-eight US states employ the reserve ratio, and nineteen employ the benefit ratio, with infrequent transitions between the two. South Carolina’s shift from a reserve ratio to a benefit ratio system offers, along with access to new data on employers’ unemployment insurance accounts, a unique opportunity to evaluate this policy and shed light on the different distribution of the tax burden among employers under the two systems. This analysis complements existing studies of the velocity of tax collection (Lachowska et al. 2020) and employers’ incentives (Miller et al. 2019) implied by the two measures. Moreover, the policy change represents a novel source of variation in labor costs and has many potential applications within the field.

Third, this paper contributes to the literature on the incidence of payroll and other employment taxes. While earlier studies found at least partial pass-through of payroll taxes on employers through reduced wages (Gruber 1997b, Anderson et al. 1997, Anderson et al. 2000), recent research supports the notion that the incidence of payroll taxes is on employers, with impacts on employment (Behaghel et al. 2008, Saez et al. 2019, Benzarti et al. 2021a, Benzarti et al. 2021b, Johnston 2021, and Guo 2023) and location decisions (Guo 2021). The same conclusions have been drawn based on analyses of other business taxes, such as corporate taxes and

depreciation bonuses (Suárez Serrato et al. 2016, Mark et al. 2021). The findings presented here are consistent with this recent strand of this literature, demonstrating that employers are unable to shift the burden of payroll taxes onto their employees, and shed light on potential explanations. Due to their limited influence in the United States, labor unions are unlikely the cause of wage rigidities. The finding that the missing employees earn average wages suggests that minimum wages are not driving these patterns either. Consequently, the present study provides additional support for the hypothesis that the variability of unemployment taxes across employers and over time limits employers' ability to pay significantly higher or lower wages in competitive markets (Lester 1960, Brechling 1977, Anderson et al. 1997). This paper also contributes to this literature by showing that employers' responses to unemployment taxes vary with the unemployment risk in their industries. In high-risk industries, where turnover is common and employers may have greater familiarity with the unemployment insurance system because of the higher taxes, it may be easier to adapt to a new tax environment than is the case in low-risk industries. The stronger impact observed for employers in high-tax rate industries compared to low-tax rate industries with the same standard deviation of employment within the year suggests that familiarity with the unemployment insurance system may play a more significant role in driving adjustments than merely experiencing high turnover.

Lastly, this paper contributes to the literature on adjustment costs. While Bentolila et al. (1990) argue that these costs do not have significant effects on hiring decisions, Hopenhayn et al. (1993) and Anderson (1993) find that they can result in more unemployment in the long-run as a result of reduced hiring. The results presented here indicate that unemployment taxes affect hiring decisions, with industry-specific factors determining the extent of the impact.

The remainder of the paper is organized as follows. In the next section, I present the theoretical framework for characterizing the optimal degree of experience rating. In section 3, I describes the data, the sample, and the empirical strategy for estimating the marginal cost of labor reallocation, captured by the labor demand elasticity in high-risk industries, and presents the findings. In section 4, I calibrate the residual parameters of the formula and discuss the implications for the optimal degree of experience rating. I present my conclusions in section 5.

2 Model of Optimal Unemployment Insurance Financing

In this section, I present the theoretical framework used to explore the welfare implications of funding a predetermined unemployment benefit level using either coinsurance or experience rating. The framework yields a formula for defining the optimal financing policy as a function of the estimable sufficient statistics representing the three forces identified in the literature, namely, the marginal value of coinsurance and the two marginal costs from labor reallocation and employer moral hazard.

The model has three key features to incorporate the forces identified in the literature. First, employers face demand shocks that halt production and lead to worker layoffs. With experience rating, the shock triggers an increase in unemployment taxes, further deteriorating employers' net worth and leading to such additional losses as increased borrowing costs. The marginal value of coinsurance consists of the progressive decrease

in these losses. Second, the probability of experiencing a shock is larger in some industries than in others. Industries with a high exposure to shocks disproportionately contribute to overall unemployment. Coinsurance redistributes the cost of unemployment benefits from high-risk industries to the broader community of employers, ultimately reducing labor costs in high-risk industries and increasing their labor demand. The sensitivity of labor demand in high-risk industries to labor costs plays a pivotal role in determining the extent of interindustry labor reallocation following changes in the degree of experience rating and, in turn, the significance of the inefficiencies associated with labor reallocation. Third, employers can reduce their exposure to shocks by exerting effort, but coinsurance, by making layoffs less costly, reduces employers' incentives to exert effort, thereby introducing an employer moral hazard.

In the remainder of this section, I introduce the agents in the model, derive the formula for the optimal degree of experience rating, and discuss its interpretation.

2.1 Four Agents: Employers, Government, Workers, and Capitalists

Employers. I assume the existence of two employers exposed to product demand shocks. In the *good* state of the world, these employers face positive output prices, which I normalize to one. In the *bad* state, a shock occurs that lowers output prices to zero, making it unprofitable for the employers to operate. The two employers belong to two distinct industries, characterized by different exposure to shocks. While the employer in the high-risk industry experiences a shock with probability $r_H \in (0, 1)$, the employer in the low-risk industry faces a stable product demand and no risk $r_L = 0$. Since the low-risk employer faces no shock, the high-risk employer is accountable for all of the unemployment in the economy.⁶ The unemployment risk of the high-risk employer, r_H , can be decomposed into the sum of an exogenous strictly positive component, p_H , and a component that the employer can reduce by exerting effort, m : $r_H = p_H + \frac{1}{m}$. The employers' expected profits are given by:

$$\Pi_x = (1 - r_x)\Pi_x^{good} + r_x\Pi_x^{bad}, \quad x \in L, H \quad (1)$$

In the good state of the world, employers produce output using labor and capital, taking wages w_L and w_H as fixed and hiring workers from the most to the least productive available.⁷ Workers, denoted by i , are distributed uniformly over the unit interval and differ by their productivity in the two industries. For example, given the production functions in the two industries, f_L and f_H , worker i would produce $f_L(i, k)$ in the low-risk industry and $f_H(i, k)$ in the high-risk industry when combined with capital k . To model the existence of industry-specific skills, I assume that productivity in the low-risk industry increases linearly over the unit

⁶I model a product demand shock following Feldstein (1976), Topel (1984) and Card et al. (1994), but productivity shocks or other shocks causing involuntary unemployment could be equivalently used. The exposure to shocks is assumed to be a fixed property of the industry, rather than a temporary characteristic of the employer. An equivalent interpretation is that the low-risk industry operates throughout the year, while the high-risk industry operates only during the high season, lasting a fraction $1 - r_H$ of the year.

⁷Wages could be fixed either because their labor supply is perfectly elastic or because of wage rigidities introduced by collective bargaining, wage floors, or equity concerns within the firm. The welfare analysis does not depend on the specific reason why wages are fixed. Section O.B.5 presents a version of the model with flexible wages that preserves all of the results of the basic model.

interval, while productivity in the high-risk industry declines linearly over the same interval.⁸ Consequently, the high-risk employer hires the worker $i = 0$ first, and then proceeds with workers with higher i . $l_H \in (0, 1)$ represents both the last worker hired by the high-risk industry and the share of workers employed in the high-risk industry. The remaining $1 - l_H$ workers are employed in the low-risk industry. Additionally, employers pay j , determined exogenously, for each unit of capital that they employ, and an unemployment tax (τ_L and τ_H , depending on the industry) for each worker hired. This tax serves to finance the provision of benefits b for the workers who become unemployed following a demand shock. Employers' profits in the good scenario are thus given by:

$$\Pi_H^{good} = \int_0^{l_H} f(i, k) di - w_H l_H - \tau_H l_H - jk \quad \text{and} \quad \Pi_L^{good} = \int_{l_H}^1 f(i, k) di - w_L l_L - \tau_L l_L - jk \quad (2)$$

In the bad state of the world, a product demand shock occurs that reduces output prices to zero in the high-risk industry, making production unsustainable and leading to the dismissal of all of the workers. Following a shock, the high-risk employer is still required to pay unemployment taxes⁹ However, the tax cost that the high-risk employer faces increases by $q\%$, with q being strictly positive and exogenous and representing the loss associated with each dollar of tax. This loss reflects the costs associated with the further deterioration of employers' net worth as a result of increased unemployment taxes following a shock, such as higher borrowing costs. Moreover, the high-risk employer incurs the cost of having, in vain, exerted effort to prevent the shock, represented as $(1 - 1_{e=1})\psi(m)$, where ψ is strictly convex and differentiable m . This cost disappears when e , the degree of experience rating of the unemployment insurance system set by the government, is equal to one. This functional form guarantees that when $e = 1$ and experience rating is complete, the high-risk employer exerts infinite effort to avoid shocks. The employers' profits in the bad state are given by:

$$\Pi_H^{bad} = -\tau_H l_H (1 + q) - \psi(m)(1 - 1_{e=1}) \quad (3)$$

Government Budget Constraint and the Degree of Experience Rating. The government levies taxes on the employers to finance the unemployment benefit spending and maintain a balanced budget in expectation. Equation 4 shows that the combined taxes paid by the two employers must match the expected total benefit spending B , which depends on the exogenous benefit level b , the unemployment risk in the high-risk industry $p_H + \frac{1}{m}$, and the fraction of workers who are employed in the industry and, hence, exposed to a

⁸The two diagonal lines in Figure 1 illustrate an example of workers' productivity in the two industries. This assumption is grounded in the idea that, at a specific skill level, an individual's productivity correlates positively with the productivity in similar industries, but not necessarily with the productivity in different industries. For instance, a worker may excel as a bank clerk but perform poorly as a waiter. Therefore, the assumption requires that high- and low-risk industries demand distinct skill sets.

⁹The modeling of unemployment taxes as head taxes paid in both states of the world is consistent with unemployment insurance financing policies in the United States. There, employers contribute unemployment taxes on the wages paid to a worker up to a threshold, known as the taxable wage base. Since most workers earn yearly wages exceeding the threshold, employers pay the lion's share of the unemployment taxes owed for the year during the first quarter. Whether a worker is retained for longer is thus irrelevant for the purpose of determining unemployment tax liabilities.

high risk of unemployment, l_H .

$$\underbrace{\tau_L l_L}_{\text{Taxes paid by low-risk employer}} + \underbrace{\tau_H l_H}_{\text{Taxes paid by high-risk employer}} = \underbrace{bl_H \left(p_H + \frac{1}{m} \right)}_{\text{Expected total benefit cost}} = B \quad (4)$$

Instead of directly determining employers' tax rates, the government chooses the degree of experience rating for the unemployment insurance system, $e \in [0, 1]$. e is the fraction of total benefit spending that the high-risk employer repays in unemployment taxes.¹⁰ The low-risk employer pays the residual share $1 - e$. τ_H and τ_L are set accordingly.

$$\underbrace{\tau_H l_H}_{\text{Total tax paid by high-risk employer}} = eB = \underbrace{ebl_H \left(p_H + \frac{1}{m} \right)}_{\text{Fraction } e \text{ of total benefit cost}} \quad (5)$$

$$\underbrace{\tau_L l_L}_{\text{Total tax paid by low-risk employer}} = (1 - e)B = \underbrace{(1 - e)bl_H \left(p_H + \frac{1}{m} \right)}_{\text{Fraction } 1 - e \text{ of total benefit cost}} \quad (6)$$

The case of $e = 1$ corresponds to the scenario of complete experience rating, in which the high-risk employer repays the full cost of the unemployment benefit spending resulting from its layoffs, while low-risk employer, which does not lay off workers, is exempt from paying unemployment taxes. When $e < 1$, the coinsurance between the two employers comes into play since a fraction $1 - e$ of the benefit cost generated by the high-risk employer is transferred to the low-risk employer. Notably, when $e = 0.5$, the two employers contribute the same amount of tax. Consequently, changes in the degree of experience rating e affect the distribution of the unemployment tax burden between the employers.

Workers. Workers, denoted by i , are distributed uniformly over the unit interval and differ in terms of their productivity in the two industries. This disparity in productivity influences the probability of workers being employed in either of the industries. However, because wages are uniform for all of the workers within the same industry, they do not impact the utility that workers derive from their jobs. The workers employed in the low-risk industry derive utility from consuming their wages, represented as $U_L = u(w_L)$, where $u(c)$ is a strictly concave utility function defined over consumption c . The workers hired in the high-risk industry consume their wages in the good state and consume the unemployment benefit b and enjoy leisure $L > 0$ in the bad state. Their expected utility is thus $U_H = u(w_H)(1 - r_H) + r_H(u(b) + L)$. To focus on the key forces of the model, I make two assumptions. First, I assume that the workers derive the same utility from the low-risk and the high-risk jobs.¹¹ Second, I assume that workers are indifferent between consuming the high-risk wage and the combination of consuming the unemployment benefit and enjoying leisure.¹² Crucially, since a gap

¹⁰Consistent with Feldstein (1976) and Topel (1984), e represents the tax cost per dollar of benefit spending for the high-risk employer.

¹¹Section O.B.6 shows that, when I relax this assumption and assume that workers have heterogeneous preferences for the two industries, a new source of inefficiency is associated with labor reallocation that is equal to the utility gap experienced by the marginal worker transferred from one industry to another, $U_L - U_H$. I discuss potential approaches to calibrating this parameter and suggests that the marginal worker would have preferred the low-risk job ($U_L > U_H$). Introducing heterogeneous preferences would thus increase the total inefficiency resulting from labor reallocation, indicating that the estimates from this simplified version of the model represent a lower bound for the true cost of reallocation and reinforcing the case for a higher degree of experience rating.

¹²This assumption is not entirely unrealistic, and may explain the existence of seasonal jobs despite their typically low wages. Nevertheless, I relax it in Section O.B.6, eliminating leisure and allowing workers to experience lower utility when they are

remains in workers' marginal utilities between the good state of the world, in which they are employed, and the bad state of the world, in which they are unemployed, $u'(b) > u'(w_H)$, unemployment insurance is still valuable for them.¹³

Capitalists. There is a continuum of capitalists owning capital $2k$, which assumed to be split identically between the employers for production. The capitalists consume the return from their investment: $U_C = 2k[j + \gamma(\Pi_L + \Pi_H) - 1]$. For each unit of capital invested, their return consists of the exogenous price of capital, j , and in the exogenous fraction $\gamma \in (0, 1)$ of the employers' net worth, $\Pi_L + \Pi_H$. In the presence of asymmetric information between the lenders (capitalists) and the borrowers (employers), the former audit their investment and incur agency costs that result in the loss of a portion of their returns. A higher net worth increases the capitalists' return by reducing these agency costs (Bernanke et al. 1989).

2.2 Model Solution

Figure 2 illustrates the timeline for the model. First, the government chooses the degree of experience rating, e , that maximizes welfare. Next, the high-risk employer observes e and sets effort m and labor demand l_H optimally. The high-risk employer hires a corresponding fraction l_H of the workers, and the low-risk employer hires the rest. Last, with probability r_H , the shock occurs and the workers in the high-risk industry become unemployed.

I solve the model by backward induction. To begin, I derive the high-risk employer's optimal responses to the government's choice of experience rating. The variation in the high-risk employer's behavior in response to the changes in the degree of experience rating is what causes the inefficiencies associated with coinsurance. From the optimal level of effort, I obtain the elasticity of effort with respect to the degree of experience rating, which serves as the sufficient statistic capturing the extent of moral hazard. From the optimal labor demand, I obtain the elasticity of labor demand with respect to the degree of experience rating, which serves as the sufficient statistic capturing the extent of labor reallocation. I then calculate the government's optimal choice of experience rating considering employers' responses as given. The optimal policy balances the inefficiencies resulting from the high-risk employer's behavioral responses against the value of providing insurance to employers exposed to shocks.

Labor Demand Declines with Experience Rating. In Section O.B.2, I derive the privately optimal labor demand of the high-risk employer by maximizing its expected profit with respect to the number of employees, l_H , and setting the first-order condition to zero. The high-risk employer stops hiring workers when the productivity of the marginal worker equals the marginal cost, given by the wage and the increased unemployment tax. The latter coincides with the fraction e of the unemployment benefit level b that the high-risk employer internalizes through taxation, scaled by the relative probability that the marginal worker

unemployed. The cost of moral hazard increases to reflect this utility loss. The simplified model thus provides a lower bound for the cost of moral hazard, reinforcing the case for a higher degree of experience rating.

¹³Chetty (2006) consistently discusses that when workers value leisure, they are willing to sacrifice more consumption to take time off, which results in a larger consumption drop and a greater value of unemployment insurance.

becomes unemployed.

$$\underbrace{\frac{f_H(l_H, k)}{\text{Marginal product of one extra unit of labor}}}_{\text{Marginal worker productivity}} = \underbrace{\left[\frac{\text{Extra tax}}{\frac{eb(p_H + \frac{1}{m})}{1 - p_H - \frac{1}{m}}} + \underbrace{w_H}_{\text{Extra wage}} \right]}_{\text{Marginal cost of one extra unit of labor}} \quad (7)$$

From this equation, it emerges that the labor demand of the high-risk employer declines with the degree of experience rating, $\frac{dl_H}{de} < 0$. Intuitively, a higher degree of experience rating increases the labor costs faced by the high-risk employer and reduces its labor demand. In the model, this occurs because, when experience rating increases, the productivity of the marginal worker must increase to match the higher marginal cost. Since productivity declines along the unit interval over which workers are distributed, the high-risk employer stops hiring workers earlier along the interval, at a lower level of l_H which corresponds to a marginal worker with a higher productivity.¹⁴ Figure 1 illustrates this dynamic. In the figure, workers i are distributed over the unit interval on the x-axis, and their productivities in the two industries, $f_H(i, k)$ and $f_L(i, k)$, is shown on the y-axis. The high-risk employer hires workers along the x-axis starting from the most productive worker with $i = 0$. With complete experience rating, the employer stops hiring when the productivity of the marginal worker is equal to labor costs, given by the wage and the total tax increase, $f_H(l_H, k) = w_H + \frac{br_H}{1 - r_H}$. This condition is satisfied by point A, which identifies l_H^{*ER} as the marginal worker and the prevailing employment share with complete experience rating. Decreasing the degree of experience rating reduces labor costs to $w_H + \frac{ebr_H}{1 - r_H}$. Point C, where productivity matches these lower labor costs, identifies a marginal worker positioned beyond the former along the unit interval, and a higher employment share in the high-risk industry $l'_H > l_H^{*ER}$. In summary, complete experience rating minimizes the labor demand of the high-risk employer.

Once the labor demand of the high-risk employer, $l_H(e)$, is established, low-risk employment is determined residually as $l_L = 1 - l_H(e)$. Therefore, a lower degree of experience rating increases the labor demand of the high-risk employer and, in turn, reduces the employment share of the low-risk employer. This effect occurs because part of the tax burden, $\frac{(1-e)br_H}{1 - r_H}$, is transferred from the high-risk employer to the low-risk employer, resulting in increased labor costs and reduced labor demand for the latter. This phenomenon of cross-subsidization, where premiums paid by all insured parties cover the costs for those experiencing a shock, is a typical aspect of any insurance system. However, a concern arises as certain employers consistently subsidize or are subsidized over time. This issue is exposed in Section O.B.1. If the two employers were equally exposed to shocks, their benefit spending and tax payments would balance out over time, and the allocation of workers between them would remain unaffected in the long run. However, since unemployment risk is a permanent trait, the high-risk employer consistently generates disproportionate benefit spending from one period to the next, and the cost of this spending is consistently transferred to the low-risk employer through coinsurance. Essentially, the continual subsidization of the high-risk employer at the expense of the low risk one fosters the growth of the former while diminishing the latter. This impact is not simply financial but also influences labor demand through the effect of unemployment taxes, resulting in labor reallocation. Since these patterns are generated by different unemployment risk across different industries, this model is showing

¹⁴This result could be equivalently obtained with a Cobb-Douglas production function with decreasing returns from labor.

that decreasing experience rating induces the reallocation of labor from the low-risk industry to the high-risk industry.

The extent of this reallocation is captured by the labor demand elasticity of the high-risk employer with respect of the degree of experience rating: $\epsilon_{m,e} = \frac{dl_H}{de} \frac{e}{l_H} < 0$. Intuitively, a higher elasticity implies more movement of workers into or out of the high-risk industry as unemployment taxes change.

Effort to Avoid Shocks Increases with Experience Rating. Section O.B.3 maximizes the high-risk employer's expected profits with respect to effort m . Setting the first order condition of this maximization problem to zero gives the privately optimal effort to avoid shocks. The optimal level is reached when the marginal benefit of additional effort equals the marginal cost. Increasing effort is associated with two marginal benefits. First, it becomes more likely that the good state of the world occurs, and that the employer earns the good-state profits rather than the bad-state profits. Second, higher effort reduces unemployment risk, the expected benefit spending, and the unemployment taxes paid by the high-risk employer. At the same time, since $\psi(m)$ is a convex function, increasing effort is associated with progressively higher monetary costs. The optimal effort balances the two marginal benefits with this marginal cost.

$$\underbrace{\frac{1}{m^2}(\overbrace{\Pi_H^{good} - \Pi_H^{bad} + eq}^{\Delta \text{ profits between states}})}_{\text{Private marginal benefit of higher effort}} + \underbrace{\frac{ebl_H}{m^2}}_{\text{Lower tax}} = \underbrace{\left(p_H + \frac{1}{m}\right)\psi'(m)(1 - 1_{e=1})}_{\text{Private marginal cost of higher effort}} \quad (8)$$

The equation also shows how the optimal effort changes with the degree of experience rating. With complete experience rating, when $e = 1$, this marginal cost of effort is nullified, and the employer finds it optimal to exert infinite effort. Consequently, the unemployment risk reaches its minimum: $\lim_{m \rightarrow \infty} r_H = \lim_{m \rightarrow \infty} p_H + \frac{1}{m} = p_H$. With risk pooling, when $e < 1$, the employer faces a positive and increasing marginal cost of effort, leading to a finite optimal effort and above minimum layoffs. Even in this case, the optimal level of effort increases with the degree of experience rating: $\frac{dm}{de} > 0$. These results mirror the notion that experience rating reduces employer moral hazard and layoffs. The elasticity of effort with the degree of experience rating, $\epsilon_{m,e} = \frac{dm}{de} \frac{e}{m} > 0$, is thus the model parameter capturing the extent of employer moral hazard.

Optimal degree of experience rating. The government chooses the degree of experience rating e that maximizes a utilitarian social welfare function, obtained by summing workers' and capitalists' utilities, subject to the rules to allocate the tax burden between employers, the high-risk employer's optimal labor demand and effort, and labor market clearing.

$$SWF = \underbrace{(1 - l_H)u(w_L)}_{\text{Utility of workers in low-risk job}} + l_H \underbrace{\left[\left(1 - p_H - \frac{1}{m}\right)u(w_H) + \left(p_H + \frac{1}{m}\right)u(b)\right] k[\gamma(\Pi_L + \Pi_H) - 1]}_{\text{Utility of workers in high-risk job}} \underbrace{k[\gamma(\Pi_L + \Pi_H) - 1]}_{\text{Utility of capitalists}} \quad (9)$$

Section O.B.4 solves this maximization problem by taking the derivative of the social welfare function with respect to e and setting it to zero. The derivative illustrates the welfare effects induced by a small change in the degree of experience rating. To provide a clearer interpretation, I scale this derivative by total benefit

spending, and obtain an equation illustrating the welfare effects of a small change in the unemployment tax paid by the high-risk employer. The optimal degree of experience rating, defined in Equation 10, is reached when the marginal benefit of such tax change equals the marginal cost. To fix ideas, I consider the case of a decline in the tax paid by the high-risk employer, which can be equivalently interpreted as an increase in the insurance against the risk of a tax increase following a negative shock which is offered to the high-risk employer at the expenses of the low-risk employer.

$$\frac{\Pi_H'^{good} - \Pi_H'^{bad}}{\underbrace{\Pi_H'^{good}}_{\text{Value of insurance for employers}}} = \underbrace{-\lambda \epsilon_{l_H, \alpha}}_{\text{Cost of labor reallocation}} + \underbrace{\mu \epsilon_{m, \alpha}}_{\text{Cost of employer moral hazard}} \quad (10)$$

Left-hand side of Equation 10 presents the marginal benefit of increasing insurance for the high-risk employer. Decreasing the tax paid by the high-risk employer after a negative shock reduces the additional losses associated with a lower employer net worth, such as higher borrowing costs. The sufficient statistic representing the marginal benefit of insurance is the loss per dollar of tax paid by the high-risk employer, q . Since q is equal to the normalized gap in the high-risk employer's marginal profits between the good and the bad state of the world, this sufficient statistic can be interpreted as the amount that the high-risk employer is willing to give up in order to shift a dollar from the good to the bad state, or to pay one less dollar in unemployment taxes.

Right-hand side of 10 presents the marginal cost of increasing the insurance offered to the high-risk employer. The total cost can be decomposed into the cost from interindustry labor reallocation and the cost from employer moral hazard. The sufficient statistic capturing the cost of labor reallocation is the elasticity of the high-risk employer's labor demand with respect to the degree of experience rating, $\epsilon_{l_H, e} < 0$. Shifting unemployment taxes from the high- to the low-risk employer reduces labor costs for the high-risk employer and increases their labor demand. As a result, the employment share in the high-risk industry increases. This reallocation of workers towards the high-risk industry is costly for two reasons, expressed by the parameters within the scaling factor λ .

$$\lambda = \frac{1}{ebr_H^2} \left[\underbrace{f_L(l_H, k) - w_L}_{\text{Misallocation of productive skills}} + \underbrace{(1-e)br_H}_{\text{Fiscal externality due to higher benefit cost}} \right] \quad (11)$$

First, the expansion of the high-risk industry results in the misallocation of productive skills. This effect is captured by the net productivity in the low-risk industry of the marginal worker employed in the high-risk industry, $f_L(l_H, k) - w_L$. Intuitively, the inefficiency emerges because the marginal worker hired in the high-risk industry, who by definition has net productivity equal to zero in that industry, would have had a positive net productivity in the low-risk industry. This point is illustrated in Figure 1. I already discussed that l_H^{*ER} , the marginal worker hired by the high-risk employer with complete experience rating, is the one with productivity equal to labor costs, $f_H(l_H^{*ER}, k) = w_H + B$ (point A). Reducing the degree of experience rating leads to the expansion of the high-risk employer, who stops hiring when the productivity of the marginal worker equals the new reduced labor costs, $f_H(l'_H, k) = w_H + eB$ (point C). This zero-net productivity condition in the

high-risk industry identifies l'_H as new marginal worker. The inefficiency emerges because this worker would have had a positive net productivity if employed in the low-risk industry, identified by the segment DE. DE measures the distance between point D, which identifies the productivity of l'_H in the low-risk industry, and point E, measuring the low-risk wage. The figure shows that all the workers between l_H^{*ER} and l'_H would have been more productively employed in the low-risk industry. However, only the net productivity of the marginal worker is relevant for welfare. A simulation reveals that for every \$100 of net productivity loss, the marginal cost of insurance increases by 20 cents. Intuitively, the greater the disparity in skill requirements between industries, the larger the gap becomes.

Second, the reallocation of workers towards the high-risk industry imposes a fiscal externality on the government budget. As more workers are exposed to a high-unemployment risk, the occurrence of layoffs increases, leading to a greater benefit spending that the government must finance with higher taxes.

The sufficient statistic representing employer moral hazard is the elasticity of effort with respect to the degree of experience rating, $\epsilon_{m,e} > 0$. Lowering the unemployment tax paid by the high-risk employer decreases the cost associated with a shock. Consequently, the high-risk employer exerts less effort to prevent such shocks, resulting in a higher number of layoffs and a higher benefit spending that the government must cover with higher taxes. For this reason, employer moral hazard constitutes a second source of fiscal externality. This externality is represented by the parameters within the scaling factor μ :

$$\mu = \frac{(1 - e)}{\underbrace{emr_H^2}_{\text{Fiscal externality due to higher benefit cost}}} \quad (12)$$

In summary, the optimal degree of experience rating balances the value of insurance for employers with the costs of labor reallocation and employer moral hazard. By comparing the marginal benefit and costs of providing insurance to *employers*, this formula for the optimal degree of experience rating mirrors the formula for the optimal unemployment benefit level, defined by the tradeoff between the marginal benefit and cost of providing insurance to *workers* (Baily 1978). In this sense, it can be considered as an employer-Baily-type formula. The primary application of the formula consists in assessing the magnitude of its parameters within a specific context, compare the marginal benefit and cost of insurance, and evaluate whether the degree of experience rating in that context should be reduced (if the benefit exceeds the cost) or increased (if the cost exceeds the benefits) to enhance welfare. This evaluation is the objective of the empirical section of this paper.

2.3 Discussion

The model is based on a set of simplifying assumption that increase its tractability but can be relaxed without altering its key insights. When I extend the model to encompass various realistic features, I consistently find that this simplified version of the model provides a lower bound for the costs of reallocation under coinsurance. If anything, the following considerations strengthen the case for a higher optimal degree of experience rating.¹⁵

¹⁵I do not incorporate positive externalities that may arise from increased layoffs and unemployment, such as the benefit of a layoff for workers who accepted jobs with excessive mobility costs (Diamond 1981). If such externalities were present, they would diminish the cost of coinsurance and the optimal degree of experience rating.

In Section O.B.5, I explore a version of the model that incorporates flexible wages. The key distinction is that the reallocation of workers across industries affects the wages offered in these industries. As workers consume their wages, the formula for the optimal degree of experience rating contains two additional sufficient statistics: the elasticities of wages in the two industries with respect to the degree of experience rating. Nonetheless, Table 2 shows that these elasticities are estimated to be zero, effectively bringing us back to the scenario with fixed wages. In Section O.B.6, I present a version of the model in which workers are no longer indifferent between industries. Introducing individual preferences for a specific industry increases the cost of labor reallocation because the reallocation of the marginal worker to the high-risk industry is associated with a utility loss. Similarly, when workers are no longer indifferent between employment and the combination of unemployment and leisure, the cost of moral hazard increases as unemployment involves a utility loss. Lastly, in Section O.B.7 I discuss the implications of allowing the low-risk employer having a strictly positive unemployment risk: $r_L = p_L + \frac{1}{m}$. Given that the crucial factor determining cross-subsidization is the relative exposure to risk of the two industries, I normalize p_L to zero and interpret p_H as the *differential* risk across the two industries. In essence, this means linking the unemployment risk of the low-risk industry to the effort of the low-risk employer. In this scenario moral hazard becomes more costly as both employers contribute to it.

A related consideration is that the model is static and does not explicitly account for economic cycles, even though most unemployment benefits are distributed during recessions. This prompts a broader discussion about the underlying nature of unemployment risk in the model. Here, p_H represents the differential unemployment risk between the two industries. If $p_H = 0$ and both industries were equally exposed to risk, then labor reallocation wouldn't be a concern, and moral hazard would be the sole source of inefficiency associated with coinsurance. In cases where p_H is positive, what exactly does it represent? p_H might represent the consistently high layoff rates in seasonal industries, where unemployment is a predictable, recurring phenomenon, rendering insurance unnecessary. If p_H represented true exposure to economic shocks, then insurance against these shocks would indeed be valuable, and changes in p_H across economic cycles would consequently alter the value of insurance for employers over time. In line with this hypothesis, East et al. (2015) proposes that the value of insurance for workers might be higher during recessions compared to periods of economic stability. This trend may extend to employers as well. The significance of employer moral hazard could also fluctuate over economic cycles, with layoffs occurring regardless of their costs during recessions. Similar patterns are observed among workers, where inefficiencies decline during economic downturns (J. Schmieder et al. 2012). Therefore, it is crucial to acknowledge that the value and costs of coinsurance may vary across different contexts and over time, influenced by factors such as the predictability of unemployment, the magnitude of shocks, and the relative exposure of different industries to these shocks. Much like the arguments for countercyclical generosity of unemployment benefits, providing increased support to workers during recessions (Kiley 2003, J. Schmieder et al. 2012), the optimal financing policy may also fluctuate over business cycles, involving more experience rating during periods of economic stability and less experience rating during recessions.

One final consideration concerns the distinction between employers and industries, which, in this model, coincide. This equation can be interpreted both at the industry and at the employer levels. The cost of labor reallocation is more pronounced when reallocation occurs across different industries, rather than across

employers within the same industry, where unemployment risk and skill requirements tend to align. Conversely, moral hazard is more significant at the employer level and diluted within an industry. Lastly, the value of insuring specific industries may be larger than the value of potentially inefficiently insuring specific employers, as discussed in Giupponi et al. (2022).

3 Estimating the Cost of Interindustry Labor Reallocation

In this section, I estimate the sufficient statistic representing the marginal cost of labor reallocation: the labor demand elasticity with respect to the degree of experience rating for the high-risk employer. There is no readily available estimate for this parameter in the literature, and relying on a generic labor demand elasticity may underestimate the cost of labor reallocation.

The idea that labor demand may be more elastic for employers in high-risk industries has long been contemplated. For instance, Lester (1960) argued that low-layoff rate employers are more resiliency to shocks compared to high-layoff rate employers. Moreover, employers in high-risk industries may find it easier to adjust their employment levels in response to tax changes. This adaptability could stem from their familiarity with fluctuations in workforce size or a deeper understanding of unemployment insurance financing policies, given their greater exposure to both high tax rates and larger variations in their tax rates.¹⁶

Since in the model an increase in the degree of experience rating results in a higher unemployment tax per worker for the high-risk employer, I can equivalently estimate a labor demand elasticity with respect to the unemployment tax per worker, $\epsilon_{l_H, \tau}$ instead of $\epsilon_{l_H, e}$. The estimation is facilitated by the existence of numerous sources of quasi-experimental variation in the unemployment tax per worker in the United States, where experience rating policies involve several discontinuities and are subject to frequent changes. I leverage novel quasi-experimental variation in the tax per worker from state-level reform of experience rating policies in South Carolina and Colorado to estimate the reduced form causal effect of the tax per worker on labor demand for employers in high-risk industries. The use of reduced form effects is particularly appropriate as they encapsulate all behavioral responses to changes in the tax per worker that ultimately influence labor demand, mirroring the total derivative in the labor demand elasticity.

This section focuses on the reform in South Carolina. The results based on the reform in Colorado, briefly presented in this section, are derived in detail in Appendix O.A.

3.1 Institutional Framework

The Unemployment Compensation program, established in response to the Great Depression with the 1935 Social Security Act of 1935, provides temporary and partial wage replacement to workers who are involuntarily laid off, ensuring they can meet necessities while unemployed. The program operates as a federal-state

¹⁶In the United States, high-layoff rate employers face higher unemployment tax rates, which make unemployment taxes more significant for them. These higher tax rates also render them more responsive to policy changes. For instance, when there are increases in the taxable wage base (representing the portion of a worker's annual wage over which the tax rate is applied to calculate the tax liability), the impact is magnified for high-tax-rate employers. Furthermore, changes in the tax rate schedule within a state often lead to substantial variability in the tax rates paid by high-layoff rate employers, while causing smaller fluctuations in the tax rates of low-layoff rate employers.

partnership, allowing states to design and manage their own unemployment insurance program within federal guidelines. Consequently, states vary widely in terms of workers' eligibility criteria, the generosity of benefits, and the financing methods employed. Each state maintains an individual Unemployment Trust Fund, where the unemployment taxes levied on employers are deposited and from which funds are drawn to provide benefits to unemployed workers. States are responsible for the solvency of their funds through the different economic cycles and regularly adjust their unemployment tax rates based on the prevailing conditions. When trust fund levels decrease due to high benefit demand, states increase unemployment tax rates on employers; once the fund is replenished, tax rates are lowered.¹⁷ This variation in unemployment tax rates over time is the first distinctive feature of unemployment insurance financing in the United States.

The second feature is that unemployment tax rates vary among employers and for each employer over time to reflect employers' experiences with unemployment. This system to assign individualized and dynamic unemployment tax rates to employers, known as "*experience rating*", is implemented in three steps. Firstly, every year states calculate for each employer an updated measure of the employer's experience with unemployment. Twenty-eight states employ a measure of experience known as "*reserve ratio*", presented in Equation 13. The reserve ratio is calculated as the ratio between the net reserves in an employer's individual account and the sum (or the average of) recently paid taxable wages. Net reserves are calculated as the difference between the sum of all the unemployment benefits ever claimed by the employees laid off by the employer and the sum of all the unemployment tax payments ever made by the employer since the date of establishment (or since the inception of the unemployment insurance system for the oldest employers). This measure thus represents the employers' net position with respect to the unemployment insurance system. Depending on whether benefit charges exceed tax payments, the reserve ratio could be positive or negative. Higher values of reserve ratio indicate greater experience with unemployment, as the dollar amount of benefit charges raises relative to tax payments.¹⁸

$$\text{Reserve Ratio}_{it} = \frac{\sum_{j=-\infty}^{t-1} \text{Unemployment Benefits}_{ij} - \sum_{j=-\infty}^{t-1} \text{Unemployment Taxes}_{ij}}{\sum_{j=x}^{t-1} \text{Taxable Wages}_{ij}} \quad (13)$$

Nineteen states measure employers' experience with unemployment using the "*benefit ratio*", illustrated in Equation 14. The benefit ratio is calculated as the ratio of the benefits charged to the employer and the sum of the taxable wages paid by the employer during the most recent x years, with x typically ranging between three and seven across different states. The benefit ratio only assumes non-negative values. Higher values of

¹⁷Most states establish specific thresholds of trust fund solvency triggering tax increases or decreases. Historically, some governments have deviated from these rules, keeping tax rates high to strengthen the fund's solvency or low to ease the tax burden on employers. As a result of different financing rules and compliance, states varied widely in their ability to cope with the recent economic shocks. Panel (a) of Figure A1 displays the trends in unemployment benefits, unemployment taxes, federal loans and trust fund reserves in the United States between 1999 and 2021. The high demand for benefits during the Great Recession and the COVID-19 pandemic resulted in the depletion of states' trust fund. Thirty-three states became insolvent during the Great Recession, and eighteen during the pandemic, borrowing nearly 50 billion dollars from the federal government to cover benefit costs. In the aftermath of these recessions, many states raised unemployment taxes on employers to settle their debts and restore their financial reserves.

¹⁸I have inverted the sign of the reserve ratio to guarantee that tax rates increase with all measures of unemployment risk. In fact, employers' net reserves are calculated as the difference between total tax payments and total benefit charges, and a higher reserve ratio indicates a lower experience with unemployment.

benefit ratio indicate greater experience with unemployment, as recent benefit charges rise.¹⁹

$$\text{Benefit Ratio}_{it} = \frac{\sum_{j=x}^{t-1} \text{Unemployment Benefits}_{ij}}{\sum_{j=x}^{t-1} \text{Taxable Wages}_{ij}} \quad (14)$$

Secondly, states assign higher unemployment tax rates to employers with higher experience with unemployment. To do so, states use tax rate schedules, which are functions specifying the unemployment tax rate corresponding to each level of reserve ratio or benefit ratio. Tax rate schedules are regularly adjusted to increase or decrease the overall tax burden. Every year, employers' experience and tax rate are recalculated to reflect employers' updated experience with unemployment as well as changes in the tax rate schedules. Employers receive a notification of their unemployment tax rate valid for the upcoming year between the end of the previous year and early into the new year.

Thirdly, the unemployment tax rate is multiplied by the employer's taxable wages in each quarter to determine their quarterly tax liability. Workers' wages are subject to taxes up to a threshold, known as the "*taxable wage base*", common to all the employers in a state. For instance, if worker earns \$10,000 per quarter in a state with a \$15,000 taxable wage base, the employer only pays taxes on all the \$10,000 paid in the first quarter and on the first \$5,000 paid in the second quarter.

The cross-sectional and temporal variations in unemployment tax rates are designed to hold employers accountable for their unemployment benefit costs. However, there are three categories of benefit costs that cannot be charged to specific employers. Firstly, "ineffective charges" result from employers reaching the maximum unemployment tax rate, who lay off workers without incurring in additional tax liabilities. Secondly, certain benefits are "non-charged" to specific employers, such as benefits claimed by workers who quit voluntarily or discharged for cause under specific circumstances, allowances for dependents, or the states' shares of the benefits paid under the Extended Benefit Program. Thirdly, "inactive charges" are claimed by workers laid off by employers who went out of business. These costs repaid collectively, making experience rating "incomplete" even in the United States.

3.2 Data and Sample

The main variables in the analysis are obtained from unemployment tax filing data provided by South Carolina Department of Employment and Workforce (SC DEW). The data cover the near-universe of employers in South Carolina²⁰ and include the information used by SC DEW to assign unemployment tax rates to employers, including their number of employees, total wages, the unemployment tax rate, the reserve and the benefit ratio, taxable wages, unemployment benefit charges, the establishment date and a NAICS four-digits industry

¹⁹The remaining states employ similar measures of employers' experience: the "average benefit cost rate" in Alaska; the "benefit-wage ratio" in Delaware and Oklahoma. Figure A2 illustrates the geographical distribution of states employing benefit-ratio, reserve-ratio, and other measures. The map suggests that there is no systematic adoption of a specific measure based on regional characteristics, as the states employing these measures are evenly distributed throughout the country. The map also shows the states that switched from reserve ratio to benefit ratio: South Carolina in 2011 and New Mexico in 2016.

²⁰The SC DEW data, excluding the top 1% largest employers to ensure confidentiality and prevent identification, represents 76% of total employment in the state. Table A1 reveals a closely aligned distribution of employers and employees across industries between the SC DEW data and the QCEW data, covering the entire labor market, indicating that excluding the largest employers does not significantly impact the representation of specific industries in the SC DEW data.

code. I also obtained access to analogous data from the Colorado Department of Labor and Employment, which enables me to estimate in parallel the same labor demand elasticity using quasi-experimental variation and a sample of employers from Colorado.

To identify state-level reforms of unemployment insurance financing policies, which I leverage to obtain quasi-experimental variation in unemployment taxes, I digitized information on the unemployment tax rate schedules in place over the recent decades in each US state.

Lastly, I obtain information about employment and wages at the state-industry-year-quarter level from the Quarterly Census of Employment and Wages (QCEW) and use state-year level data on unemployment benefit and tax payments, the taxable wage base, and unemployment trust fund solvency from the ET Financial Handbook 394 (ET 394).

The sample used for the analysis is a subset of the SC DEW data. To focus on employers affected by unemployment financing reforms, I restrict the SC DEW data to private sector employers, whose unemployment tax rate is determined based on their measure of experience with unemployment. I thus exclude two categories of non-experience rated employers: new employers, subject to a common tax rate of 3.4% for the first two years of liability, while building their own experience; and employers with a delinquent contribution report or unpaid unemployment taxes, subject to delinquent tax rate of 3.4% until defects are fixed. To avoid compositional changes around the time of the reform, I further restrict the sample to employers observed continuously and with complete employee data between 2005 and 2014, spanning a ten-year period surrounding the 2011 reform I leverage for identification.

Table 1 shows summary statistics for the sample in 2009. The sample predominantly comprises small employers but also includes large ones, with a median of 5 employees and an average of 12. The median employer offers an average wage of \$30,000 and was established in 1995, indicating sixteen years of operation by the time of the 2011 reform. Regarding sector distribution, primary sector employers make up 1.6% of the sample, construction 12%, manufacturing 6%, trade 22%, transportation 2.5%, and services 56%. Employers exhibit significant variation in their reserve ratios, spanning from -158 to 963, with an average of -.05 and a median of -.14. These negative values indicate that unemployment tax payments exceed benefit charges for most employers. This variation in reserve ratios induce large variation in unemployment tax rates, ranging between 1.3 and 6.1%, and in the tax per worker, calculated by multiplying the tax rate by the taxable wage base of \$7,000, varying between \$91 and \$427.²¹

3.3 Identification strategy

To generate quasi-experimental variation in employers' unemployment tax per worker, I leverage the reform of unemployment financing policies occurred in South Carolina in 2011. During the Great Recession, the unemployment trust fund in South Carolina was depleted due to an extraordinary demand for unemployment

²¹Compared to the original sample, the study sample is positively selected. Table A2 shows that the selected employers have six more employees and offer average annual wages \$4,000 (10%) higher than excluded employers. Consistent with the exclusion of new employers, selected employers have eleven additional years of operation; and consistent with the exclusion of new and delinquent employers, selected employers face lower tax rates despite maintaining similar reserve ratios.

benefits and insufficient reserves. To cover benefit costs, the state borrowed \$1 billion in federal loans. To settle its debt and replenish the fund, South Carolina reformed its unemployment insurance financing policies to increase tax collection. The reform was initiated in 2010, with tax changes impacting employers from 2011. By the end of 2014, the federal loan was repaid, and South Carolina gradually reduced the tax burden on employers.²²

The reform introduced three main changes. First, the taxable wage base increased from \$7,000 to \$14,000 in five years. Second, the unemployment tax rate schedule was expanded to introduce new lower and higher tax rates. Third, South Carolina replaced the reserve ratio with the benefit ratio as measure of employers' experience with unemployment.²³ Equation 15 presents the formulas for the reserve ratio and the benefit ratio in effect in South Carolina before and after the reform. Comparing the two measures reveals two key differences between them. First, they differ in the length of the lookback period j used for assessing employers' experiences with unemployment. While the reserve ratio is calculated using data spanning from the employer's establishment date to the calculation date, the benefit ratio utilizes a rolling seven-year lookback period, discarding any data predating this period. Second, while unemployment taxes are a component in the calculation of the reserve ratio to determine an employer's net position within the unemployment insurance system, they are irrelevant for the calculation of the benefit ratio, determined solely based on benefit charges.²⁴

$$RR_{it} = \frac{\sum_{j=-\infty}^{t-1} \text{Unempl. Benefits}_{ij} - \sum_{j=-\infty}^{t-1} \text{Unempl. Taxes}_{ij}}{\text{Taxable Wages}_{i,t-1}} \longrightarrow BR_{it} = \frac{\sum_{j=-7}^{t-1} \text{Unempl. Benefits}_{ij}}{\sum_{j=-7}^{t-1} \text{Taxable Wages}_{ij}} \quad (15)$$

The South Carolina government switched from the reserve ratio to the benefit ratio to expedite the replenishment of the unemployment insurance trust fund. As most employers had built up substantial reserves through years of unemployment tax payments, the benefit costs charged during the Great Recession did not lead to significant increases in their reserve ratios, and consequently, their unemployment tax rates remained largely unaffected. By employing the benefit ratio, the government could effectively ignore unemployment taxes and impose elevated tax rates on employers who faced substantial layoffs during the Great Recession. The findings from Lachowska et al. (2020) that benefit ratio systems restore fund solvency at double the rate of reserve ratio systems support the concept also pointed by Miller et al. (2019) that the reserve ratio tends to be a “sticky” metric of experience, predominantly reflecting an employer’s historical condition rather than their present one. The reform was a notable event for employers, many of which experienced a sharp increase in their tax rates just as the economy was beginning to bounce back.²⁵

²²Trends in unemployment benefits, taxes, trust fund reserves and federal loans for South Carolina are presented in panel (b) of Figure A1.

²³Figure A3 displays the increase in the taxable wage base. Figure A4 illustrates the unemployment tax rate schedules in place before and after the reform. Figure A5 plots employers by their tax per worker and reserve ratios, pre-reform (panel [a]), or benefit-ratios, post-reform (panel [b]). Changes in the tax per worker reflect both the higher taxable wage base and the expanded tax rate schedule. Visual inspection suggests a significant increase in tax liability per worker, with the maximum rising from \$427 to \$879. Given the different measure for experience with unemployment on the x-axis, the figure does not allow the reader how the tax per worker changed for individual employers.

²⁴Given that taxable wages in year $t - 1$ and the sum of taxable wages between $t - 7$ and $t - 1$ have a correlation of 0.94 in my study sample, the difference in the denominators of the reserve ratio and the benefit ratio plays a minor role to the variation in employers' measure of experience.

²⁵In April 2011, the Greenville Business Magazine featured an employer concerned with the use of the benefit ratio: “*Two of those years, 2008 and 2009, are what I call the ‘Katrina’ years as far as the economy is concerned. They were devastating. I’ve*

The transition from the reserve ratio to the benefit ratio caused a sudden change in employers' measured experiences with unemployment and unemployment tax rates, resulting in the redistribution of the unemployment tax burden among employers in the state. Intuitively, employers who had laid off workers in the distant past benefitted from the oblivion of those charges. In contrast, employers with substantial tax payments were penalized because unemployment taxes were disregarded in experience calculations, with greater emphasis placed on any benefit costs incurred during the Great Recession.

With a differences-in-differences approach, I compare employers with the same benefit ratios post-reform but different reserve ratios pre-reform. Because of their similar benefit ratios, these employers displayed comparable trends during the seven-year lookback period used to calculate the benefit ratio (the “*recent past*”), coinciding with the reform pre-period. The different reserve ratios, shaped by different compositions of their “*distant past*” reserves, lead to different changes in their unemployment tax rates. I illustrate this identification strategy with an example in Panel (a) of Figure 3 On the graph, the x-axis measures time, divided into the distant past, ranging from employers’ establishment up to July, 2003, and the recent past, covering the seven-year lookback period of the benefit ratio. The y-axis portrays employers’ layoff rates (solid lines) and tax rates (dashed lines). The figure displays two employers, one in orange and one in green, with the same benefit ratio but different reserve ratios. The reason why these employers share the same benefit ratio is that they both maintained a consistently low layoff rate during the recent past. Before the reform, the orange employer had a high reserve ratio resulting from a high layoff rate during the distant past; the green employer maintained a low layoff rate in the distant past, resulting in a low reserve ratio before the reform. When the benefit ratio replaced the reserve ratio in 2011, the distant past layoffs made by the orange employer were disregarded and their recent stability was emphasized. Consequently, this employer’s measured experience with unemployment saw a significant decrease at the time of the reform, resulting in a lower unemployment tax rate for them. Because the green employer’s behavior remained consistent over both the distant and recent past, the reform had no impact on this employer’s experience with unemployment or their unemployment tax rates. As a result of the reform, the unemployment tax rates of these employers, which differed pre-reform due to their different distant past behavior, were equalized to reflect their similar behavior during the recent past.

Panel (b) of Figure 3 shows that the same pattern emerges in my study sample. The figure illustrates the average tax rate for employers with predicted benefit ratio equal to zero, hence with no layoffs during the recent past, and either positive (orange) or negative (green) reserve ratio in 2009.²⁶ Despite the parallel trends, orange employers’ tax rates were substantially than green employers’ tax rates pre-reform. With the 2011 reform, orange employers’ tax rates suddenly decreased by 3.9 percentage points, reaching the same level of the green employers. Due to the availability of new lower tax rates, the tax rates of green employers declined by one percentage point as well. Nevertheless, it is evident that the reform favored orange employers – the ones with numerous distant past layoffs and a positive reserve ratio pre-reform.

been in business here for thirty years. Do the other twenty-three years not count for anything?”. The magazine also emphasized widespread concerns that “the new rates will discourage companies from hiring new employees as the economy begins its uptick.”

²⁶The 2010 predicted benefit ratio is the benefit ratio that employers would have had if the reform took place one year earlier. Figure A7 shows that the 2011 benefit ratio and the 2010 predicted benefit ratio are highly positively correlated, supporting the use of the latter for my analysis. The 2009 reserve ratio and the 2010 predicted benefit ratio are entirely determined based on employers’ behavior before 2010, the year in which the details of the reform were defined and are thus clean from employers’ behavioral responses in anticipation of the reform.

This example focused on employers with no layoffs during the recent past and a predicted benefit ratio equal to zero. In practice, because of the influence of the Great Recession and the substantial difference in employers' reserve ratio pre-reform, I observe a variety of predicted benefit ratios. Within each benefit-ratio group, I compare employers with negative reserve ratios (treatment group), penalized by the disregard of unemployment taxes, and employers with positive reserve ratios (control group), favored by the disregard of distant past benefit charges. I display the full variation in employers' reserve ratios pre-reform and benefit ratios post-reform in Panel (a) of Figure 4. The figure shows employers by their recent benefits (numerator of the benefit ratio) in 2011 and total reserves (numerator of the reserve ratio) in 2010, both scaled by recent taxable wages to emphasize differences driven by the numerators. Although there is a noticeable positive correlation, there remains substantial variation between these two measures. As a result, employers who were previously categorized similarly and assigned the same unemployment tax rate under the old system now find themselves categorized differently and subject to different treatment under the new system. I compare employers with the same benefit ratios, i.e. horizontally: these are employers that, despite their different reserve ratios, behave similarly in the pre-period. Comparing employers with the same reserve ratios, i.e. vertically, signifies comparing employers with the same net position but potentially very different historical trends.

Equation 16 shows my preferred specification. $Y_{i,t}$ is the outcome for employer i in year t ; α_i are employer fixed effects, $Treat_i$ is an indicator for employers with negative reserve ratios; b_i are predicted benefit ratio-groups sized 0.000001; $\alpha_{b(i),t}$ are group-year fixed effects; and $\epsilon_{i,t}$ is an error term. Standard errors are clustered at the employer level. β_{2010} is normalized to zero. I multiply the predicted benefit ratio bins by year fixed effects because employers with different levels of predicted benefit ratio are expected to display different layoff and employment trends during the pre-period. For example, employers with a predicted benefit ratio of zero (with no layoffs during the recent past) likely maintained a much more stable employment than employers with positive predicted benefit ratios (with layoffs during the recent past).

$$Y_{i,t} = \alpha_i + \sum_{y=2005}^{2014} \beta_y 1_{y=t} Treat_i + \alpha_{b(i),t} + \epsilon_{i,t} \quad (16)$$

For the β coefficients to identify the Average Treatment Effect on the Treated, the parallel trend and the no-anticipation assumptions need to be satisfied. I begin by discussing the plausibility of the parallel trend assumption. The assumption requires that negative reserve ratio employers would have evolved in the same way as the positive reserve ratio employers within the same benefit ratio bins in absence of the reform. The first approach to establish the credibility of this assumption involves the direct examination of parallel trends in employers' outcomes. The second approach consists in showing that the reserve ratio primarily reflects employers' distant past behavior. If this is the case, the reserve ratio should be uncorrelated with current outcomes in itself, and especially after accounting for recent trends through the benefit ratio.

To this goal, Equation 17 decomposes the numerator of the reserve ratio, the employer's *total reserves*, into three components: the *recent benefits*, corresponding to the numerator of the benefit ratio, the *distant past*

reserves, calculated as the difference between the benefits charged to the employer and the unemployment taxes paid by the employer from the establishment to seven years before the calculation date, and the *recent taxes* paid by the employer. The variation in distant past reserves and recent taxes generates variation in the reserve ratios of employers with the same benefit ratio. Figure 4 show that most of the variation between the reserve ratio and the benefit ratio can be attributed to the reduced *memory* of the unemployment insurance system. Panel (b) illustrates that substantial variation between the two experience measures emerges when forgetting the distant past balance while keeping recent taxes fixed. Conversely, the variation induced by recent taxes *matching* recent benefits in various ways to determine the same reserve ratio is much more limited when the distant past balance is kept fixed, as shown in panel (c). This reinforces the credibility of the parallel trend assumption by supporting the notion that the treatment is uncorrelated with current outcomes conditional on the benefit ratio.²⁷

$$\underbrace{\sum_{-\infty}^0 \text{Benefits}_i - \sum_{-\infty}^0 \text{Taxes}_i}_{\text{RR num} = \text{Tot. reserves}} = \underbrace{\sum_{-7}^0 \text{Benefits}_i + \left(\sum_{-\infty}^{-7} \text{Benefits}_i - \sum_{-\infty}^{-7} \text{Taxes}_i \right)}_{\text{BR num} = \text{recent benefits}} - \underbrace{\sum_{-7}^0 \text{Taxes}_i}_{\text{Recent Taxes MATCH}} \quad (17)$$

Secondly, identification hinges on the non-anticipation assumption. Several factors make it unlikely that the reform influenced employers before its actual implementation in 2011. Firstly, the steady depletion of the unemployment trust fund was largely ignored until December 2008, when South Carolina became insolvent and the need to increase unemployment tax rates became evident.²⁸ Secondly, employers had no means to anticipate the broad impact of the reform until Spring 2010, when it was approved, and they couldn't anticipate the individual effects until late November 2010, when unemployment tax rate notifications were sent out. This was not solely because of the extensive data required for calculating benefit ratios, but also because the new system assigned tax rates based on employer ranking by experience rather than the absolute value of their experience.²⁹ Additionally, the reform stipulates a ten-year lookback period for the calculation of the benefit

²⁷To isolate the contribution of distant past reserves to the total variation between the two measures of experience, I plot employers by their scaled recent benefits and residualized scaled total reserves, obtained from a regression of scaled total reserves on scaled recent taxes, in Panel (b) of Figure 4. The variation between these two measures expands relative to the original variation, supporting the central role of distant past reserves, or *memory*, as driver of the variation. Many employers with negative distant past reserves, built up through regular tax payments over time, accumulated positive benefit charges during the Great Recession. Ignoring these negative distant past reserves increases the measure of experience, explaining the high recent benefits of many employers with low total reserves. Symmetrically, some employers with positive distant past reserves from past benefit charges experienced no layoffs in the recent past. Disregarding the positive reserves reduces their measure of experience, explaining the low recent benefits of many employers with high total reserves. I then isolate the contribution of recent taxes to the original variation. Panel (c) plots scaled recent benefits against scaled total reserves for employers “without memory”, namely, employers established in 2003 or later, whose total reserves coincide with their recent reserves. The variation between the two variables is due to benefit charges *matching* unemployment tax payments in multiple ways to give the same total reserve balance. The amount of taxes that employers pay during the recent past is determined by the reserve ratio. Once we remove the variation from the distant past by focusing on employers without memory, match seems to have a much more limited contribution to the total variation.

²⁸On March 19, 2010, The Sun News reported that, despite the warnings raised by the South Carolina Chamber of Commerce since 2005, the General Assembly had overlooked the steady fund depletion until March 2008, when it became evident insolvency was inevitable. Additionally, the reform process started in 2009 and was only approved in spring 2010. This delay was attributed to legislators, who, seeking re-election at that time, “*said nothing. None publicly told his colleagues what he had heard. Not one alerted the media nor, as far as I can tell, anyone else. Another option would have been simply to tell someone - the press, the colleagues, anyone, and begin working on a solution in April 2008*”.

²⁹See the notes to Figure A4 for details about tax rate assignment after the reform.

ratio, but SC DEW only had seven years of data available, leading to a discrepancy between the law and its implementation. Predicting an individual ranking in the state using the new formula and the corresponding tax rate was, therefore, unfeasible. When tax rates were announced to employers, it was too late to adjust: it happened “*after most companies began their fiscal years with budgets already in place*”, leaving employers “*blindsided*” with “*tens of thousands of dollars in unplanned expenses*” (The Greenville Business Magazine, April 2011). To further reduce the risk of anticipation effects, I classify employers as treated and control based on their 2009 reserve ratios and using the 2010 predicted benefit ratio instead of the true 2011 benefit ratios to create benefit-ratio bins.

I estimate Equation 16 for the full study sample and separately for employers in low- and high-risk industries. The SC DEW data provides information on employers’ NAICS-4 digits codes, which I use to define 305 industries. I categorize these industries as low- or high-risk depending on their average within-year standard deviation of employment between 2001 and 2006 using the QCEW data. This measure aims at identifying industries with a high degree of seasonality, where most layoffs result from the nature of the industry rather than individual employer choices or aggregate shocks. To this end, the selected period excludes variations in employment during the Great Recession.³⁰ I then define a cutoff value above which industries are considered high-risk. The distribution of industries’ average employment within-year standard deviation illustrated in Figure A9 shows that the value of 250 identifies industries with exceptionally large variation in employment within the year. The results are robust to alternative cutoff values. Table A3 lists the forty-nine industries (16%) classified as high-risk with this definition. As shown in panel (a) of Figure A10, these industries are spread across the primary, secondary and tertiary sectors, with notable concentration in construction, manufacturing, retail, professional and technical services, and hospitality. I thus test for heterogeneous effects between industries with low and high employment standard deviation. To ensure that the heterogeneity is driven by industries where layoffs result in unemployment benefit claims charged to employers’ accounts, rather than by industries with high turnover but short unemployment duration, I further test the existence of heterogeneous effects between employers in industries with low and high average unemployment tax rate between 2001 and 2006 in South Carolina based on the QCEW data, and expect similar patterns. The average industry tax rate in the sample, 0.0059, identifies the cutoff to separate low- and high-tax rate industries. Moreover, I compare effects between industries with high employment standard deviation and high average tax rate (agriculture, construction, textile, retail, accommodation, food services, and recreation, as shown in Table A3) and industries with high-employment standard deviation but low average tax rate (healthcare and other manufacturing). This distinction aims at understanding whether employers can adjust their workforce size primarily because of their high turnover or through a greater familiarity with the unemployment insurance system, possibly motivated by exposure to higher tax rates.

The last step of the analysis is to map the reduced form effects from Equation 16 to elasticity estimates. I calculate the labor demand elasticity with respect to the unemployment tax per worker using Equation 18: I divide the reduced form effect on employment by the reduced form effect on the tax per worker, and scale

³⁰Figure A8 shows a correlation of 0.99 between industries’ median and average within-year employment standard deviation. This suggests that the average is not influenced by years with exceptionally low or high standard deviations but is instead a persistent characteristic of the industries.

this ratio by the ratio of the average tax per worker and employment in the last-pre reform year, 2010, for the treatment group. I calculate the elasticity for the full sample and the subsamples of employers in low- and high-unemployment risk industries. With a similar approach, I also estimate the corresponding wage elasticities with respect to the unemployment tax per worker.

$$\epsilon_{l_x, \tau_x} = \frac{\beta_{l_x}}{\beta_{\tau_x}} \frac{\tau_{x,2010,Treat}}{l_{x,2010,Treat}} \quad (18)$$

3.4 Results

Full sample effects and the incidence of payroll taxes. Figure 5 presents the estimated β_y coefficients from Equation 16 for South Carolina employers in the study sample. To reduce the noise introduced by the largest employers, I focus on employers with a quarterly workforce ranging between one and fifty in 2010, with fifty representing the 95th percentile of the distribution. These estimates represent the reduced form causal effects of the transition from a reserve ratio to a benefit ratio system on employers' outcomes. Firstly, the reform increased the unemployment tax per worker of treated employers by \$197 in 2011 relative to control employers, or by 144% relative to the average tax per worker in 2010. This effect endured in subsequent years, when the benefit ratio was recalculated using a lookback period shifted by one year each year, leading to similar tax rate assignments for employers. Secondly, the reform decreased the average number of employees of treated employers by 0.37-0.9, equivalent to 4.6-11.1% of their workforce in 2010. The decline in employment began in 2011 and continued in 2012 and 2013, until employment started recovering in 2014. This progressively larger effect is consistent with gradual employers' adjustment to unplanned expenses. Thirdly, the reform resulted in a reduction in the total wages paid by treated employers by \$19,500-43,000, or 6.2-13.6% of the 2010 wage level. However, there is no evidence of effects on the average wage, indicating that the decrease in wages was solely driven by the reduction in the number of employees. Scaling the effect on wages by the effect on employment allows for the estimation of the yearly wages of the missing employees in the treated group. For example, these wages are \$52,700 in 2011 (the ratio of \$19,500 and 0.37) and \$55,136 in 2012 (the ratio of \$38,320 and 0.695), and are 1.2 and 1.4 larger than the mean average wage in 2010 respectively. Fourthly, there is no effect on taxable wages, suggesting that the reduced number of employees exactly compensates the higher taxable wage base. This hypothesis is confirmed by the increase in the taxable wages based on the 2010 payroll, which represent an estimate of employers' taxable wages if they did not reduce their workforce at the time of the reform. The gap between true and non-behavioral taxable wages, sized \$10,000, exactly coincides with the taxable wage base of the missing worker of negative reserve ratio employers. Lastly, the unemployment taxes paid by treated employers increased by \$839 (or 59%) in 2011. The tax increase was more limited in 2012 and 2013, due to a combination of a lower tax per worker and more reduced number of employees. The comparison with total taxes based on the 2010 payroll indicates that if treated did not reduce their workforce, they would have paid \$213 more in 2012, \$506 more in 2013 and \$264 more in 2014 in unemployment taxes.

In summary, the unemployment tax per worker of negative reserve ratio employers increased by \$200 per year compared to positive reserve ratio employers. In response, negative reserve ratio downsized their workforce by

nearly one employee. Since the average wage remained unchanged, the reduction in wages can be attributed solely to the reduction in workforce size. These findings suggest that the incidence of unemployment taxes is on employers, who do not pass the tax backward to workers in the form of lower wages. Furthermore, since the results are consistent with the absence of a one-average wage employee, it appears that wage rigidities due to minimum wage regulations are not a driving factor in these outcomes.

Additionally, these findings indicate that the reform effectively increased employers' unemployment taxes, aligning with South Carolina's goal to replenish the unemployment trust fund. However, the revenue collected was diminished by employers' responses to the tax increase.

Robustness. I test the stability of my findings in several ways. First, I expand the sample to include employers with more than fifty employees in 2010. Given the large variability introduced by large employers, I rescale the outcomes by their level in 2010. Figure A11 presents the β coefficients from Equation 16 estimated for the sample of employers with an year-average number of employees greater than one. Results remain consistent. Negative reserve ratio employers experienced a 60% increase in their unemployment tax per worker relative to positive reserve ratio employers. In response, they reduced their number of employees by 4-21% and their total wages by 3-13%, without changing the average wage offered to their employees. I also find that taxable wages decline by 5-33%, indicating that the decline in employment more than compensates the increase in the taxable wage base. Unemployment taxes grew by 64% in 2011 and by approximately 30% in 2012 and 2013. These results confirm not only the validity of the initial findings for large employers as well but also demonstrate that the observed patterns are not driven by outliers when using outcomes in level.

Second, my findings are robust to using a different definition of benefit ratio groups. My original approach consists in creating very small bins (sized 0.000001) of predicted benefit ratio and include fixed effects for each of these bins. Alternatively, I calculate employers' yearly benefit ratios based on the benefits charged and the taxable wages paid in each of the seven-year lookback period of the 2011 benefit ratio. I then create bins of the yearly benefit ratios (sized 0.1) and of the predicted benefit ratio (sized 0.001) and create groups of employers falling in the same bins. The bins are larger than in the original to guarantee the presence of enough employers sharing the same history. This approach allows me to compare employers with not only the same overall layoff rate during the pre-period, but also the same distribution of layoffs over the seven years. Figures A12 present the reduced form effects of the reform on firm outcomes in levels using this alternative set of fixed effects. Negative reserve ratio employers experienced an increase in their unemployment tax per worker of \$245 in 2011 and \$140 thereafter relative to positive reserve ratio employers. In response, they reduced their number of employees by 0.37-0.65 and their total wages by \$20,000-26,000, without changing the average wage offered to their employees. These effects emerged only in 2012. I also find that taxable wages are unaffected, but would have increased by \$6,400-11,000 per year if employers did not decrease the size of their workforce. As a result, total taxes increased by \$1,800 in the first year and \$600 thereafter, but would have increased by \$1,900 and \$900 per year in absence of behavioral responses.

Finally, I present an alternative version of these findings using a continuous treatment measuring employers' account reserves in 2009. This demonstrates that my results are not contingent on the specific zero-reserve

ratio cutoff that I use to distinguish treated from control employers. An increase in account reserves by \$1,000,000 leads to a 2% increase in taxes per worker, a 1% reduction in the number of employees, a 2-2.5% decrease in wages, no impact on the average wage, a 2% decline in taxable wages, and a 1% increase in taxes –1% less than the absence of behavioral responses.

Additional considerations and findings. First, given that the South Carolina Department of Employment and Workforce (SC DEW) conducts routine audits of 1,000-1,500 employers annually to verify the accuracy and honesty of the information provided by employers, as well as the presence of penalty rates for employers found misreporting, it is improbable that the observed effects are a result of employers manipulating their data to lower their tax liabilities.

Second, my ability to back up a labor demand elasticity from the reduced form effects relies on the assumption that the decline in the number of employees among treated employers is primarily due to reduced hiring rather than increased separations. While my data lacks explicit information on hirings and separations, several factors support this assumption. Firstly, if the gradual employment reduction were driven by separations, we wouldn't observe a gap between true taxable wages and taxable wages based on the 2010 payroll in 2011, because employers pay taxes on wages paid to employees they lay off during the year. Then, the reform took place in the aftermath of the Great Recession, when most separations had already taken place and employers' primary decision-making margin was related to hiring.³¹. Furthermore, Guo (2023) shows that the rise in unemployment taxes after the Great Recession had a detrimental effect on employment in a group of U.S. states, including South Carolina. By examining data on both hirings and separations, she identified reduced hirings as the primary factor behind the decline in employment. Finally, the lack of impacts on wages makes it unlikely that the reform generated labor supply responses.

I then explore the existence of heterogeneous effects of the reform by firm size, age, and productivity, proxied by average wage. Figure A14 reveals that the impact is more pronounced for larger and younger firms, with no notable variations by productivity. I use these findings to discuss whether the observed effects are driven by liquidity or price effects. The rise in the tax per worker can deter hiring for two potential reasons: either the increased financial burden on current employees creates liquidity constraints for employers, or new hirings become costlier. To determine the relative importance of these effects, I follow Saez et al. (2019)'s approach and assess whether the reform's impact on employment is more significant for small and young firms, which may face liquidity constraints. The larger drops in younger firms may suggest liquidity effects, but the more substantial effects on larger firms point in the opposite direction.

Lastly, I examine whether the reform influenced firm shutdown rates. I expand my sample to include employers that entered or exited the sample between 2005 and 2014 and estimate Equation 16 using as outcome an indicator which equals one in the last year of observation for each employer. The results, presented in Figure A15, do not offer substantial evidence of differential firm exit rates, both in the full sample and in the subsamples of younger and smaller employers.

³¹This sentiment is echoed in reports from the Greenville Business Magazine, which, in April 2011, suggested that "*the new rates will discourage companies from hiring new employees as the economy begins its uptick.*" and voiced employers' concerns that "*no employer should feel safe. This structure will keep South Carolina in a recession and make sure we will not recover.*"

Heterogeneous effects by industries' unemployment risk. Figure 6 illustrates the estimated β_y coefficients from Equation 16 separately for employers in low- and high-employment within year standard deviation industries. Despite facing similar increases in their unemployment taxes per worker, employers in low- and high-standard deviation industries display markedly different responses.³² Firstly, the decrease in the number of employees and wages, as observed in the full sample, is primarily driven by employers in high-standard deviation industries. These employers see a reduction in the number of employees by 0.8-2.4 and a decline in wages by 40,000–117,000. In contrast, employers in low-standard deviation industries witness an increase in the number of employees by 0.3-0.8 over the period, although this increase appears to stem from a positive trend initiated in the pre-reform period. Average wages remain unaffected for employers in both types of industries. Consistent with their stable payroll, employers in low-standard deviation industries experience a sharp increase in their taxable wages driven by their higher tax rates and the higher taxable wage base: by \$7,000 in 2011 and then by \$13,000-18,000. In contrast, the taxable wages of employers in high-standard deviation industries remain unaffected, or even decline (although the estimates are insignificant) with their lower number of employees. Consequently, taxes increase for both sets of employers in 2011 and then diverge, with low-risk employers still facing higher taxes by \$800 per year and high-risk employers drastically reducing their tax burden. Figure A17 shows that these effects are robust to classifying industries into high- and low- risk based on their average unemployment tax rate. These differences are consistent with employers in high-risk industries having more flexibility or a deeper understanding of the unemployment insurance system, allowing them to precisely adjust their workforce to offset the higher taxes. Meanwhile, the lack of an effect for employers in low unemployment risk industries implies that unemployment taxes curtail profits in these sectors. To explore whether the larger effects observed in high-risk industries are determined by their high turnover or their greater familiarity with the unemployment insurance system, in Figure A18 I restrict the sample to high-employment standard deviation industries, and test for heterogeneous effects between industries with high- and low- unemployment tax rates. I find more pronounced effects for industries with high tax rates, suggesting that high turnover without a comprehensive understanding of the system may lead to suboptimal workforce size adjustment when employers cannot offset taxes by reducing wages.

Elasticities calculation. Table 2 presents the labor demand elasticities with respect to the unemployment tax per worker, calculated using Equation 18, for the full sample of South Carolina employers and the subsamples of employers in low- and high-unemployment risk industries. For the calculation, I use the β_{2013} coefficients from Equation 16. These coefficients are selected to best represent the impact of the reform after allowing time for adjustments to take place. I estimate a full sample labor demand elasticity of -0.1. In line with their comparable increase in the unemployment tax per worker but differing employment responses, the labor demand elasticity varies significantly for employers in low- and high-risk industries. I observe a labor demand elasticity of 0.047 for employers in low-risk industries and -0.26 for employers in high-risk industries. The estimated value of $\epsilon_{l_H,e} = -0.26$ is the one I utilize in my formula for the optimal degree of experience rating. The table also includes the estimated wage elasticities with respect to the unemployment tax per worker.

³²Figure A16 shows that the distribution of the change in the unemployment tax per worker between 2010 and 2011 is also very similar between low- and high-employment standard deviation industries. The tax per worker changed similarly across industries both before (panel [a]) and around the reform (panel [b]).

Since I do not find any reduced form effects on the average wage in either the full sample or for employers in low- and high-unemployment risk industries, these elasticities are small and statistically insignificant.

The Colorado experiment. The Colorado experiment, detailed in Section O.A, provides robustness and validation to the evidence obtained from South Carolina. I estimate the same labor demand elasticities using employer-level data from CO DLE, leveraging the elimination of a surcharge in Colorado as a source of variation in unemployment taxes. In 2018, the state government removed the surcharge after replenishing its unemployment trust fund depleted during the Great Recession. This change primarily benefited employers with positive reserve ratios. I compare the evolution of firm outcomes for different cohorts of employers with a positive reserve ratio in different points of time. Only the cohort with positive reserve ratio in 2017 (treatment group) benefitted from the reduction in taxes in 2018. The results show that reducing the tax per worker increased employment and wages of treated employers, with no impact on average wages. The implied labor demand elasticity with respect to the unemployment tax is -0.66. Notably, the effects are more pronounced in high-unemployment risk industries, where the elasticity is -1.06, compared to -0.28 in low-risk industries.

4 Optimal Unemployment Insurance Financing Policy

In this section, I use the estimated sufficient statistic representing the cost of interindustry labor reallocation to evaluate the optimal unemployment insurance financing policy. First, I finalize the calibration of the different parameters in the formula for the optimal degree of experience rating using various moments from the data and estimates from the literature. Then, I present and discuss the findings.

4.1 Calibrating the Marginal Cost of Labor Reallocation

Equation 10 shows that the marginal cost of labor reallocation is calculated by multiplying the labor demand elasticity for the high-risk employer, $\epsilon_{l_H,e}$, by the scaling factor λ . This scaling factor, defined in Equation 11, captures the fiscal externality and the loss from the misallocation of productive skills induced by labor reallocation. Table 3 presents the calibrated values for the parameters in λ , along with a description of the approach and the data used for their calibration. These parameters are: e , b , r_H , w_L , and $f_L(l_H, k)$.

To calibrate the degree of experience rating e , representing the tax cost per dollar of unemployment benefit claimed by laid off workers, I leverage the rich information on employers' unemployment benefit charges and tax payments available in the SC DEW data. I focus on employers with positive benefit charges between 2005 and 2006 (the base period) and no other charges in the surrounding years. For each employer, I calculate the cumulative unemployment taxes paid in each year between 2007 and 2010 and divide them by the base charges. This allows me to track the evolution of the tax cost per dollar of benefit charge over time. As illustrated in Figure 7, the median tax cost increased from 0.29 in 2007 to 0.61 in 2008, 0.94 in 2009, and 1.15 in 2010. This indicates that the median employer paid 29 cents in unemployment taxes in 2007 for every dollar of benefit charged during the base period. The cost had increased to 61 cents by 2008, 94 cents by 2009, and \$1.15 by 2010. Reflecting the gradual increase in unemployment taxes under a reserve ratio system, the median employer repaid the cost of the base charges over the following four years. The average of these median

tax costs, 75 cents, summarizes the pre-reform short-term cost of a dollar of benefit charge for an employer in South Carolina. I thus calibrate $e = 0.75$. This value aligns with other estimates from the literature, ranging between 75 and 87 cents (Topel 1984, Johnston 2021).

I then calibrate the unemployment benefit level b with the average unemployment benefit claimed in South Carolina in 2006, to avoid the influence of the Great Recession. The average benefit is calculated by multiplying the average benefit duration in weeks by the average weekly benefit amount from the ET 394 data. I find that the average claimant in South Carolina received $b = \$2,986$.

To calibrate the unemployment risk in the high-risk industry, r_H , I use the ratio between the trough and the peak quarterly employment in high-risk industries in South Carolina in 2006 based on the QCEW data. Using the definition of high-unemployment risk industries based on the standard deviation of employment within the year, I find that $r_H = 0.046$, meaning that employment in high-risk industries is 4.6% lower in the trough quarter than in the peak quarter. For reference, the unemployment risk in low-risk industries is four times smaller, $r_L = 0.016$.

I calibrate w_L with the average annual wage offered in low-risk industries in South Carolina, calculated as the ratio between total wages and average employment in 2006 from the QCEW data. I find that $w_L = \$37,274$.

Lastly, the marginal productivity in the low-risk industry of the marginal worker employed in the high-risk industry, $f_L(l_H, k)$, coincides with the measure of point D on the y-axis in Figure 1. I thus calibrate this marginal productivity with the labor costs in the low-risk industry with incomplete experience rating: $f_L(l_H, k) = w_L + (1-e)B$. The total expected benefit cost B , defined in Equation 4, depends on the employment share in the high-risk industry, l_H , the benefit level b , and the unemployment risk in the high-risk industry, r_H . I calibrate $l_H = 0.56$ using the employment share of high-risk industries in South Carolina in 2006 in the QCEW data, and use the values for r_H , e , and b just derived to obtain $B = 77$ and $f_L(l_H, k) = \$37,293$.

I find that the reallocation of an additional worker in the high-risk industry induces a fiscal externality of -7.25 and a loss from skill misallocation of -4.01. The smaller contribution of skill misallocation is driven by the modest net productivity loss of \$19. This suggests that the marginal worker is similarly productive across different industries. Combined, these parameters give a total value of λ of -11.26. Multiplying the estimate for λ by the estimate for the high-risk labor demand, $\epsilon_{l_H, e}$, gives a total cost of labor reallocation of 2.93. This value indicates that for every dollar of insurance offered to employers, \$2.93 are lost due to the skill misallocation and fiscal externality associated with the reallocation of workers towards high-unemployment risk industries.

4.2 Calibrating the Marginal Cost of Employer Moral Hazard

Equation 10 shows that the marginal cost of employer moral hazard is calculated by multiplying the elasticity of effort to prevent negative shocks with respect to the degree of experience rating, $\epsilon_{m,e}$, by the scaling factor μ . This scaling factor, defined in Equation 12, captures the fiscal externality associated with employers' reduced effort to avoid layoffs. Table 4 presents the calibrated values for $\epsilon_{m,e}$ and the parameters within μ (r_H , m , and e), along with a description of the approach and the data used for their calibration.

To calibrate the effort elasticity, I leverage the relationship in the model between effort, m , and unemployment risk in the high-risk industry, $r_H = p_H + \frac{1}{m}$. Section O.B.8 shows that the effort elasticity is a transformation of the elasticity of the unemployment risk in the high-risk industry with respect to the degree of experience rating: $\epsilon_{e,m} = -r_H m(\epsilon_{r_H,e})$. This transformation is convenient because I can calibrate $\epsilon_{r_H,e}$ with an estimate of the layoff elasticity with respect to the degree of experience rating from the literature on employer moral hazard. Table A6 present various estimates from this literature, ranging between -0.43 and zero. I selected -0.27 from Topel (1984), lying in the middle of the range, as preferred estimate, and explore the implications of using alternative estimates.³³

To calibrate the effort exerted to avoid negative shocks, $m = \frac{1}{r_H - p_H}$, I need to quantify p_H , the exogenous part of unemployment risk in the high-risk industry. To do so, I assume that the unemployment risk structure in the low-risk industry resembles that of the high-risk industry, $r_L = p_L + \frac{1}{m}$, with the exception that there is no exogenous risk, $p_L = 0$, and further assume that employers in low- and high-risk industries exert the same level of effort m . This allows me to calculate p_H as the difference in the unemployment risk between high- and the low- risk industries, $p_H = r_H - r_L$. Using the calibrations for r_H and r_L previously described, I find that $p_H = 0.03$, and thus that $m = 62.5$. These values yield an elasticity of effort with respect to the degree of experience rating equal to $\epsilon_{m,e} = 0.78$.

Lastly, I use Equation 12 to calculate μ , representing the fiscal externality associated with reduced effort to prevent layoffs. I find that $\mu = 2.52$. Multiplying this value by the effort elasticity gives a marginal cost of employer moral hazard of 1.97. This indicates that for every dollar of insurance offered to employers, \$1.97 are lost due to the fiscal externality generated by increased layoffs.

4.3 Calibrating the Marginal Value of Insurance for Employers

In Equation 10, the sufficient statistic that embodies the marginal benefit of insurance for employers is the normalized gap in marginal profits between the good and the bad states of the world for the high-risk employer. A lower degree of experience rating functions as insurance for the high-risk employer by closing this gap. The marginal profit gap, equivalent to q , measures the loss associated with each dollar of unemployment tax increase, due, for example, to higher borrowing costs.

In the model, these losses affect welfare because profits enter the social welfare function through capitalists' utilities. A lower degree of experience rating increases employers' net worth, consequently increasing the return from capital investment consumed by capitalist. However, the value of insurance for employers does not depend on this specific modeling choice. Here, I explore two alternative modeling approaches that yield equivalent implications for optimal policy and offer additional insights into calibrating the marginal value of insurance for employers.

The first approach incorporates profits in the social welfare function through workers' utilities by assuming

³³In particular, the estimate of zero from Johnston (2021) would minimize the marginal cost of insurance by setting the marginal cost of moral hazard to zero. However, it's important to note that this estimate is derived from a sample of employers in Florida who are assigned the maximum unemployment tax rate. These employers are likely to be firms that either have already laid off workers or have a consistently high layoff rate, regardless of the cost associated with layoffs. As a result, the estimated layoff elasticity of zero for this sample likely represents a lower bound for the layoff elasticity in the state.

that workers, instead of capitalists, value the continuity and survival of employers. This could occur either because workers themselves supply capital and consume the return from their investment, or because shocks to employers result in layoffs and unemployment for workers, creating a gap in workers' marginal utility of consumption between states. This suggests that the value of insurance for employers may be proxied with the value of insurance for workers. Table A7 illustrates various estimates for the value of insurance for workers from the literature. The upper bound of these estimates is 3.13 from Landais et al. (2021). Interpreted as the value of insurance for employers, this estimate indicates that employers are willing to pay \$3.13 to shift a dollar from the good to the bad state of the world.

The second approach directly incorporates profits as a factor in social welfare. One possible justification is the existence of liquidity constraints or wage rigidities preventing employers from optimally adjusting following a shock. Giupponi et al. (2022) find that subsidizing jobs with short time work policies increases employment and the probability of survival especially for liquidity constrained employers, suggesting these inefficiencies may be in place. Therefore, the value of insurance for employers could be calibrated with their estimated elasticity of employment with respect to the number of hours subsidized with short-time work. The estimate of 2.53 from Giupponi et al. (2022) would indicate that employers are willing to pay \$2.53 to shift a dollar from the good to the bad state.

4.4 Optimal Degree of Experience Rating

The calibration of the various parameters in Equation 10 enables me to quantify the marginal benefit and the marginal cost of insurance for employers. Comparing their values provides insights into the optimal unemployment insurance financing policy. If the marginal benefit exceeds the marginal cost, reducing the degree of experience rating is welfare-improving. Conversely, if the marginal cost exceeds the benefit, experience rating should be increased to achieve greater welfare.

First, the total marginal cost of insurance for employers is calculated by summing the costs from labor reallocation (2.93) and employer moral hazard (1.97). The resulting total marginal cost is 4.9. Labor reallocation, accounting for 60% of the total cost, emerges as the primary driver of the inefficiency from incomplete experience rating in South Carolina. The key role of labor reallocation is confirmed in panel (a) of Figure 8 showing that the cost of employer moral hazard ranges between zero and 3.12 depending on the estimate for the layoff elasticity used. Across these scenarios, labor reallocation remains at least as important as moral hazard in determining the marginal cost of insurance. This finding is important both conceptually, given the limited attention that the inefficiencies from labor reallocation received relative to those from employer moral hazard in existing literature, and for its policy implications. Acknowledging the inefficiencies from labor reallocation implies recognizing that coinsurance remains inefficient even in even those contexts in which employer moral hazard is limited. Such settings include European countries, where layoffs are reduced by robust employment protection policies, and seasonal industries, compelled to downsize their workforce during the low season.

Next, I compare the marginal cost of insurance, 4.9, with the two calibrations for the marginal value, 3.13 and 2.58. These figures indicate that for every dollar of insurance offered to employers, up to \$3.13 are

gained in insurance value, but \$4.9 are lost due to labor reallocation and employer moral hazard. The finding that the marginal cost of insurance exceeds the marginal value suggests that in South Carolina employers were overinsured and the degree of experience rating was suboptimal before the reform. Supporting this interpretation, panel (b) of Figure 8 shows that the marginal cost of insurance becomes slightly smaller than the value only when using the layoff elasticity of zero and there is no employer moral hazard. Moreover, Section 2.3 discussed that the cost of insurance is likely to increase when extending the model to incorporate other features, such as individual preferences for industries or employment.

While this analysis suggests that increasing the degree of experience rating was welfare-improving in South Carolina pre-reform, this conclusion should be interpreted with caution. The current calibrations of the value of insurance for employers, based on estimates from other countries and historical periods, may not fully capture the magnified value of insurance for employers during the Great Recession. Therefore, refining the characterization of the value of insurance for employers and understanding its variations over economic cycles is essential before making definitive policy recommendations. Depending on the findings, the optimal policy may involve less experience rating during recessions and more experience rating during periods of economic stability, reflecting changes in the underlying value of insurance for employers. An initial avenue for exploration in this context is suggested by Nekoei et al. (2020), who demonstrate that the proportion of temporary layoffs serves as a proxy for an employer's outlook regarding the future of the business. This metric could be employed to assess the value of insurance for employers both at the individual and industry level.

Additionally, this evaluation is based on local estimates and applies to the specific context from which these estimates were derived, namely, South Carolina. The broader relevance of these results depends on how closely South Carolina resembles other US states in terms of their labor markets and experience rating policies. The substantial differences in labor market institutions between the United States and European countries or Canada further limit the generalizability of these findings to those regions. Determining the desirability of experience rating across different periods and regions is thus the next step on the agenda. The theoretical and empirical foundations laid out in this paper provide a basis for further research evaluating experience rating policies across US states and exploring the implications of adopting of experience rating in countries where it is not currently implemented.

5 Conclusions

Unemployment insurance provides crucial support for unemployed workers. However, the program entails significant costs, ranging between 0.12% and 2.8% of the GDP in western economics. A significant portion of the funding for unemployment benefits is derived from payroll taxes imposed on employers. However, there are notable differences in how governments determine and allocate unemployment tax rates to employers across various countries. While in the United States employers are assigned individualized unemployment tax rates based on the benefit cost of their layoffs (experience rating), most other countries assign a common tax rate to all employers irrespective of individual costs. (coinsurance). Which of these two approaches is preferable is unclear, and policymakers often lack clear guidance for making informed choices in this regard.

This paper investigates theoretically and empirically the optimal design of unemployment insurance financing policies. First, I derive a formula for the optimal financing scheme as a function of estimable sufficient statistics. This employer-Baily-type formula specifies that the optimal scheme balances the marginal value and cost of insuring employers through coinsurance. On the one hand, coinsurance acts as a safeguard for employers, insuring them against steep increases in unemployment taxes in case of negative shocks. On the other hand, coinsurance comes with two costs. First, it reduces the private cost of layoffs internalized by employers, leading to more frequent layoffs. This employer moral hazard imposes a fiscal externality on the government budget through a higher benefit spending. Second, it subsidizes the expansion of high-unemployment risk industries, leading to the reallocation of workers towards those industries. This both results in the misallocation of productive skills and imposes a fiscal externality through a higher benefit spending, as more workers are exposed to high-unemployment risk.

In the empirical part of the paper, I put the formula into practice by assessing the magnitude of the marginal benefit and cost of insurance. I estimate the marginal cost of labor reallocation using unemployment tax filing data from South Carolina and Colorado and leveraging quasi-experimental variation in unemployment taxes from state-level reforms of experience rating policies. Then, I calibrate the other statistics in the formula using various moments from the data and estimates from the literature.

My results suggest that labor reallocation is the predominant source of inefficiency arising from incomplete experience rating in South Carolina. This finding emphasizes the crucial role of this channel, which has received relatively less attention in the literature compared to employer moral hazard. Moreover, the extent of interindustry labor reallocation determines the inefficiency of coinsurance in settings with limited employer moral hazard. These settings include European countries, where layoffs are limited by robust employment protection policies, and seasonal industries, compelled to reduce their workforce during the low season irrespective of the associated layoff costs.

Additionally, the combined marginal cost of moral hazard and labor reallocation is larger than the marginal value of insurance, suggesting that the degree of experience rating was suboptimal in South Carolina. Nonetheless, further research characterizing the value of insurance for employers over economic cycles is needed before making definite policy recommendations. Depending on the outcomes of such research, the optimal policy may entail reducing the experience rating during recessions, when the marginal value of insurance is at its peak, and increasing it during periods of economic stability.

The theoretical and empirical foundations laid out in this paper provide a basis for further research evaluating experience rating policies across US states and exploring the implications of adopting of experience rating in countries where it is not currently implemented. This research is particularly pressing in the European Union, where the recent introduction of layoff taxes in some countries and the ongoing design of the European Unemployment Benefit Scheme have sparked interest in potentially moving closer to the United States' experience rating model, following recommendations from experts (Fuest et al. 2005, Simonetta 2017).

While this paper primarily explores unemployment tax rates for employers, it's important to recognize that this policy choice is interconnected with the design of worker tax rates and the generosity of unemployment

benefits. Future research should also explore the implications of experience rating for workers and investigate the optimal joint design of unemployment benefits and taxes, providing a more comprehensive understanding of the unemployment insurance system and more informed policy recommendations.

The evaluation of the policy reforms in South Carolina and Colorado leads to two concluding considerations. First, South Carolina's switch from a reserve ratio system to a benefit ratio system provides insights into the labor market effects of alternative designs of experience rating policies. The choice between these two systems, each with its unique lookback periods and factors used to assess experience, significantly affects the distribution of unemployment tax burdens among employers. Policymakers need to consider these implications when deciding which measure to use for allocating unemployment taxes among various employer groups and stakeholders. Lastly, governments should consider employers' reactions to increased taxes, as these responses can significantly affect the tax revenue they can collect. These considerations hold particular relevance in the ongoing debate about the generosity of unemployment benefits in the United States. After substantial reductions in these benefits following the Great Recession, there's a proposal to increase them with higher unemployment taxes (Wandner 2023). The results of the paper indicate that higher unemployment taxes reduce employment in industries with high average unemployment tax rate, potentially contributing to increased unemployment in the short term.

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Main Tables

Table 1: Summary Statistics for South Carolina Employers in 2009

	N	Mean	Std. dev.	Min	Median	Max
<i>Panel A: Main Outcomes</i>						
Tax per worker	31,878	128.258	79.020	91	91	427
Number of employees	31,878	11.980	20.422	0	5	480
Total wages	31,878	451,578.079	953,671.469	0	155,714.133	26,304,760
Average wage	31,583	40,225.009	59,957.251	0	30,000	6,212,177.500
Taxable wages	31,878	97,559.060	168,956.792	0	39,899.460	3,459,624.406
Total taxes	31,878	1,890.495	4,151.008	0	637	117,627.234
<i>Panel B: Other Characteristics</i>						
Year of establishment	31,878	1,991.553	10.978	1930	1995	2004
Primary	31,767	0.016	0.126	0.000	0.000	1.000
Construction	31,767	0.121	0.326	0	0	1
Manufacturing	31,767	0.060	0.238	0	0	1
Trade	31,767	0.221	0.415	0	0	1
Transport	31,767	0.024	0.152	0	0	1
Services	31,767	0.557	0.497	0	1	1
Reserve ratio	31,855	-0.051	6.629	-157.819	-0.144	962.185

Notes: This table shows summary statistics for South Carolina employers in the study sample in 2009. The tax per worker is obtained by multiplying employers' individual tax rates by the taxable wage base (\$7,000). The number of employees is the average across the four quarters of the year. The quarterly number of employees is the average across the three months in the quarter. Each month, employers are asked to count the number of employees on payroll for the week containing the 12th of the month. Total wages are the sum of the yearly wages of all the employees. The average wage is obtained by dividing total wages by the number of employees. Taxable wages are the part of workers' yearly wages subject to taxes. Total taxes are obtained by multiplying employers' individual tax rate by the taxable wages. The reserve ratio is calculated as in Equation 13.

Table 2: Employment and Wage Elasticities with respect to the Unemployment Tax Per Worker

	Full Sample	Low Risk	High Risk
<i>Panel A: Number of Employees</i>			
Treated \times 2013: β	-0.895**	0.384**	-2.415**
Treated \times 2013: <i>se</i>	(0.387)	(0.183)	(0.994)
Mean 2010 Treated	6.060	5.104	6.054
<i>Panel B: Average Wage</i>			
Treated \times 2013: β	1532.841	-879.258	3408.994
Treated \times 2013: <i>se</i>	(1938.173)	(2257.449)	(3648.855)
Mean 2010 Treated	40948.286	41466.840	40584.313
<i>Panel C: Tax Per Worker</i>			
Treated \times 2013: β	143.267***	154.368***	148.038***
Treated \times 2013: <i>se</i>	(14.116)	(19.707)	(24.756)
Mean 2010 Treated	98.185	96.678	96.269
<i>Panel D: Elasticities</i>			
Employment elasticity w.r.t. tax per worker	-0.101	0.047	-0.259
Wage elasticity w.r.t. tax per worker	0.026	-0.013	0.055

Notes: This table illustrates the elasticities of employment and wages with respect to the unemployment tax per worker and the components that contribute to their calculation for South Carolina employers with 1-50 quarterly employees in 2010. Elasticities are calculated using Equation 18. The *Treated* \times 2013 coefficients and standard errors are estimated from Equation 16. The elasticities and their determinants are reported for the full sample and the subsamples of employers in low- and high-unemployment risk industries. High-unemployment risk industries have a median within-year standard deviation in employment between 1998 and 2006 greater than 250 according to the Quarterly Census of Employment and Wages data for South Carolina. Industries are defined using the NAICS-4 digits code.

Table 3: Marginal Cost of Interindustry Labor Reallocation: Parameters' Estimated and Calibrated Values

Parameter	Description	Approach	Data	Value
e	Degree of experience rating of the unemployment insurance system	Average value, calculated between 2007 and 2010, of the median tax cost per dollar of unemployment benefit charged to South Carolina employers between July 2005 and July 2006	SC DEW	.75
b	Unemployment benefit level	Average unemployment benefit in South Carolina in 2006	ET 394	\$2,986
r_H	Unemployment risk in the high-risk industry	Trough-to-peak employment in high-risk industries in South Carolina in 2006	QCEW	.046
w_L	Wage in the low-risk industry	Average yearly wage in low-risk industries in South Carolina in 2006	QCEW	\$37,274
l_H	Employment share in the high-risk industry	Employment share of high-risk industries in South Carolina in 2006	QCEW	0.56
B	Total expected unemployment benefit cost	$bl_H r_H$, using Equation 4	-	\$77
$f_L(l_H, k)$	Productivity of the marginal worker in the low-risk industry	$w_L + (1-e)B$, using Figure 1	-	\$37,293
$\frac{f_L(l_H, k) - w_H}{e b r_H^2}$	Skill misallocation	Equation 11	-	-4.01
$\frac{(1-e)}{e r_H}$	Fiscal externality	Equation 11	-	-7.25
λ	Skill misallocation + fiscal externality	Equation 11	-	-11.26
$\epsilon_{l_H, e}$	Labor demand elasticity w.r.t. degree of experience rating for high-risk employer	Estimated labor demand elasticity w.r.t. unemployment tax per worker for employers in high-risk industries	SC DEW	-.26
$\lambda \epsilon_{l_H, e}$	Marginal cost of labor reallocation	-	-	2.93

Notes: This table reports the approach and data source used to estimate or calibrate the parameters determining the marginal cost of labor reallocation, together with their values.

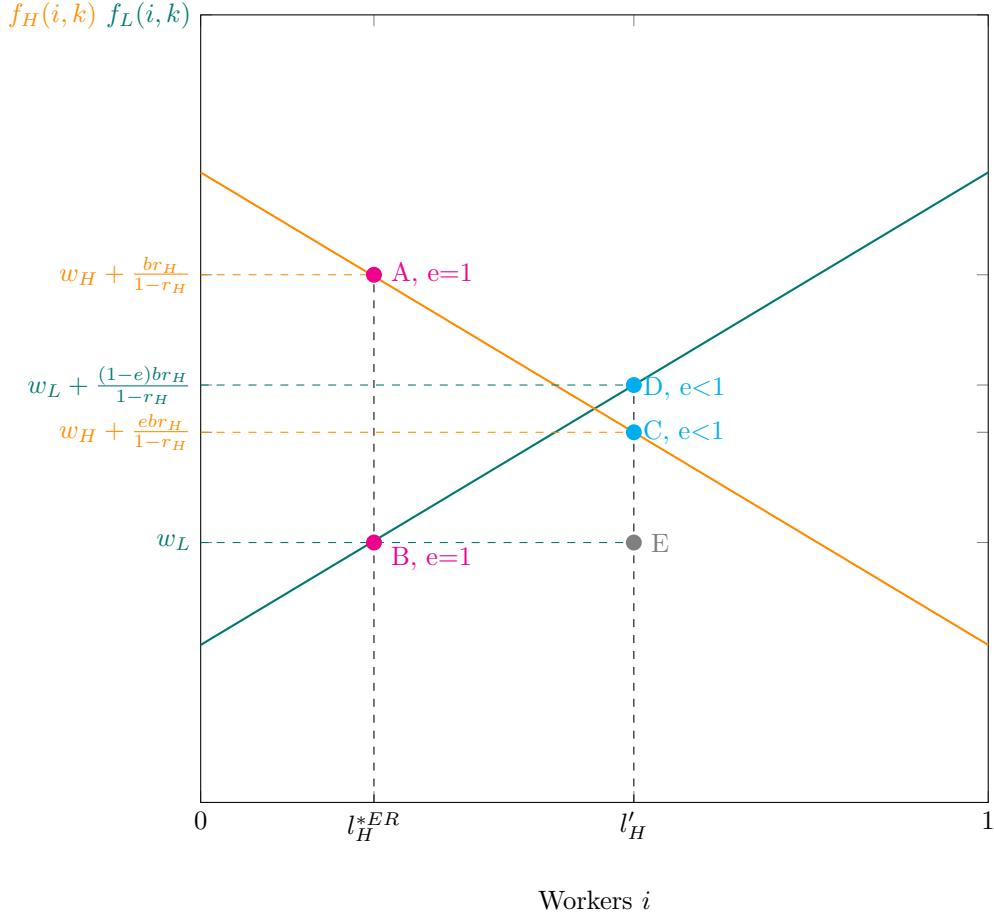
Table 4: Marginal Cost of Employer Moral Hazard: Parameters' Calibrated Values

Parameter	Description	Approach	Data	Value
$\epsilon_{r_H,e}$	Elasticity of unemployment risk w.r.t. degree of experience rating	Elasticity of temporary layoffs w.r.t. experience rating	Topel (1984)	-0.27
r_H	Unemployment risk in the high-risk industry	Trough-to-peak employment in high-risk industries in South Carolina in 2006	QCEW	.046
r_L	Unemployment risk in the low-risk industry	Trough-to-peak employment in low-risk industries in South Carolina in 2006	QCEW	.016
p_H	Exogenous component of unemployment risk in the high-risk industry	$r_H - r_L$, assumption	-	.03
m	Effort to avoid shock	$\frac{1}{r_H - p_H}$ from definition of r_H	-	62.5
e	Degree of experience rating of the unemployment insurance system	Average value, calculated between 2007 and 2010, of the median tax cost per dollar of unemployment benefit charged to South Carolina employers between July 2005 and July 2006	SC DEW	.75
μ	Fiscal externality	Equation 12	-	2.52
$\epsilon_{m,e}$	Elasticity of effort to avoid shocks w.r.t. degree of experience rating	$-r_H m(\epsilon_{r_H,e})$	-	.78
$\mu\epsilon_{m,e}$	Marginal cost of insurance due to employer moral hazard	-	-	1.97

Notes: This table reports the approach and data source used to estimate or calibrate the parameters determining the marginal cost of employer moral hazard, together with their values.

Main Figures

Figure 1: Experience Rating and the Misallocation of Productive Skills in the Economy

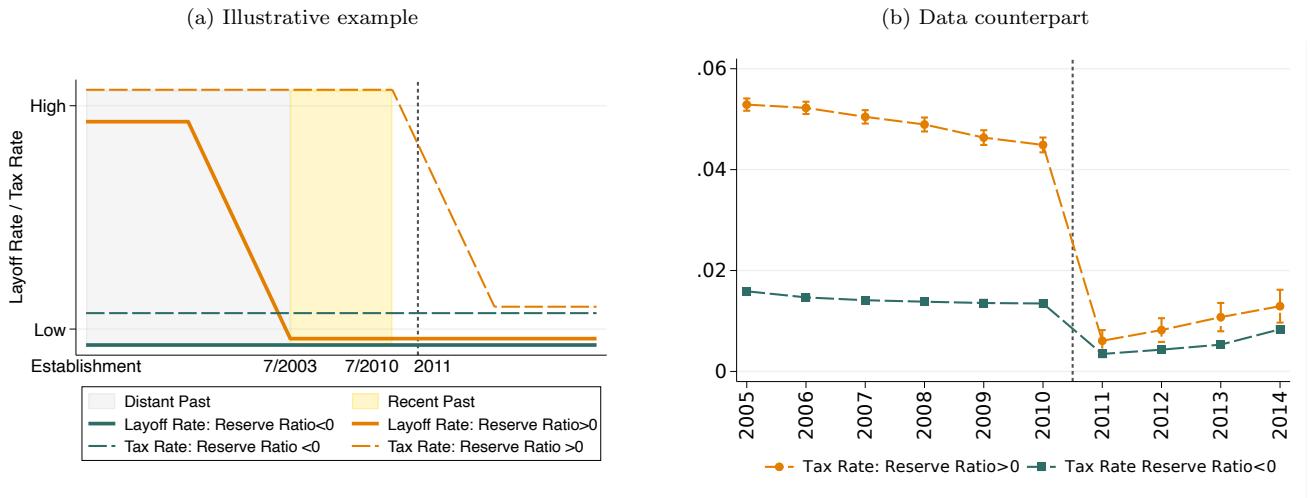


Notes: This graph illustrates the productivity in the low-risk industry, $f_L(i, k)$ and in the high-risk industry, $f_H(i, k)$ for each worker $i \in [0, 1]$ on the x-axis. Points A and B specify the allocation of workers between industries with complete experience rating ($e = 1$); points C and D with a coinsurance ($e < 1$). l_H^{*ER} is the prevailing employment share in the high-risk industry and the marginal worker hired in the high-risk industry with complete experience rating. l_H' with coinsurance.

Figure 2: Model Timeline

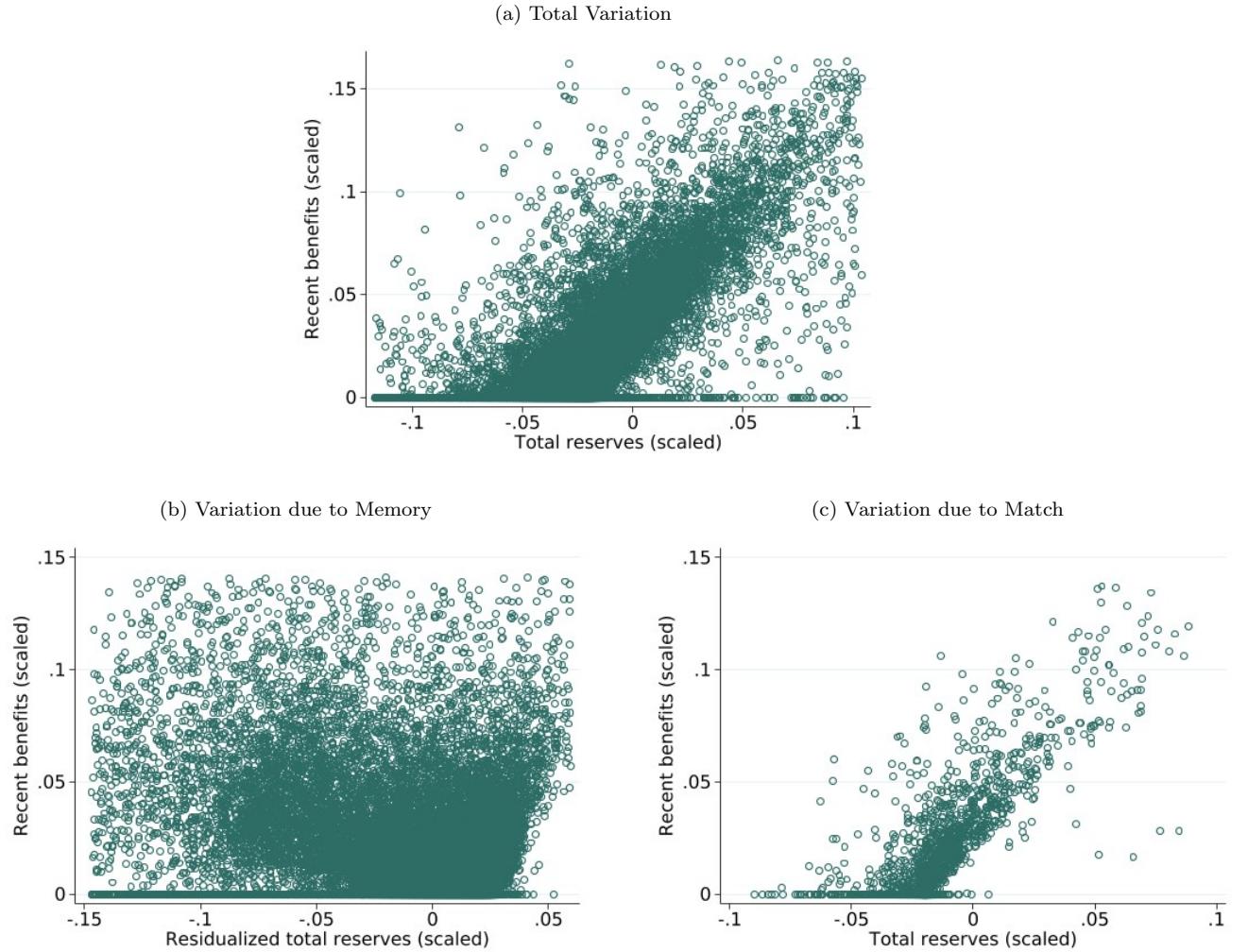


Figure 3: Variation in Unemployment Tax Rates by Reserve Ratio Conditioning on the Benefit Ratio



Notes: Panel (a) illustrates the layoff rates (solid lines) and tax rates (dashed lines) of two representative employers with equal benefit ratio but different reserve ratio (positive: orange; negative: green) over time. Time is split into the distant past, ranging between the employers' establishment date and seven years before the 2011 reform, and the recent past, covering the seven years before the reform. Panel (b) plots the average tax rate for South Carolina employers with positive (orange) or negative (green) reserve ratio and a predicted benefit ratio equal to zero. 95% confidence intervals are reported.

Figure 4: Variation between South Carolina Employers' Reserve Ratios and Benefit Ratios



Notes: This figure illustrates the variation between South Carolina employers' reserve ratios and benefit ratios and the drivers of this variation. Panel (a) plots employers by their 2011 recent benefits and 2010 total reserves, both scaled by recent taxable wages. Scaled recent benefits thus coincide with the benefit ratio, while scaled total reserves are a modified version of the reserve ratio maintaining the original numerator but using the benefit ratio's denominator. This allows me to isolate the variation between the reserve ratios' and benefit ratios' numerators. Equation 17 shows that the variation between the numerators of the reserve ratio and the benefit ratio is driven by the distant past balance and recent taxes. Panels (b) and (c) aim at understanding the relative contribution of these two factors to the total variation. Panel (b) plots employers by their scaled recent benefits and residualized scaled total reserves. The latter are obtained from a regression of scaled total reserves on scaled recent taxes. This allows me to isolate the variation driven by the distant past balance and observe the role of “*memory*.” Panel (c) plots scaled recent benefits against scaled total reserves for employers “without memory”, namely, employers established in 2003 or later, whose total reserves coincide with their recent reserves. This allows me to focus on the role of “*match*”. All these variables have been trimmed at the first and ninety-ninth percentile.

Figure 5: Full Sample Reduced Form Effects on Employer Outcomes

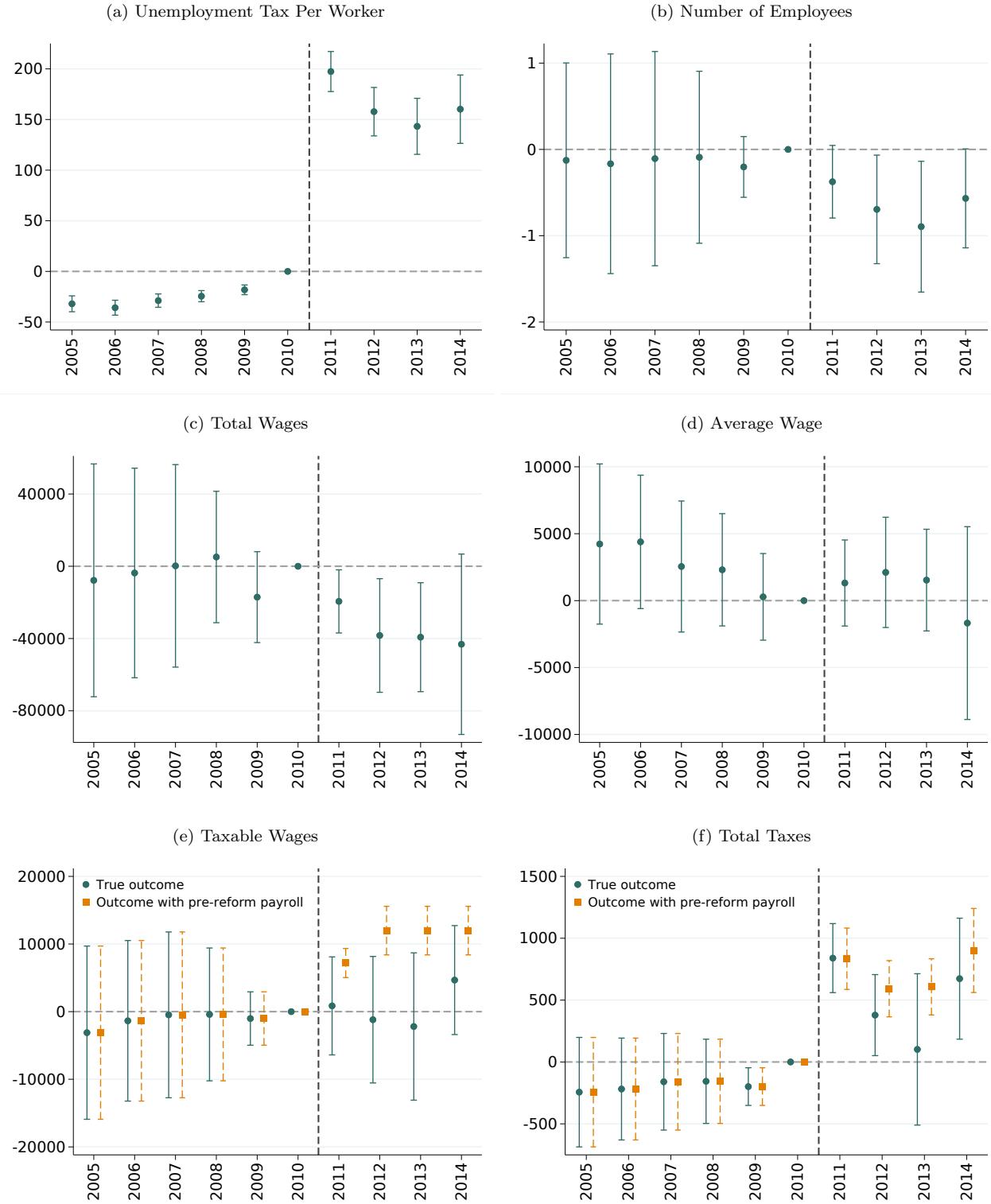
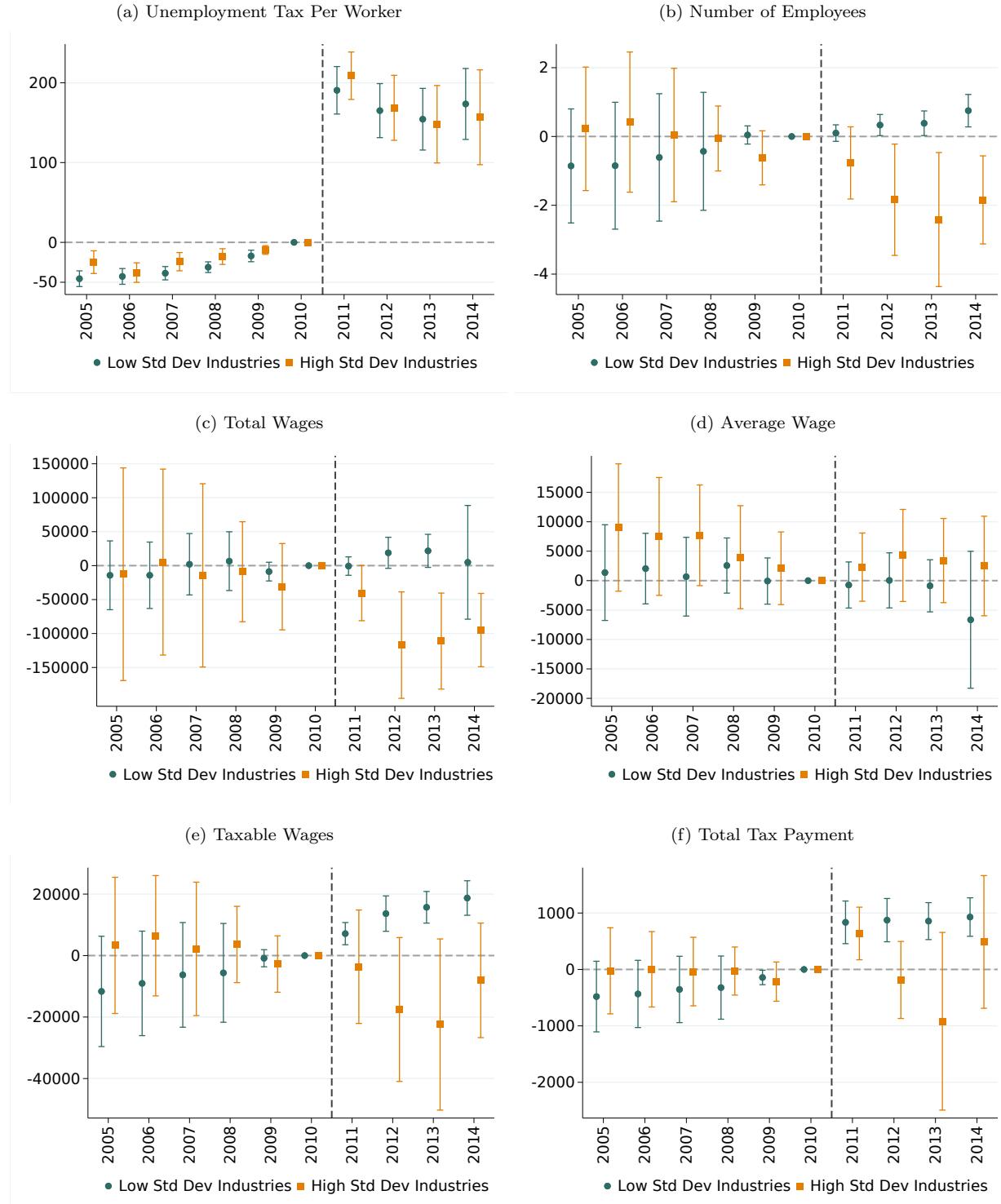
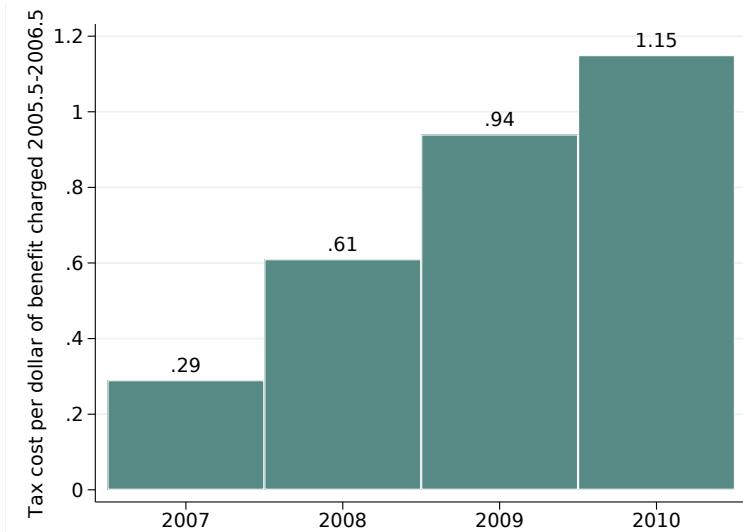


Figure 6: Heterogeneous Reduced Form Effects by Industry-Within Year Employment Standard Deviation



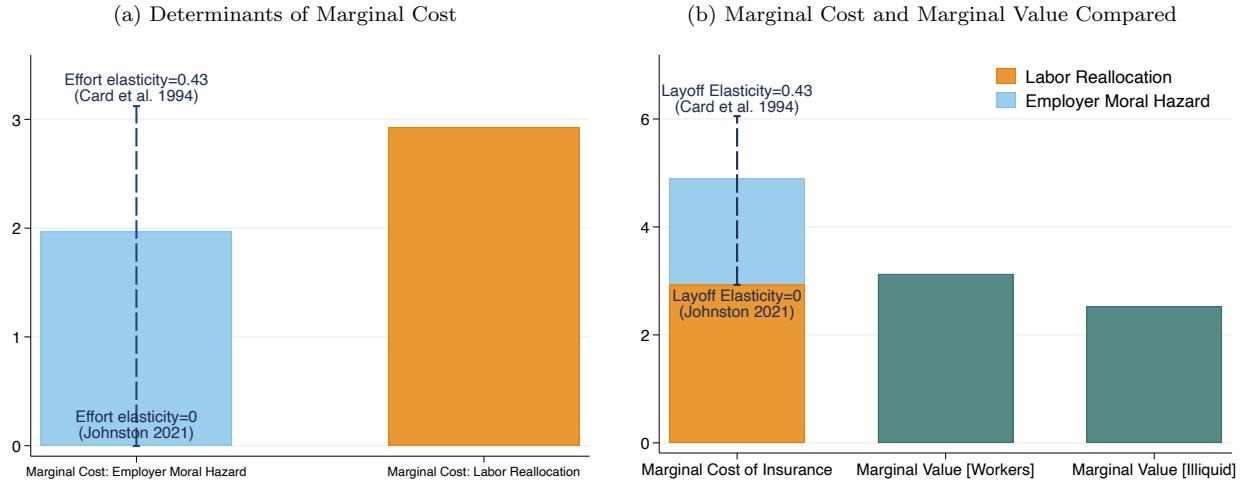
Notes: This figure illustrates the estimated β_y coefficients from Equation 16 for South Carolina employers with 1-50 quarterly employees in 2010 in industries with low- and high-within year employment standard deviation. High-standard deviation industries have average within-year standard deviation of employment between 2001 and 2006 greater than or equal to 250 based on the QCEW data for South Carolina. Refer to the Table 1 notes for information on the main outcomes. 95% confidence intervals are reported. Coefficients and standard errors are reported in Table A5.

Figure 7: The Degree of Experience Rating in South Carolina, 2005-2010



Notes: This figure illustrates the median cumulated tax cost per dollar of unemployment benefit charged to South Carolina employers between July 2005 and July 2006. The tax cost in each year represents the cumulated tax cost between 2007 and that year. These values are calculated for South Carolina employers observed continuously between 2007 and 2010 and with no other benefit charges between July 2003 and July 2011 than the ones charged between July 2005 and July 2006. The value of e in Tables 3 and 4 is calculated as the average of these median tax costs per dollar of benefit charge.

Figure 8: Marginal Cost and Marginal Value of Insurance for Employers in South Carolina



Notes: Panel (a) compares the two components of the marginal cost of insurance for employers in South Carolina: the cost from labor reallocation, calculated in Table 3, and the cost from employer moral hazard, calculated in Table 4. The cost of moral hazard is based on an estimate for the layoff elasticity with respect to the degree of experience rating from Topel (1984). The dashed line shows how the cost of moral hazard would change with alternative estimates for the layoff elasticity. The cost ranges between zero, when using the null layoff elasticity from Johnston (2021), and 3.12, when using the layoff elasticity of -0.43 from Card et al. (1994). Panel (b) compares the marginal cost of insurance for employers, obtained by summing the costs from labor reallocation and employer moral hazard, with the marginal value of insurance for employers. The marginal value is calibrated either using the value of insurance for workers from Landais et al. (2021), or with the employment elasticity with respect to the number of hours subsidized with short-term work for employers with liquidity constraints from Giupponi et al. (2022). The dashed line shows that the marginal cost of insurance ranges between 2.93 and 6.05 depending on the estimated layoff elasticity used in the calculation of the cost of employer moral hazard.

Supplementary Tables and Figures

Table A1: Representativeness of the SC DEW Dataset

	% Employers		% Employees		Average yearly wage	
	SC DEW	QCEW	SC DEW	QCEW	SC DEW	QCEW
Primary	.011	.011	.014	.010	\$31,016	\$29,601
Construction	.141	.118	.094	.067	\$32,900	\$40,264
Manufacturing	.043	.046	.098	.112	\$39,828	\$43,815
Trade	.199	.234	.178	.199	\$41,602	\$31,724
Transport	.028	.025	.030	.034	\$39,806	\$36,357
Services	.578	.567	.586	.579	\$36,546	\$33,127

Notes: This table compares the distribution of the share of employers, the share of employees, and the average wage across broad economic sectors between the SC DEW data, excluding the top 1% largest employers, and the QCEW data, covering all private sector employers in South Carolina in 2009.

Table A2: South Carolina Study Sample and Excluded Employers: Summary Statistics and Balance Tests

	Study Sample (SC DEW)			Excluded Employers (SC DEW)			Difference	P-value
	N	Mean	Std. dev.	N	Mean	Std. dev.		
<i>Panel A: Main Outcomes</i>								
Tax per worker	31878	128.258	79.020	82120	179.759	82.704	-51.501	0.000
Number of employees	31878	11.980	20.422	71978	5.686	18.705	6.293	0.000
Total wages	31878	451578.079	953671.469	71975	172348.859	647988.999	279229.220	0.000
Average wage	31583	40225.009	59957.251	62052	35983.206	92069.699	4241.803	0.000
Taxable wages	31878	97559.060	168956.792	82120	41571.602	133931.239	55987.458	0.000
Total taxes	31878	1890.495	4151.008	82120	1020.303	3694.009	870.191	0.000
<i>Panel B: Other Characteristics</i>								
Year of establishment	31878	1991.553	10.978	81893	2002.622	8.160	-11.069	0.000
Primary	31767	0.016	0.126	81668	0.009	0.096	0.007	0.000
Construction	31767	0.121	0.326	81668	0.149	0.356	-0.029	0.000
Manufacturing	31767	0.060	0.238	81668	0.037	0.188	0.024	0.000
Trade	31767	0.221	0.415	81668	0.190	0.393	0.031	0.000
Transport	31767	0.024	0.152	81668	0.029	0.168	-0.005	0.000
Services	31767	0.557	0.497	81668	0.585	0.493	-0.028	0.000
Reserve ratio	31855	-0.051	6.629	79671	-5.068	895.472	5.018	0.317

Notes: This table presents summary statistics for a set employer characteristics in 2009 and tests for difference in means between the group of South Carolina employers satisfying the criteria to enter the study sample and the remaining employers. See Section 3.2 for details on the study sample.

Table A3: South Carolina Industries with High-Standard Deviation: Turnover and Unemployment Risk

NAICS	Denomination	High Std Dev	High Tax Rate
1113	Fruit and Tree Nut Farming	✓	✓
1119	Other Crop Farming	✓	✓
2111	Oil and Gas Extraction		✓
2211	Electric Power Generation, Transmission and Distribution	✓	
2361	Residential Building Construction	✓	✓
2362	Nonresidential Building Construction	✓	✓
2381	Foundation, Structure, and Building Exterior Contractors	✓	✓
2382	Building Equipment Contractors	✓	✓
2383	Building Finishing Contractors	✓	✓
2389	Other Specialty Trade Contractors	✓	✓
3131	Fiber, Yarn, and Thread Mills	✓	
3132	Fabric Mills	✓	✓
3133	Textile and Fabric Finishing and Fabric Coating Mills	✓	✓
3141	Textile Furnishings Mills	✓	✓
3222	Converted Paper Product Manufacturing	✓	
3252	Resin, Synthetic Rubber ...	✓	
3261	Plastics Product Manufacturing	✓	
3359	Other Electrical Equipment and Component Manufacturing	✓	
3363	Motor Vehicle Parts Manufacturing	✓	
4235	Metal and Mineral (except Petroleum) Merchant Wholesalers	✓	
4431	Electronics and Appliance Stores.	✓	
4441	Building Material and Supplies Dealers	✓	
4451	Grocery Stores	✓	✓
4461	Health and Personal Care Stores		
4471	Gasoline Stations	✓	✓
4481	Clothing Stores	✓	✓
4511	Sporting Goods, Hobby, and Musical Instrument Stores	✓	✓
4521	Department Stores	✓	✓
4921	Couriers	✓	
5121	Motion Picture and Video Industries	✓	✓
5221	Depository Credit Intermediation	✓	
5222	Nondepository Credit Intermediation	✓	
5312	Offices of Real Estate Agents and Brokers	✓	
5411	Legal Services	✓	
5412	Accounting, Tax Preparation, Bookkeeping, and Payroll Services	✓	✓
5413	Architectural, Engineering, and Related Services	✓	✓
5416	Management, Scientific, and Technical Consulting Services	✓	
5613	Employment Services	✓	✓
5616	Investigation and Security Services	✓	
5617	Services to Buildings and Dwellings	✓	✓
6211	Offices of Physicians	✓	
6216	Home Health Care Services	✓	
6221	General Medical and Surgical Hospitals	✓	
7112	Spectator Sports	✓	✓
7131	Amusement Parks and Arcades	✓	✓
7139	Other Amusement and Recreation Industries	✓	✓
7211	Traveler Accommodation	✓	✓
7221	Full-Service Restaurants	✓	✓
7222	Limited-Service Eating Places	✓	✓
7223	Special Food Services	✓	✓

Notes: This table reports the NAICS four-digits code and the denomination of high-employment standard deviation industries in South Carolina. The table also indicates which, among these industries, also have high-average unemployment tax rate. High-unemployment risk industries have average within-year standard deviation of employment greater or equal to 250 according to the Quarterly Census of Employment and Wages data for South Carolina and Colorado between 2001 and 2006. High-unemployment tax rate industries have an average unemployment tax rate between 2001 and 2006 larger than 0.0059 (the study sample mean) based on the QCEW data for South Carolina.

Table A4: Full Sample Reduced Form Effects on Employer Outcomes

Outcome:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Tax per worker	Employees	Total wages	Average wage	Taxable wages	Taxable wages (2010 payroll)	Total taxes	Total taxws (2010 payroll)
Treated \times 2005	-31.999*** (4.003)	-0.126 (0.576)	-7,797.990 (32,870.817)	4,228.489 (3,053.160)	-3,109.353 (6,534.490)	-3,109.353 (6,534.490)	-243.931 (225.698)	-243.931 (225.698)
Treated \times 2006	-35.865*** (3.763)	-0.166 (0.649)	-3,713.626 (29,593.515)	4,389.001* (2,543.692)	-1,357.292 (6,055.655)	-1,357.292 (6,055.655)	-218.614 (210.029)	-218.614 (210.029)
Treated \times 2007	-28.877*** (3.367)	-0.107 (0.633)	220.419 (28,594.757)	2,549.163 (2,497.509)	-477.089 (6,254.873)	-477.089 (6,254.873)	-160.087 (199.126)	-160.087 (199.126)
Treated \times 2008	-24.484*** (2.803)	-0.091 (0.509)	5,123.444 (18,555.025)	2,304.777 (2,139.768)	-409.987 (5,010.487)	-409.987 (5,010.487)	-156.198 (173.741)	-156.198 (173.741)
Treated \times 2009	-18.204*** (2.441)	-0.203 (0.180)	-17,086.746 (12,837.579)	281.240 (1,651.322)	-1,019.697 (2,014.504)	-1,019.697 (2,014.504)	-198.974** (77.630)	-198.974** (77.630)
Treated \times 2011	197.396*** (10.086)	-0.374* (0.215)	-19,447.029** (8,914.287)	1,316.513 (1,640.092)	850.952 (3,698.944)	7,189.328*** (1,099.152)	839.321*** (142.305)	834.164*** (126.471)
Treated \times 2012	157.744*** (12.200)	-0.695** (0.321)	-38,320.585** (16,045.541)	2,111.847 (2,101.428)	-1,192.993 (4,771.922)	11,982.213*** (1,831.920)	378.604** (167.081)	591.968*** (115.900)
Treated \times 2013	143.267*** (14.116)	-0.895** (0.387)	-39,252.149** (15,382.852)	1,532.841 (1,938.173)	-2,201.282 (5,557.137)	11,982.213*** (1,831.920)	101.648 (312.096)	607.170*** (115.905)
Treated \times 2014	160.190*** (17.231)	-0.567* (0.292)	-43,169.141* (25,472.853)	-1,677.546 (3,675.095)	4,665.711 (4,110.560)	11,982.213*** (1,831.920)	673.278*** (249.413)	901.010*** (173.229)
Observations	184,610	184,610	184,610	182,663	184,610	184,610	184,610	184,610
R-squared	0.555	0.916	0.921	0.670	0.887	0.922	0.785	0.797
Mean outcome 2010	139.1	8.126	315906	40674	66509	66509	1417	1417
P-value post	0	0.241	0.103	0.691	0.0370	0	0	0
P-value pre	0	0.825	0.307	0.670	0.740	0.740	0.173	0.173

Notes: This table reports the estimated β_y coefficients from Equation 16 for South Carolina employers with 1-50 quarterly employees in 2010. The table reports the p-values from the tests that the post-reform coefficients (2011-2014) and the pre-reform coefficients (2005-2009) are jointly significant. Refer to the Table 1 notes for information on the main outcomes. The taxable wages based on the 2010 payroll in column (6) are equal to true taxable wages until 2010. In each year from 2011 on, they are equal to the taxable wages in 2010 scaled by the relative increase in the taxable wage base between that year and 2010. Total taxes based on the 2010 payroll in column (8) are calculated by multiplying employers' unemployment tax rates by the taxable wages based on the 2010 payroll. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Heterogeneous Reduced Form Effects on Employer Outcomes by Industry-Unemployment Risk

Industry Std Dev:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Tax per worker	Employees	Total wages	Average wage	Taxable wages	Total taxes						
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Treat \times 2005	-45.560*** (5.020)	-24.789*** (7.258)	-0.856 (0.846)	0.222 (0.915)	-14,250.890 (25,850.679)	-12,661.847 (79,897.823)	1,358.923 (4,147.385)	9,028.679 (5,521.515)	-11,656.399 (9,155.613)	3,303.906 (11,303.263)	-480.804 (319.278)	-24.114 (389.099)
Treat \times 2006	-42.699*** (5.039)	-37.867*** (6.247)	-0.850 (0.941)	0.418 (1.039)	-14,235.774 (24,962.774)	5,202.093 (69,872.337)	2,037.770 (3,060.986)	7,507.791 (5,107.744)	-9,041.350 (8,671.797)	6,450.197 (9,985.209)	-434.044 (303.795)	2.774 (340.871)
Treat \times 2007	-38.684*** (4.259)	-24.214*** (5.824)	-0.609 (0.945)	0.042 (0.989)	-2,047.508 (23,067.460)	-14,345.965 (68,858.868)	657.935 (3,412.869)	7,690.872* (4,363.426)	-6,283.966 (8,682.084)	2,176.472 (11,071.737)	-354.345 (299.976)	-37.234 (309.720)
Treat \times 2008	-31.128*** (3.411)	-17.803*** (5.026)	-0.432 (0.875)	-0.059 (0.482)	6,593.939 (22,081.521)	-8,987.301 (37,558.624)	2,564.390 (2,389.372)	3,982.117 (4,464.233)	-5,626.820 (8,197.852)	3,609.465 (6,330.474)	-321.938 (285.600)	-28.251 (217.298)
Treat \times 2009	-17.028*** (3.685)	-9.601*** (2.779)	0.044 (0.135)	-0.621 (0.401)	-8,777.727 (7,027.705)	-31,031.428 (32,449.815)	-68.559 (2,003.066)	2,099.945 (3,149.207)	-870.793 (1,420.345)	-2,749.813 (4,679.612)	-142.379** (65.212)	-215.762 (177.446)
Treat \times 2010	190.600*** (15.183)	208.869*** (15.158)	0.099 (0.123)	-0.768 (0.535)	-654.158 (6,929.547)	-40,477.216* (20,730.810)	-743.843 (1,998.971)	2,292.330 (2,958.278)	7,134.948*** (1,843.887)	-3,635.398 (9,413.994)	835.116*** (192.910)	637.599*** (237.769)
Treat \times 2012	165.132*** (17.263)	168.663*** (20.776)	0.332** (0.157)	-1.830** (0.825)	18,860.967 (11,661.894)	-117,087.278*** (39,986.545)	41,072 (2,386.749)	4,280.126 (3,991.172)	13,653.276*** (2,934.013)	-17,537.650 (11,937.507)	873.949*** (195.633)	-186.252 (348.062)
Treat \times 2013	154.368*** (19.707)	148.035*** (24.756)	0.354** (0.183)	-2.415** (0.994)	21,742.379* (12,420.317)	-111,160.953*** (36,080.743)	-879.214 (2,257.448)	3,409.050 (3,648.855)	15,707.891*** (2,623.257)	-22,432.566 (14,202.658)	856.606*** (166.975)	-918.472 (803.190)
Treat \times 2014	173.492*** (22.679)	156.827*** (30.317)	0.751*** (0.241)	-1.843*** (0.653)	4,862.005 (42,721.812)	-94,926.631*** (27,529.836)	-6,651.810 (5,935.416)	2,487.624 (4,313.896)	18,722.628*** (2,864.794)	-8,061.617 (9,505.419)	928.585*** (173.952)	487.653 (599.927)
Observations	100,680	70,460	100,680	70,460	100,680	70,460	99,644	69,630	100,680	70,460	100,680	70,460
R-squared	0.504	0.473	0.911	0.908	0.887	0.926	0.662	0.670	0.877	0.874	0.780	0.732
Mean Outcome 2010	135.7	143.5	7.785	8.569	314279	318105	41960	39019	63345	70624	1330	1530

Notes: The table reports the estimated β_y coefficients from Equation 16 for South Carolina employers with 1-50 quarterly employees in 2010 in low- and high-unemployment risk industries. High-unemployment risk industries have average within-year standard deviation of employment between 2001 and 2006 greater than or equal to 250 based on the QCEW data for South Carolina. Refer to the Table 1 notes for information on the main outcomes. *** p<0.01, ** p<0.05, * p<0.1

Table A6: Estimates for the Elasticity of Layoffs w.r.t the Degree of Experience Rating from the Literature

Study	Estimated value	Parameter
Topel (1984)	-0.27	Elasticity of temporary layoffs w.r.t. experience rating
Card et al. (1994)	-0.43	Elasticity of temporary layoffs w.r.t. experience rating
Card et al. (1994)	-0.1	Elasticity of permanent layoffs w.r.t. experience rating
Anderson et al. (1994)	-0.15 – -0.33	Elasticity of temporary layoffs w.r.t. experience rating
Johnston (2021)	0	Elasticity of layoffs w.r.t. unemployment tax rate

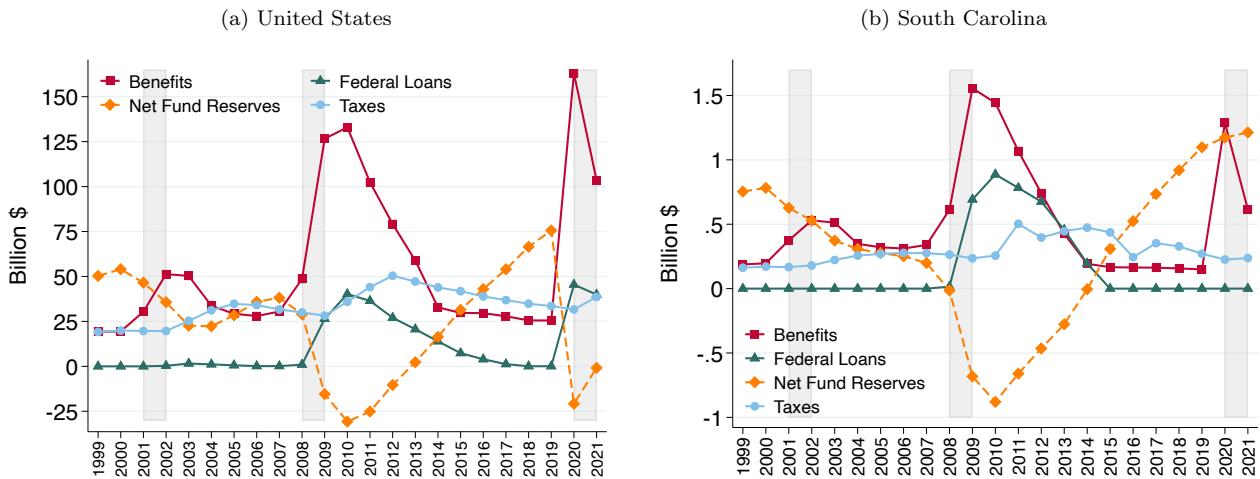
Notes: This table lists various estimates for the elasticity of layoffs with respect to the degree of experience rating. The value of -0.27 for Topel (1984) is backed up from the conclusions of the paper. The values of -0.43 and -0.1 for Card et al. (1994) are taken from Table 2. Anderson et al. (1994) reports various estimates ranging between -0.15 and -0.33 in Section 5. The value of zero for Johnston (2021) is taken from Table 2.

Table A7: Estimated Value of Insurance for Workers from the Literature

Study	Estimated value	Approach
Gruber (1997a)	0.89	Consumption drop
Hendren (2017)	1.32	Consumption drop
Hendren (2017)	1.87	Ex-ante consumption drop
Landais et al. (2021)	1.52	Consumption drop
Landais et al. (2021)	1.59	Marginal propensity to consume
Landais et al. (2021)	3.13	Revealed preference

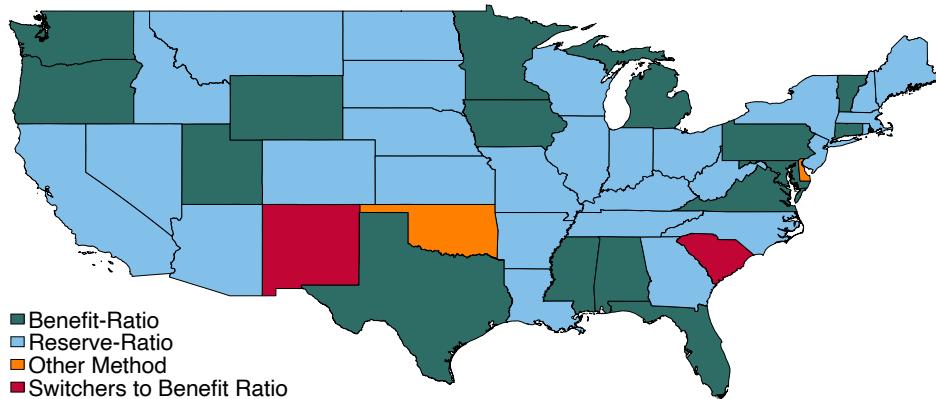
Notes: This table lists various estimates for the value of insurance for workers. The value of 0.89 for Gruber (1997a) is obtained by multiplying the percentage drop in consumption at layoff, 22.2% in their Table 1 by the highest value of risk aversion considered, 4. The value of 1.32 for Hendren (2017) comes from column 1 of their Table 5. Hendren (2017) comes from column 1 of their Table 6. The value of 1.52 for Landais et al. (2021) is the highest estimate in their Figure 1. The value of 1.59 for Landais et al. (2021) comes from column 1 of their Table 2. The value of 3.13 for Landais et al. (2021) comes from column 1 of their Table 3.

Figure A1: Recent Trends in Unemployment Benefits, Taxes, and Unemployment Trust Fund Solvency



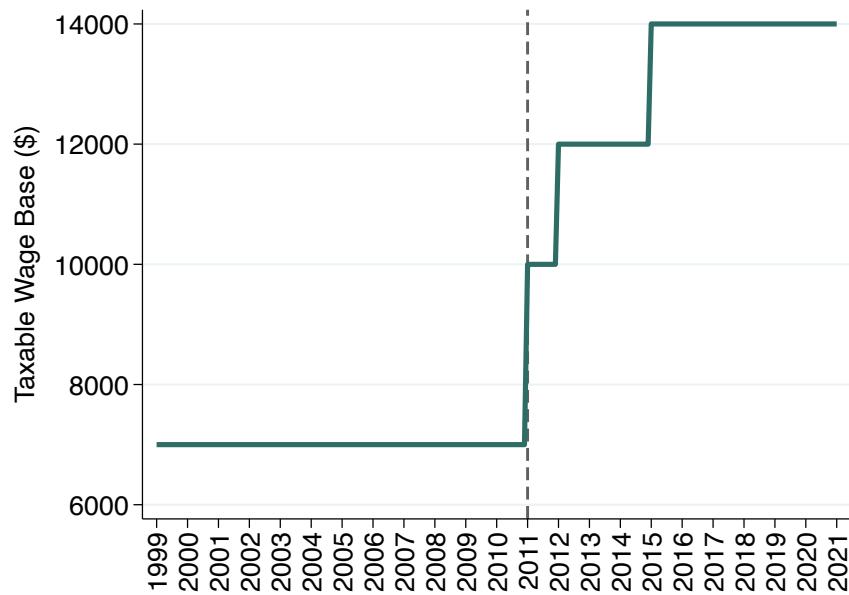
Notes: This figure illustrates the change in the total amount of unemployment benefits paid out to workers (including regular, extended, and emergency benefits), federal government loans, reserves in the Unemployment Trust Fund net of federal loans, and unemployment taxes collected in the United States (panel [a]) and in South Carolina (panel [b]). The cumulative figures in panel [a] are derived by aggregating the values from all states. Gray areas correspond to economic recessions. Data sources: ET 394 and US Business Cycle Expansions and Contractions from the NBER.

Figure A2: States' Measure of Unemployment Risk for Tax Rate Assessment



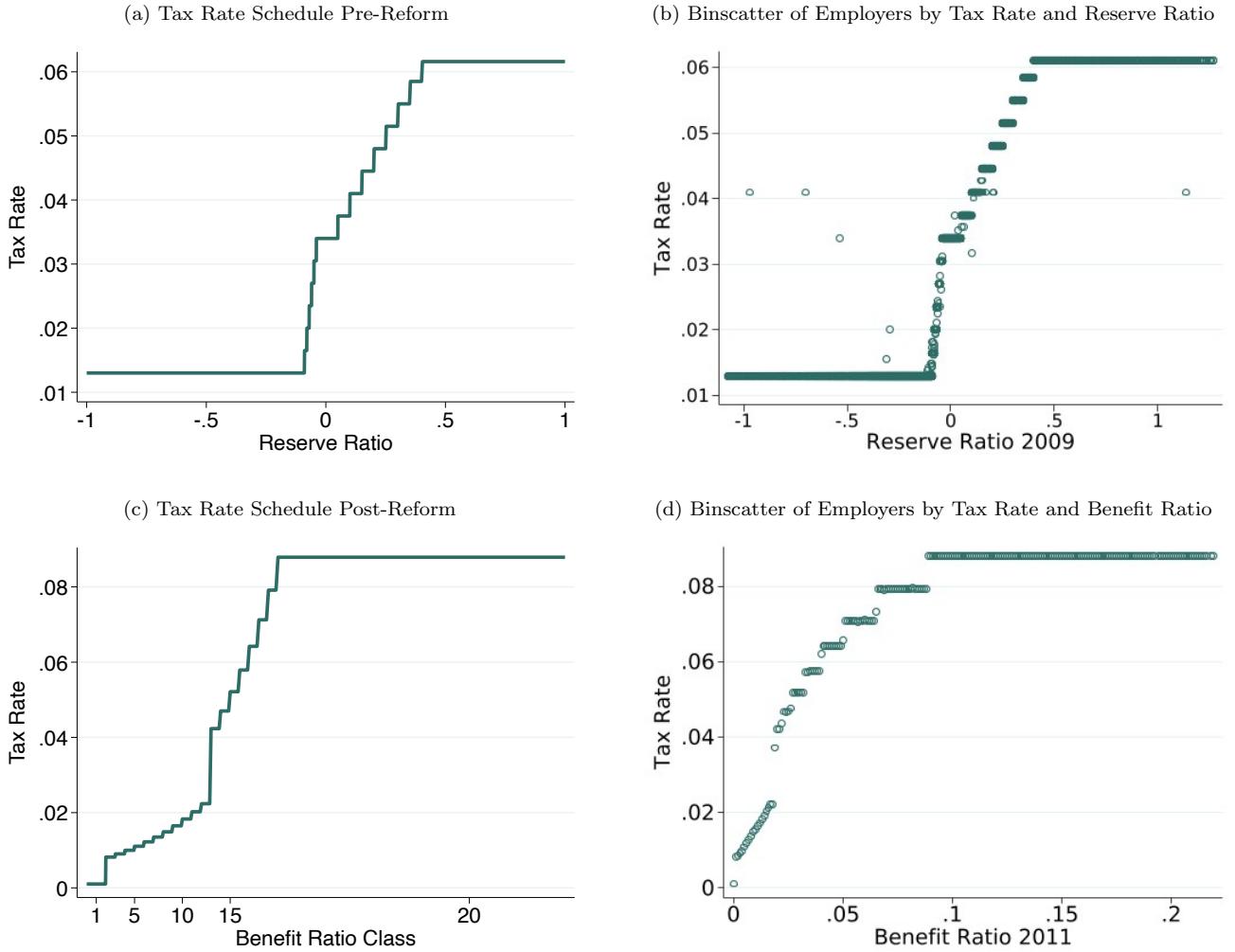
Notes: This figure illustrates the states currently using the benefit ratio, the reserve ratio, and other measures of experience with unemployment to assign unemployment tax rates to employers. The figure also shows the states that switched from a reserve ratio to a benefit ratio system: South Carolina in 2011, and New Mexico in 2015.

Figure A3: Taxable Wage Base in South Carolina



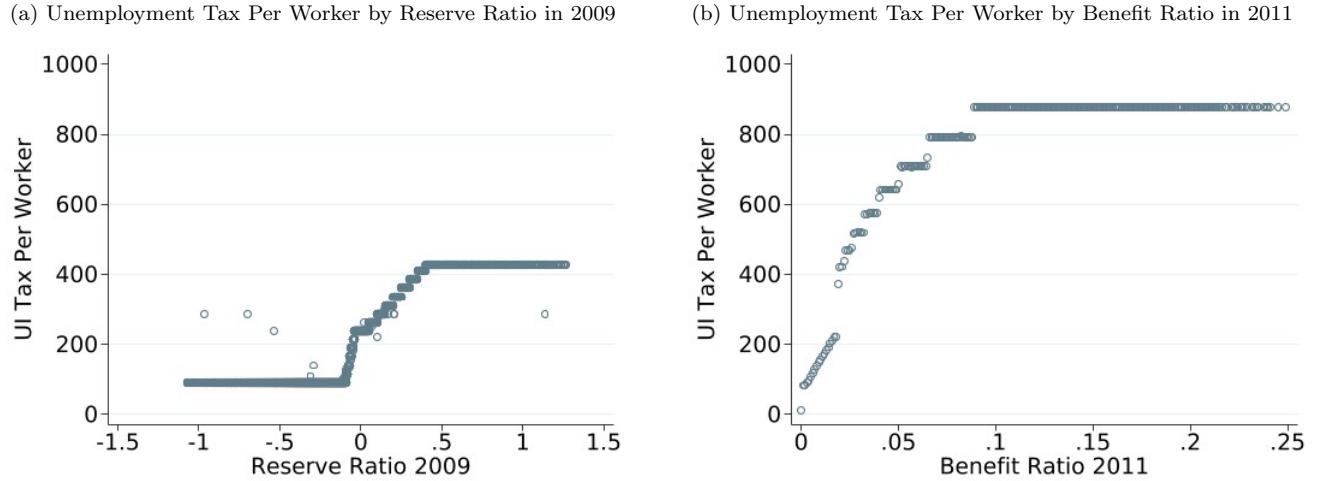
Notes: This figure illustrates the change the taxable wage base in South Carolina between 1999 and 2021.
Data source: ET 394.

Figure A4: Pre- and Post-Reform Unemployment Tax Rate Schedules in South Carolina



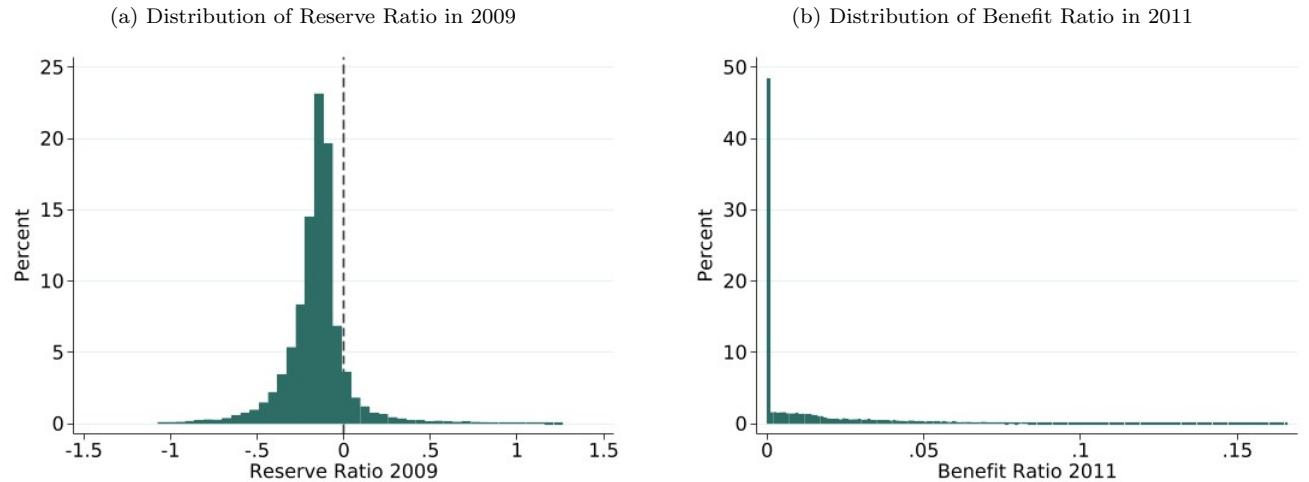
Notes: Panel (a) illustrates the unemployment tax rate schedule in effect in South Carolina between 2004 and 2010 from the US Unemployment Insurance Financing Policy Database. The schedule specifies the unemployment tax rates, ranging from 1.3 to 6.1%, associated each level of reserve ratio. Panel (b) is a binscatter of South Carolina employers, plotted by their unemployment tax rates and reserve ratios in 2009. Each marker corresponds to the average tax rate in a bin of reserve ratio sized 0.0001. The reserve ratio is trimmed to the first and ninety-ninth percentile. Panel (c) illustrates the unemployment tax rate schedule in effect in South Carolina in 2011 from the US Unemployment Insurance Financing Policy Database. Employers are ranked based on their benefit ratios and divided into twenty classes, each including approximately five percent of the state's taxable wages. All the employers within a class are assigned the same tax rate. Tax rates range between from 0.103% for bottom class employers to 8.789% for top class employers. Panel (d) is a binscatter of South Carolina employers, plotted by their unemployment tax rates and benefit ratios in 2011. Each marker indicates the average tax rate in a bin of benefit ratio sized 0.001. The benefit ratio is trimmed at the ninety-ninth percentile. Both before and after the reform, the binscatters match the schedules, confirming compliance with unemployment financing policies.

Figure A5: Pre- and Post- Reform Unemployment Tax Per Worker by Experience with Unemployment in South Carolina



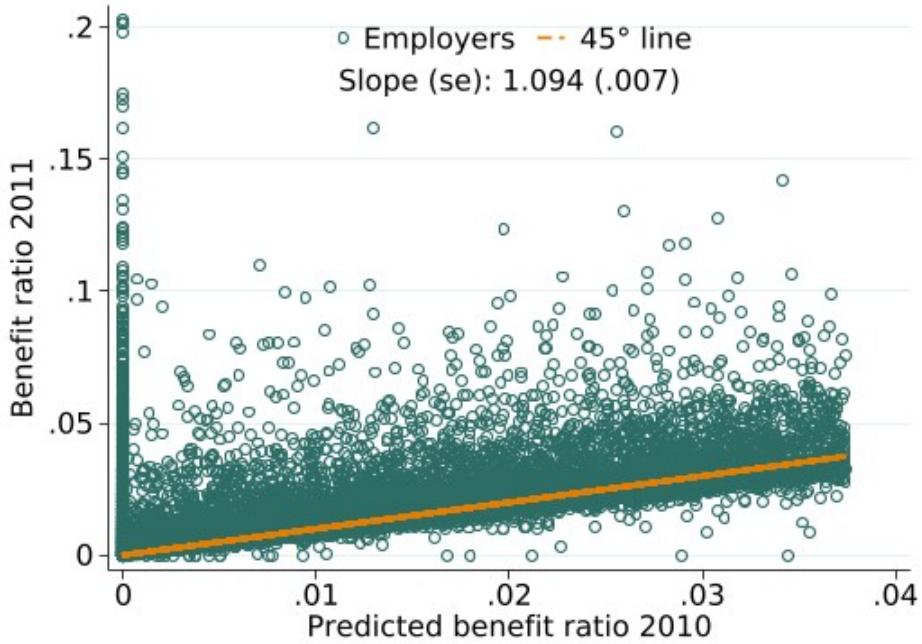
Notes: This figure plots South Carolina employers by their unemployment tax per workers and reserve ratios in 2009 (panel [a]) and by their unemployment tax per workers and benefit ratios in 2011 (panel [b]). The tax per worker is obtained by multiplying the taxable wage base, common to all employers in the state in a given year, by employers' individual unemployment tax rates.

Figure A6: Distribution of Reserve Ratio Pre-Reform and Benefit Ratio Post-Reform in South Carolina



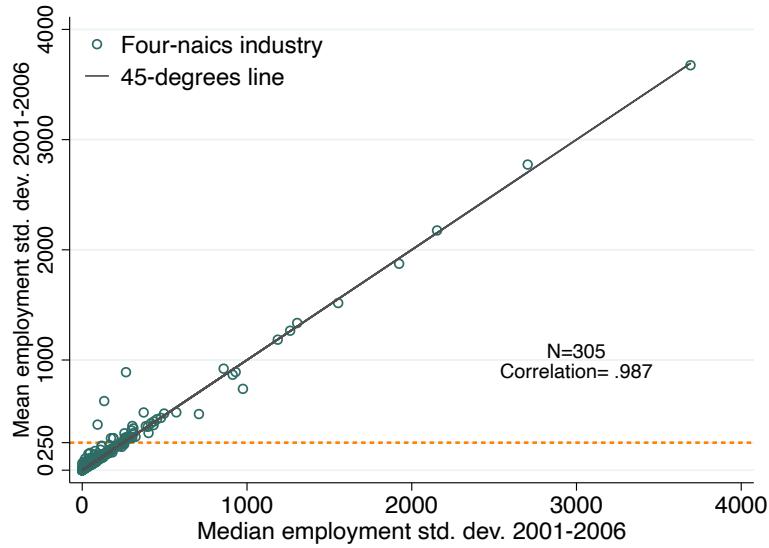
Notes: This figure illustrates the distribution of South Carolina employers' reserve ratios in 2009 (panel [a]) and benefit ratios in 2011 (panel [b]). The reserve ratio and the benefit ratio are trimmed at the first and ninety-ninth percentiles.

Figure A7: South Carolina Employers' Benefit Ratio in 2011 and Predicted Benefit Ratios in 2010



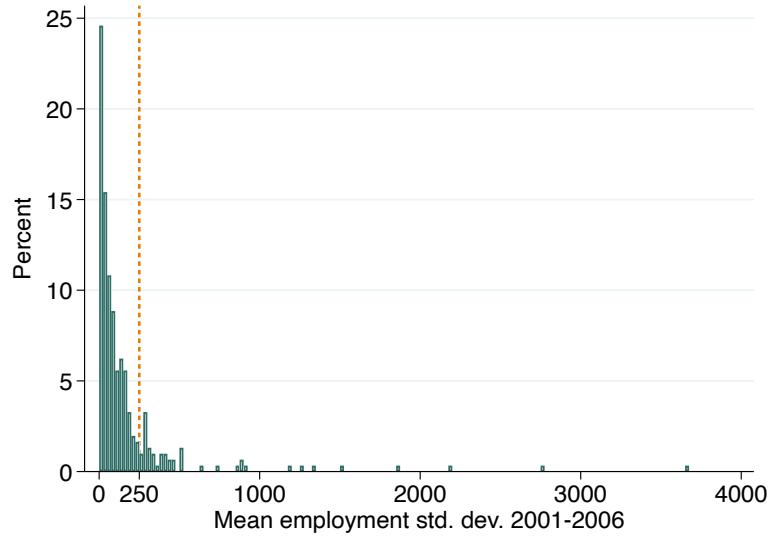
Notes: This figure plots South Carolina employers by their benefit ratio in 2011 and their predicted benefit ratios in 2010. The latter is the benefit ratio that employers would have had if the reform took place in 2010 instead of 2011. Because of data availability, it is calculated over a lookback period of six years instead of seven. This means that it is calculated as the ratio of the total benefits charged to the employer between July 1, 2003 and July 1, 2009 to the total taxable wages paid during the same period. The variables are trimmed to the ninety-fifth percentile. The figure also reports the slope and standard error of a regression of the 2011 benefit ratio on the 2010 predicted benefit ratio. The 2011 benefit ratio tends to be higher than the 2010 predicted benefit ratio, and this can be attributed to the fact that the period between July 1, 2009, and July 1, 2010, is included in the 2011 benefit ratio's lookback period but not in the 2010 predicted benefit ratio's lookback period. This specific period saw a significant amount of unemployment benefit charges.

Figure A8: Average and Median Industry Within-Year Standard Deviation in Employment in South Carolina



Notes: This figure illustrates the correlation between industries' average and median employment within-year standard deviations between 2001 and 2006 in South Carolina from the QCEW data. Each marker corresponds to a different industry identified by a NAICS four-digit code. Markers tend to be distributed along the forty-five degrees line. The figure also reports the number of industries and the correlation between the mean and the median within-year standard deviations in employment. The dashed line indicates the value of the mean distinguishing high- (above) and low- (below) unemployment risk industries.

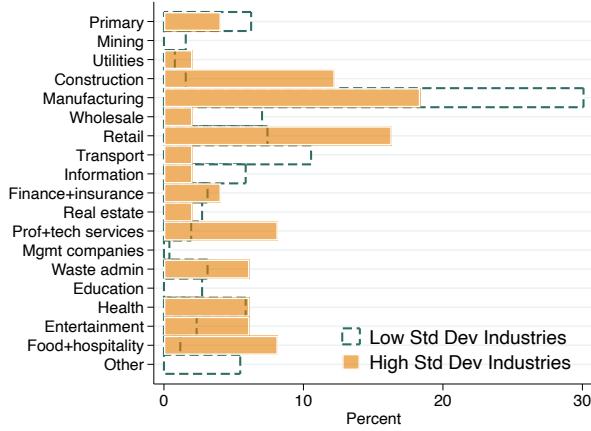
Figure A9: Distribution of South Carolina Industries' Average Within-Year Employment Standard Deviation



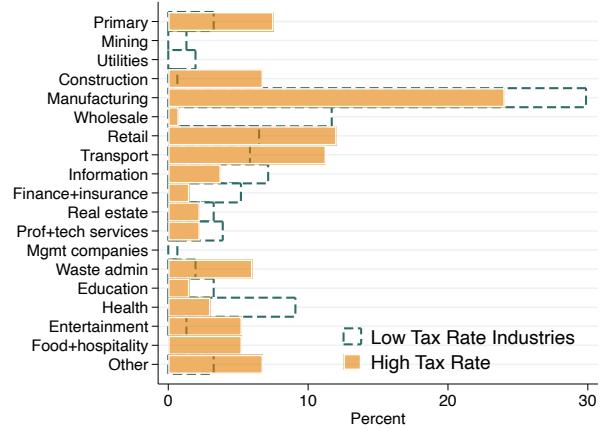
Notes: This figure illustrates the distribution of the average within-year standard deviation of employment between 2001 and 2006 for South Carolina industries in 2006. The dashed line indicates the value of the mean distinguishing high- (above) and low- (below) unemployment risk industries. Each bar corresponds to bins of average standard deviation sized 25.

Figure A10: Broad Sectoral Distribution of Low- and High- Unemployment Risk Industries in South Carolina

(a) Distribution by Industry Employment Standard Deviation

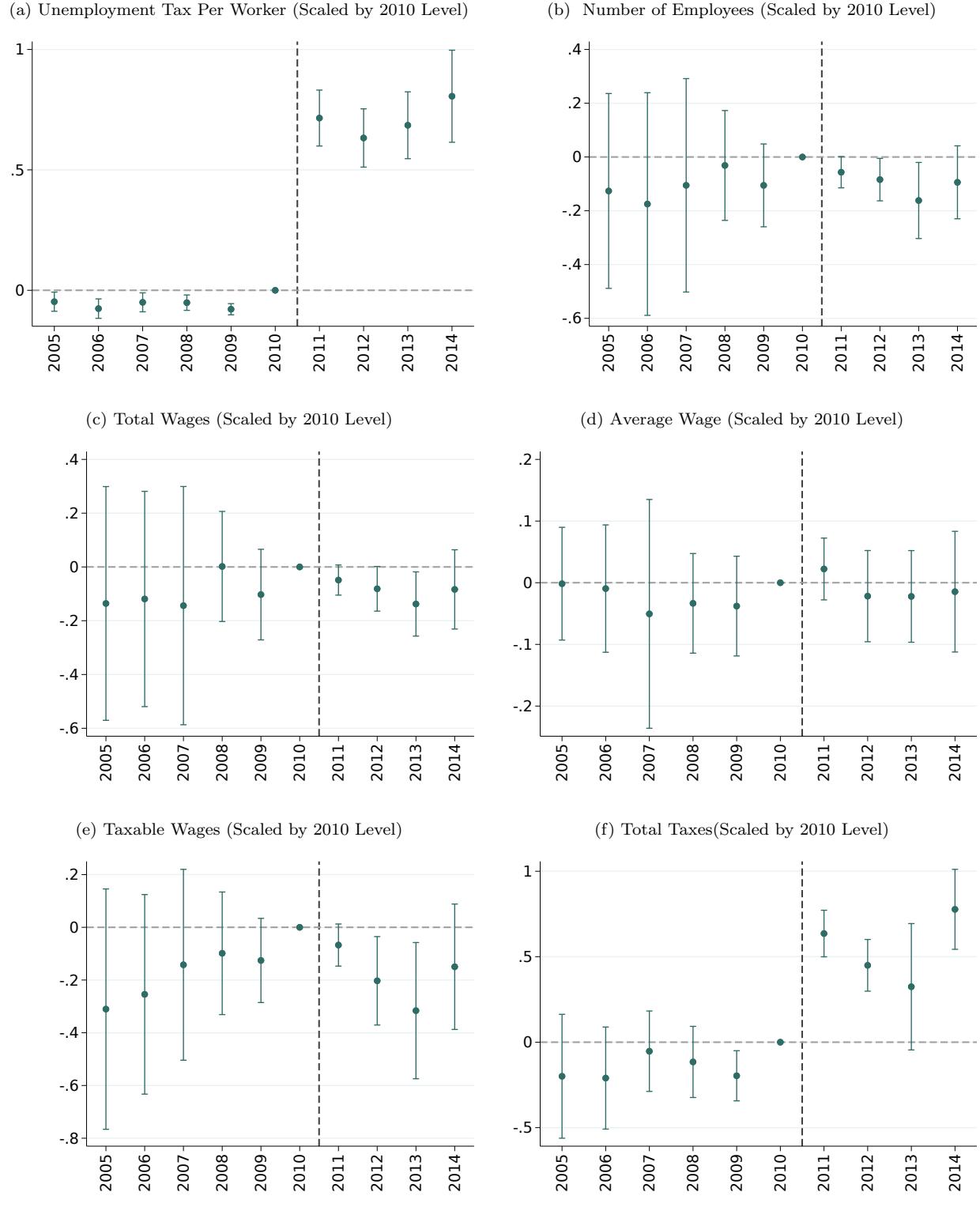


(b) Distribution by Industry Tax Rate



Notes: The figure illustrates the distribution of low- and high- unemployment risk industries in South Carolina across broad economic sectors. Unemployment risk is based on the within-year employment standard deviation in panel (a) and on the average unemployment tax rate in panel (b). Industries are defined using NAICS four-digit codes. High employment-standard deviation industries have average within-year standard deviation of employment between 2001 and 2006 greater than or equal to 250 based on the QCEW data for South Carolina. High-unemployment tax rate industries have an average unemployment tax rate between 2001 and 2006 larger than 0.0059 (the study sample mean) based on the QCEW data for South Carolina. Broad economic sectors are defined using NAICS two-digit codes.

Figure A11: Full Sample Reduced Form Effects: Large Employers and Outcomes Scaled by 2010 Level



Notes: This figure illustrates the estimated β_y coefficients from Equation 16 for South Carolina employers with at least one employee in 2010. All the outcome variables are scaled by their 2010 level. Refer to the Table 1 notes for information on the main outcomes. 95% confidence intervals are reported.

Figure A12: Full Sample Reduced Form Effects: Alternative Benefit Ratio Groups

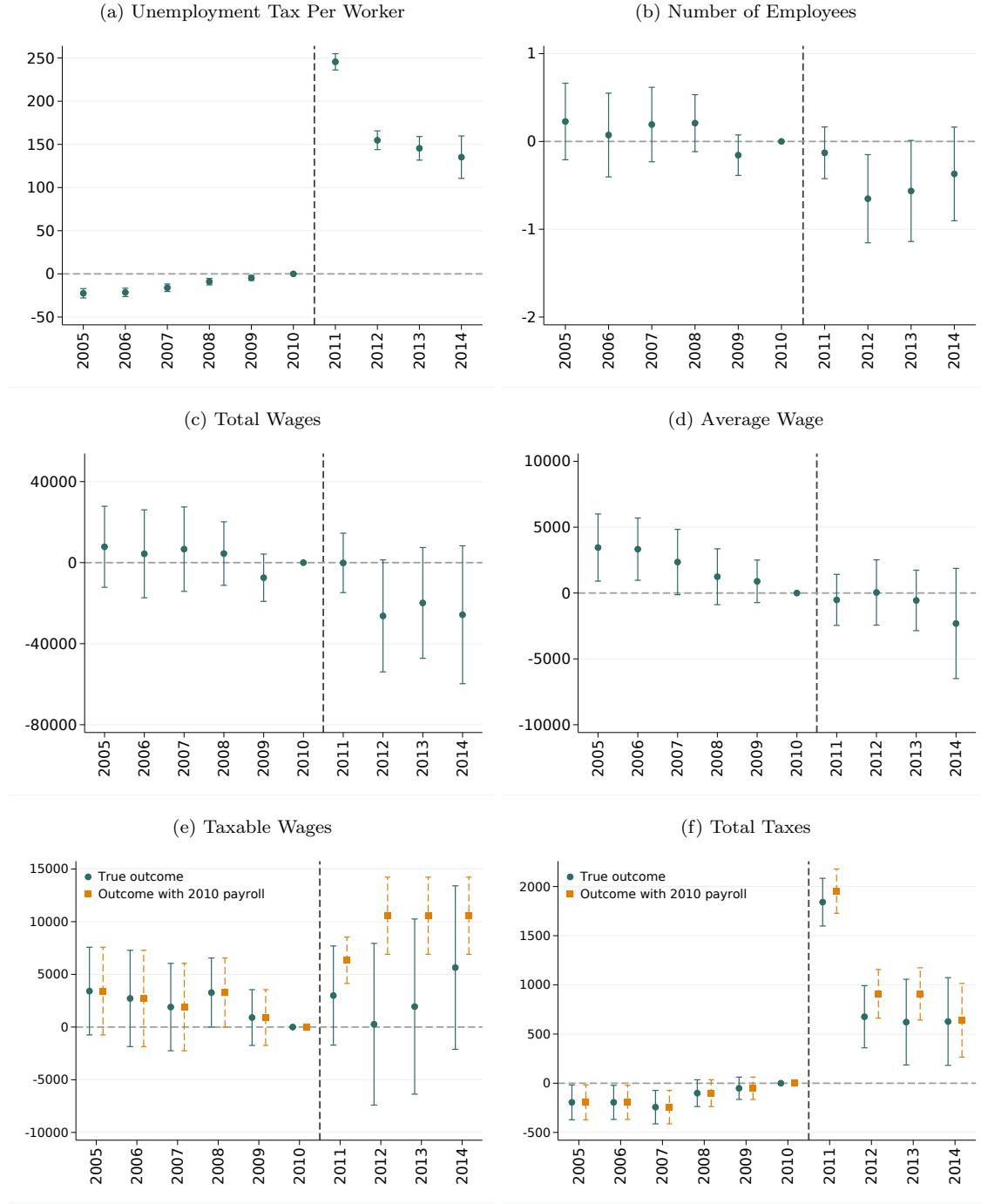


Figure A13: Full Sample Reduced Form Effects: Continuous Treatment

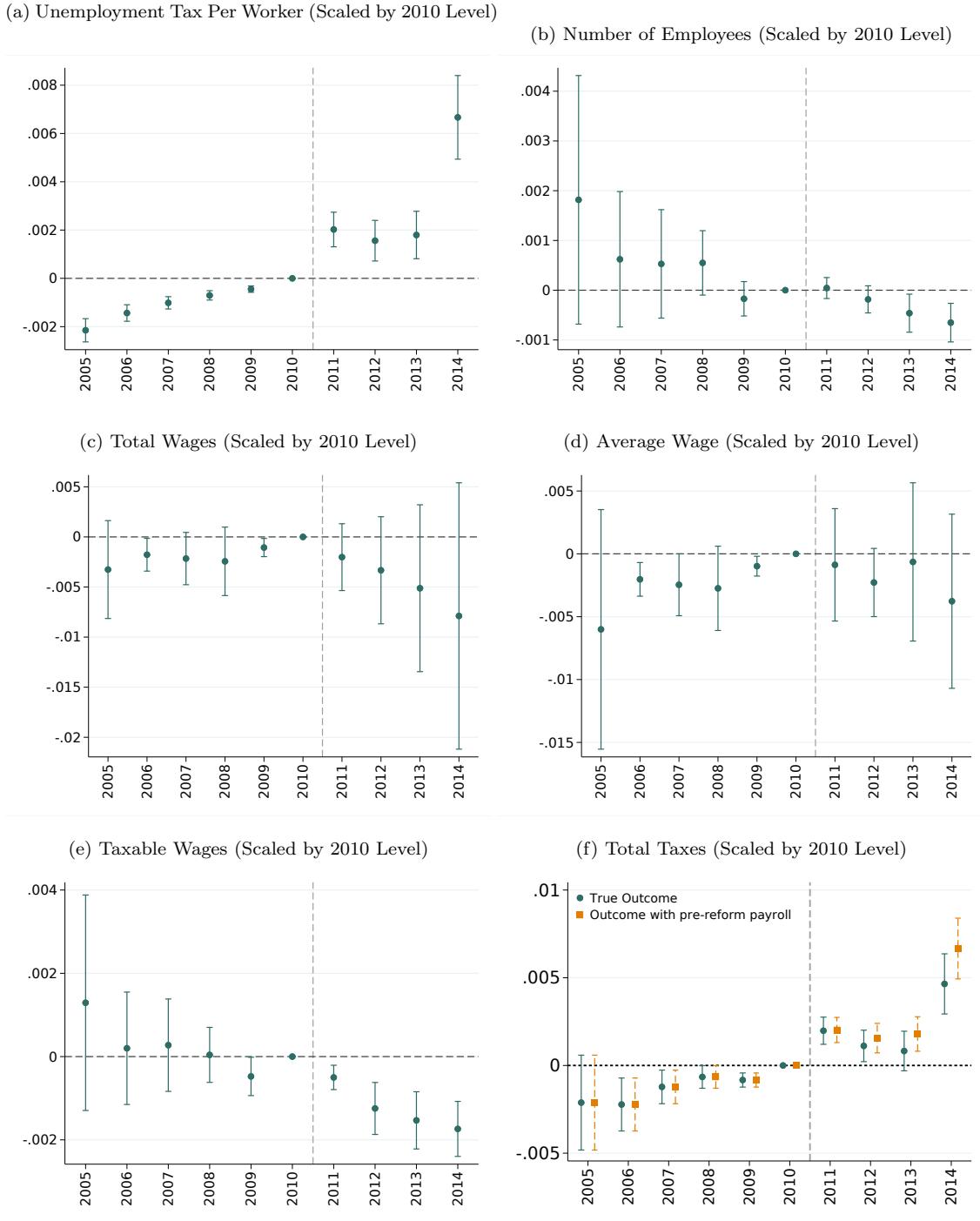


Figure A14: Heterogeneous Reduced Form Effect on Employment by Firm Size, Age, and Productivity

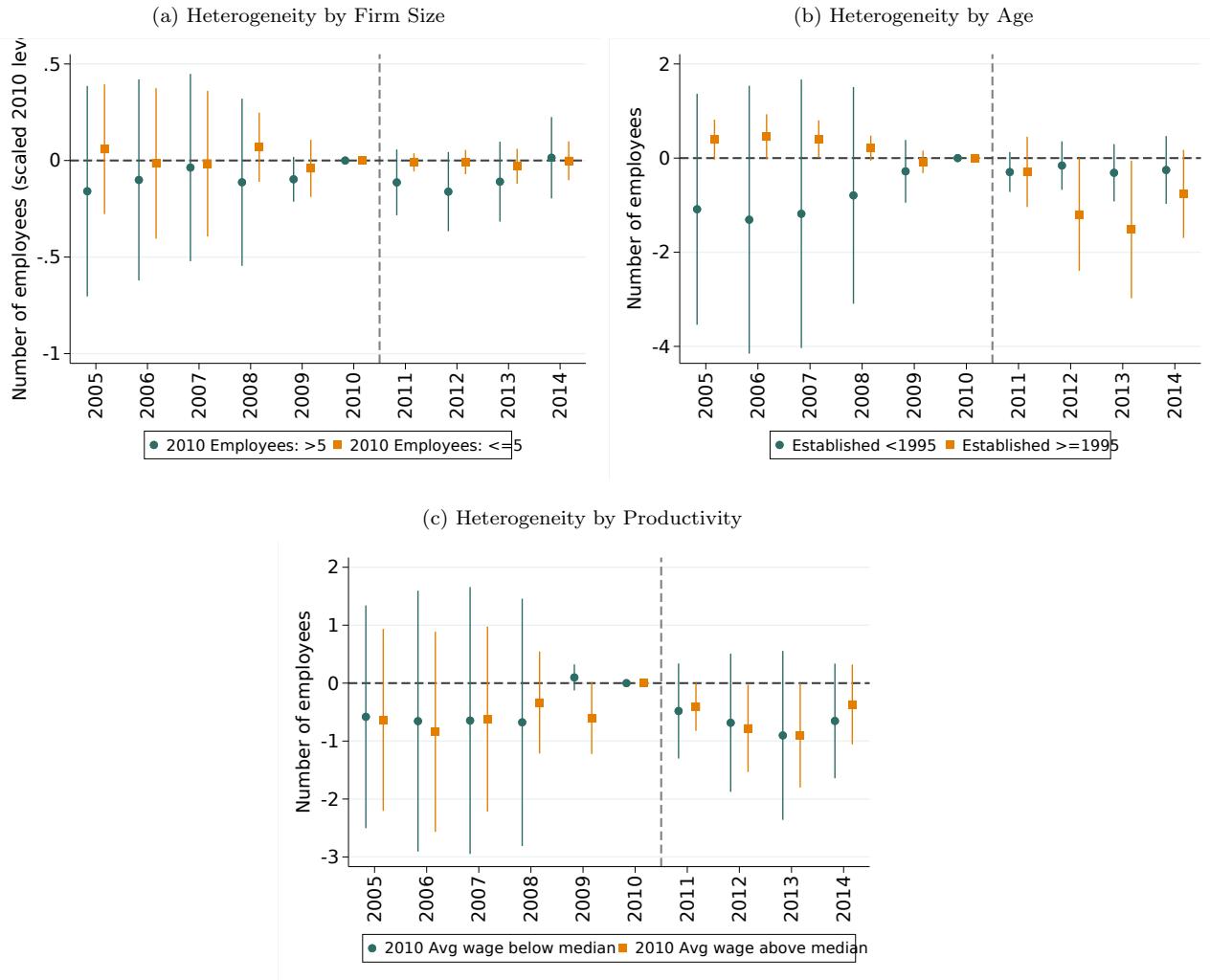
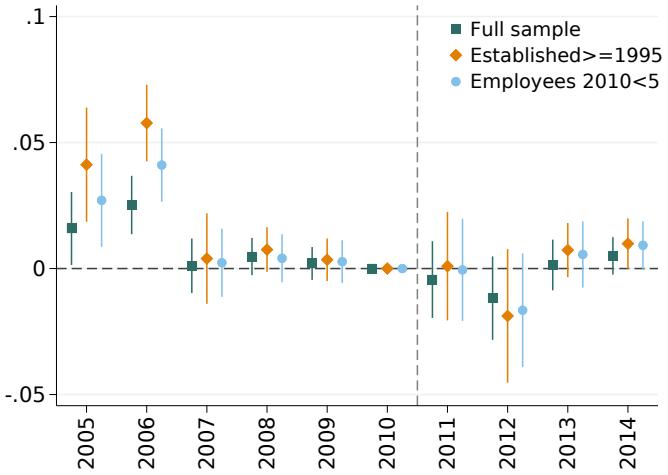
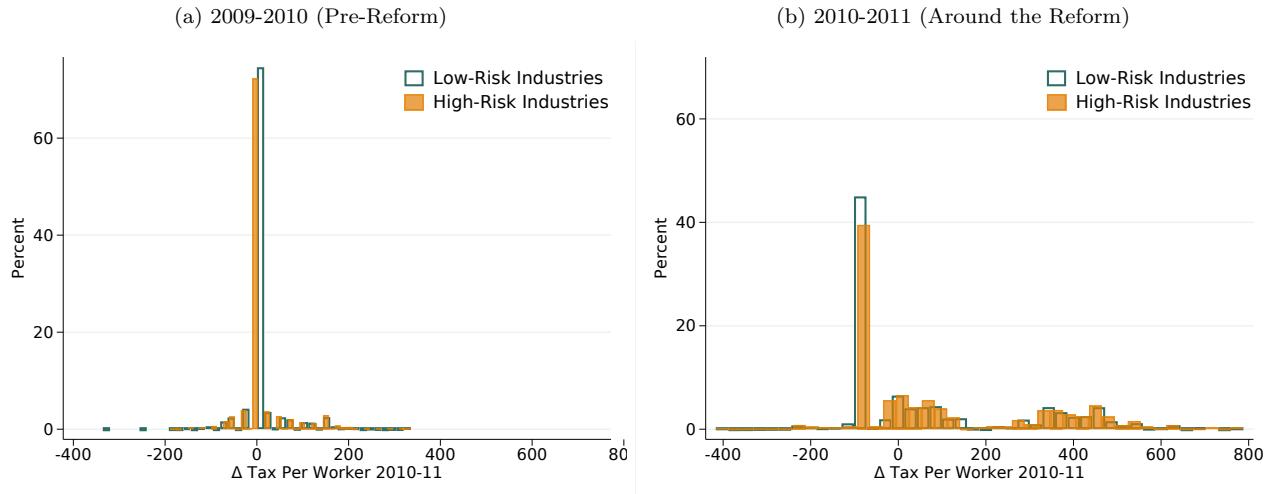


Figure A15: The Impact of the Transition from Reserve Ratio to Benefit Ratio on Firm Exit Rate



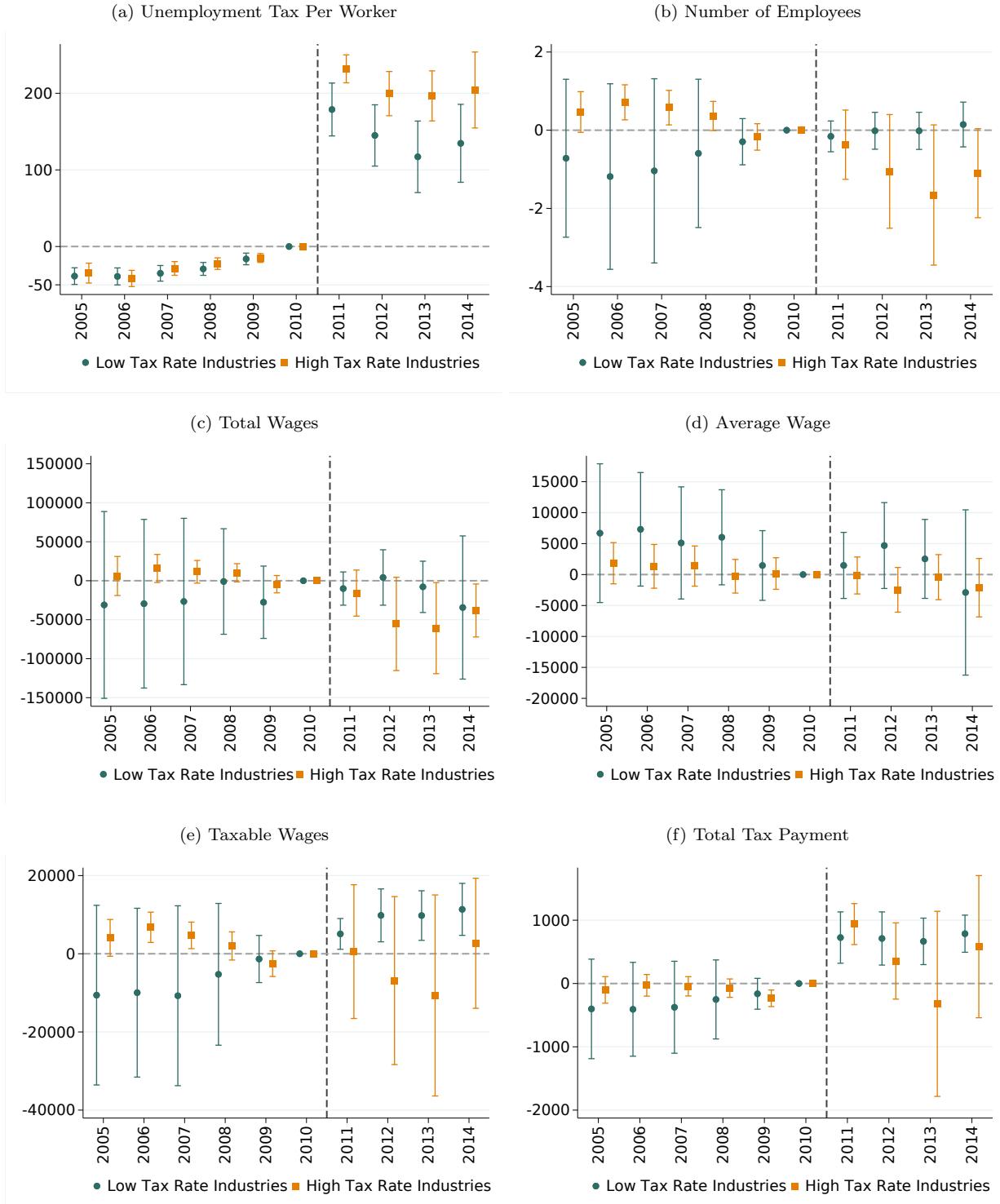
Notes: This figure illustrates the estimated β_y coefficients from Equation 16 for all South Carolina employers observed between 2005 and 2014, including those that enter and exit the sample in any point of this period. The outcome is an indicator equal to one in the last year in which an employer is observed. I also perform the estimation for the subsamples of small and young firms. Small firms are firms with up to five employees. Young firms are established after 1995. 95% confidence intervals are reported.

Figure A16: Δ Tax Per Worker for Employers in Low- and High-Employment Standard Deviation Industries



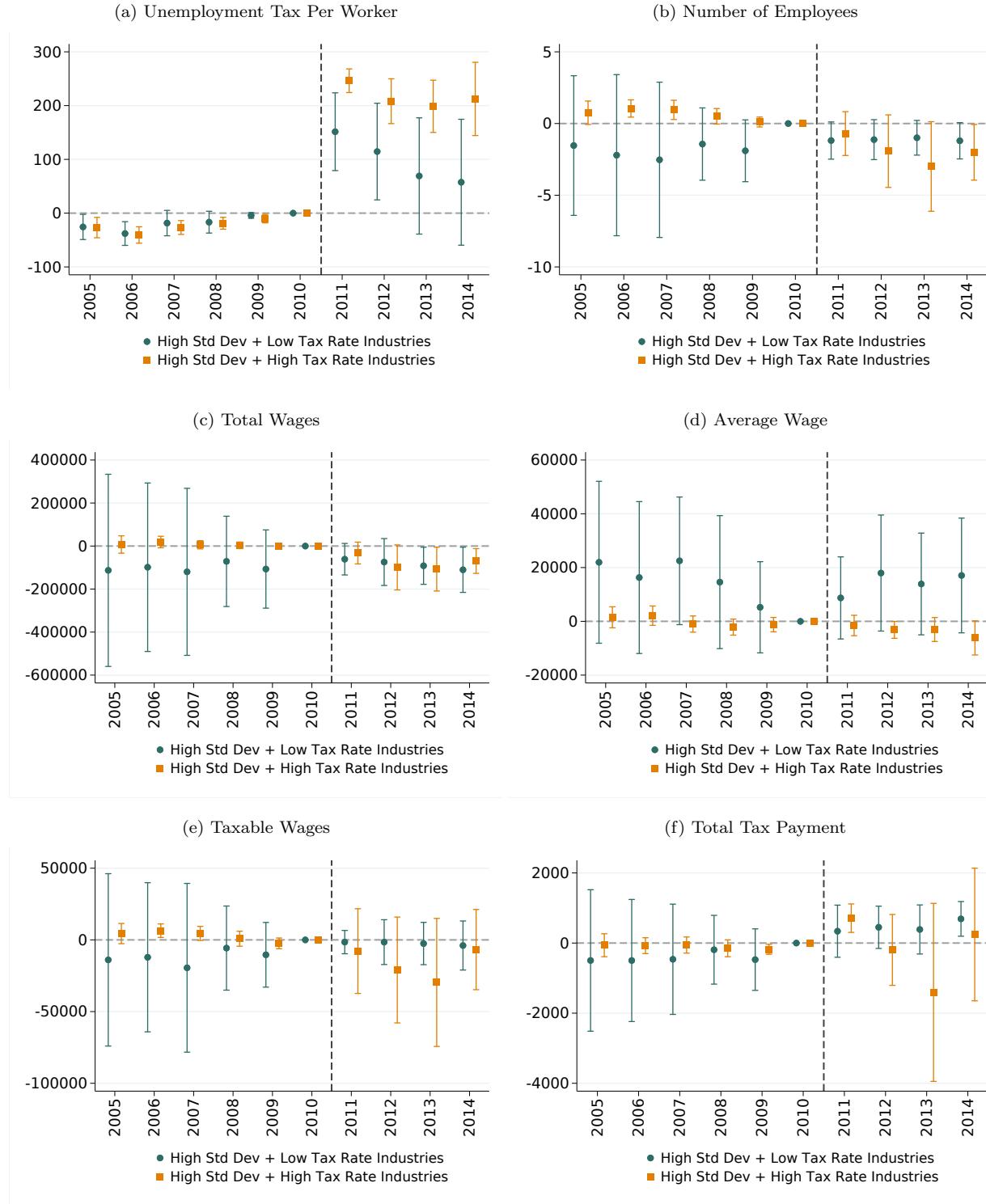
Notes: This figure illustrates the distribution of the dollar change in the tax per worker for employers in high- and low-employment standard deviation industries pre-reform (2009-2010, panel [a]) and around the time of the reform (2010-2011, panel [b]). High employment-standard deviation industries have average within-year standard deviation of employment between 2001 and 2006 greater than or equal to 250 based on the QCEW data for South Carolina.

Figure A17: Heterogeneous Reduced Form Effects on Employer Outcomes by Industry Average Tax Rate



Notes: This figure illustrates the estimated β_y coefficients from Equation 16 for South Carolina employers with 1-50 quarterly employees in 2010 in low- and high-average tax rate industries. High-unemployment tax rate industries have an average unemployment tax rate between 2001 and 2006 larger than 0.0059 (the study sample mean) based on the QCEW data for South Carolina. Refer to the Table 1 notes for information on the main outcomes. 95% confidence intervals are reported.

Figure A18: Distinguishing Unemployment Risk from Labor Turnover



Notes: This figure illustrates the estimated β_y coefficients from Equation 16 for South Carolina employers with 1-50 quarterly employees in 2010 in industries with high employment standard deviation industries and low- or high- average industry unemployment tax rate. High employment-standard deviation industries have average within-year standard deviation of employment between 2001 and 2006 greater than or equal to 250 based on the QCEW data for South Carolina. High-unemployment tax rate industries have an average unemployment tax rate between 2001 and 2006 larger than 0.0059 (the study sample mean) based on the QCEW data for South Carolina. Refer to the Table 1 notes for information on the main outcomes. 95% confidence intervals are reported.

Online Appendix

“Optimal Unemployment Insurance Financing: Theory and Evidence from two US States”

by Sara Spaziani

O.A The Colorado Experiment

This section describes an alternative strategy to identify the elasticity of employment with respect to the unemployment tax. This approach is based on a reform of unemployment financing rules in Colorado and employer-level data covering 2013-2020 provided by the Colorado Department of Labor and Employment. I estimate the elasticity both the full sample and in the subsamples of employers in high- and low-unemployment risk industries.

O.A.1 Context and source of variation

Structural changes of unemployment financing rules, like the transition of South Carolina from a Reserve Ratio to a Benefit Ratio system, are unusual. Most fluctuations in unemployment taxes are driven by either increases in the Taxable Wage Base, or transitions to lower or higher tax-rate schedules, or the institution or elimination of surcharges. Colorado used a mix of these strategies to increase unemployment taxes following the depletion of its Unemployment Trust Fund in 2009. Firstly, as Figure OA.2 shows, the Taxable Wage Base was progressively increased from \$10,000. Secondly, tax rate schedules were reduced from twelve to six, with new higher tax rates. Additionally, the state issued \$630 million in bonds in 2012 ([Post 2020](#)). To pay the principal on those bonds, the state instituted a surcharge representing the percent amount by which the unemployment tax rates in the schedule in effect in each year had to be incremented to obtain the effective tax rates. Table OA.1 shows the surcharge in effect in each year between 2013 and 2019. For example, the surcharge in 2017 was equal to 23.94%, meaning that an employer with a tax rate of $\tau\%$ from the schedule had to pay a final tax rate equal to $(\tau \times 1.2394)\%$. Panel (c) of Figure OA.1 shows the trends in unemployment benefits, taxes, and fund solvency in Colorado. The figure shows that the combinations of these measures allowed the state to collect almost half billion more unemployment taxes. After paying off the bonds’ principal in May 2017, the surcharge was eliminated in 2018.

Since the surcharge was proportional to the original tax rate, employers with initially higher tax rates disproportionately benefitted from its elimination. This asymmetric effect becomes evident when comparing the unemployment tax rate schedules in effect in 2017 and 2018, presented in panel (a) of Figure OA.3. While the tax rate associated to negative values of Reserve Ratio remained relatively stable, the tax rate assigned to positive Reserve Ratios decreased by up to 2 percentage points.

Panel (b) plots employers in Colorado by their tax rate in 2017 and 2018 and their Reserve Ratio, revealing a corresponding reduction in tax rates for each Reserve Ratio bin. Consistently, panel (c) shows that in 2018 the maximum Unemployment Tax Per Worker decreased by up to \$250 for positive Reserve Ratio levels and remained stable for negative ones. The same patterns emerge when plotting Colorado employers by their Tax

Per Worker and Reserve Ratio in 2017 and 2018 in panel (d). The variation in the Tax Per Worker induced by the elimination of the surcharge in 2018 is the variation with which I identify the causal effect of unemployment taxes on employment.

O.A.2 Empirical strategy

The disproportionate reduction in unemployment taxes for Reserve Ratios just above zero seems to provide an ideal setting for a Regression Discontinuity Design. However, the very low variability in the coarsely rounded Reserve Ratio prevents its use in this approach. An alternative strategy consists in comparing outcomes for employers in a small window around the zero Reserve Ratio cutoff using a differences-in-differences strategy. Employers with negative Reserve Ratios would serve as the control group, while those with positive Reserve Ratios as the treatment group. However, given the association between past layoffs and the Reserve Ratio, positive Reserve Ratio employers are more likely to be on a recovery trend than negative Reserve Ratio ones, and may display a larger employment increase even in the absence of a tax cut. I thus compare different cohorts of employers with positive Reserve Ratio in different years. These cohorts were all on a similar recovery pattern, but only the one with positive Reserve Ratio in 2017 benefitted from the elimination of the surcharge.

Table OA.2 illustrates the conditions used to classify employers into treatment and control cohorts. Treated employers have positive Reserve Ratio in 2017, the year before the reduction in the Tax Per Worker. Control employers have positive Reserve Ratio in 2015, the year before a “placebo event” in which the Tax Per Worker remains relatively stable. Additionally, there is a non-overlapping condition between the two cohorts, where treated employers must have a negative Reserve Ratio in 2015. Lastly, a similarity condition requires that control employers also have a positive Reserve Ratio three years before the placebo event, in 2013.

Figure OA.5 illustrates the change in the Tax Per Worker associated to each level of Reserve Ratio around the true event (2017 vs 2018) and the placebo event (2015 vs 2016). In 2018, there is a progressively larger decline in the Tax Per Worker for higher Reserve Ratio levels, which is not observed in 2016, when the Tax Per Worker modestly increases due to a Taxable Wage Base increase from \$ 11800 to \$ 12200.

My identification strategy consists in comparing the differential evolution of firm outcomes of treated and control employers for eight quarters around the time of event (2018Q1 for the treated cohort, and 2016Q1 for the control cohort). I estimate the following differences-in-differences equation:

$$Y_{i,t} = \alpha_i + \sum_{y=-8}^8 \beta_y Treated_i \times 1_{y=t} + \epsilon_{i,t} \quad (19)$$

In Equation 19, $Y_{i,t}$ is the outcome for employer i at time t , measured in quarters relative to the time of event; α_i are employer fixed effects; $Treated_i$ is equal to one for the treated cohort of employers; $\epsilon_{i,t}$ is an error term. The β_y coefficients measure the differential effect of the elimination of the surcharge on the treated cohort relative to the control cohort. β_{-1} is normalized to zero. Standard errors are robust to heteroskedasticity and clustered at the employer level.

Table OA.3 presents summary statistics for treatment and control employers along with tests for baseline differences. Treated and control employers have similar number of employees in the pre-event quarter and sectoral distribution. However, treated employers offer higher wages, resulting in a higher average wage. This difference may be attributed to the treated cohort being selected to be further away in time from the Great Recession compared to the control cohort. Regarding tax-related metrics, treated and control employers exhibit similar average Reserve Ratios. However, treated employers have a lower tax rate but a higher Tax Per Worker. These differences likely stem from the lower surcharge in effect in 2015 compared to 2017, leading to higher effective tax rates in 2015 than in 2017. Additionally, the higher Taxable Wage Base in 2017 contributes to the higher Tax Per Worker for the same average Reserve Ratio in that year. Due to the higher wages they pay, treated employers also have higher taxable wages and pay higher unemployment taxes. However, these employers are similar in terms of the benefits they were charged.

Given the strong positive correlation between employers' Reserve Ratios over time (shown in Figure OA.4), control employers may have positive Reserve Ratio in 2017 as well and also experience a reduction in their taxes. Reassuringly, 55% of the control employers have negative Reserve Ratio in 2017 and 76% of them have a lower Reserve Ratio in 2017 than in 2015, suggesting that the exposure of the control group to the elimination of the surcharge was diluted. Overall, these statistics suggest that the control cohort represents a good counterfactual for the treated cohort in absence of the tax reduction.

O.A.3 Findings

O.A.3.1 Reduced form effects of the elimination of the surcharge

Figure OA.6 and Table OA.4 present the β coefficients obtained from Equation 19. Firstly, treated employers experienced a disproportionate reduction in their Tax Per Worker of \$136 compared to control employers, equivalent to 19% of the average Tax Per Worker in the pre-reform year.

Secondly, there was a notable increase in the quarterly number of employees right at the time of the event for treated employers. The number of employees remained permanently higher for the following eight quarters. The estimated effect ranges between 0.57 and 1.3 employees, representing a 4.4-10.1% increase in the workforce in 2010Q4. Thirdly, total wages significantly increased at the time of the event for the treatment group and persistently remain higher than for the control group. The effect ranges between \$9,000 and \$35,000 or 4.3-17% of the pre-reform quarter. However, the average wage remained unaffected, indicating that the increase in total wages was solely driven by the increase in employment. To estimate the yearly wage of the additional workers in the treatment group, I calculate the ratio of the effect on wages to the effect on employment. For $t = 3$, the first year with a significant effect on employment, the ratio is \$16,077 (the ratio of \$25,402 to 1.158), which is equivalent to 92% of the average wage in the pre-reform quarter. The analysis suggests that the additional employees in the treated group were average-wage employees.

Fourthly, in the treatment group, taxable wages in quarter one significantly increase by approximately \$36,000 or 83% of the taxable wages in the pre-reform quarter. However, this effect would have been smaller if taxable wages were related to quarter one, rather than quarter four, of the pre-reform year. By subtracting the

taxable wages from time $t - 4$, which correspond to quarter one of the pre-reform year, we obtain a net effect of \$18,000, taking into account that taxes are higher in any quarter one for the treated group. The effect on taxable wages is influenced by two components: the differential increase in the Taxable Wage Base experienced by the treated and control cohorts at the time of the event, as it occurs in different years, and the behavioral responses displayed by the treated group. The change in the Taxable Wage Base was \$400 in 2016 and \$100 in 2018. Consequently, if the cohort had experienced the same increase in the Taxable Wage Base, the effect on taxable wages for the treated group would have been even larger. With the Taxable Wage Base at \$12,500 in 2018, the increase in taxable wages by \$18,000 relative to quarter one of the previous year is equivalent to each existing employee's taxable wages increasing by \$100 and the addition of 1,336 new employees throughout the year, which is consistent with the observed employment increase.

Lastly, the comparison between behavioral and non-behavioral unemployment taxes reveals that treated employers would have experienced a reduction in unemployment taxes if they did not display behavioral responses. However, the increase in taxable wages compensates for the reduction in the tax rate, leading to higher or equal total unemployment taxes relative to the control group.

The findings from the Colorado experiment are highly consistent with those found for South Carolina. In this case, a reduction in unemployment taxes enables employers to expand their workforce. I now turn to investigating heterogeneities in this effect for employers in low-and high-unemployment risk industries.

O.A.3.2 Heterogeneity of employment effects by industry unemployment risk and elasticities calculation

Following the same approach used in the South Carolina experiment, I classify industries into the high- and low- unemployment risk category based on their seasonality in employment. To define industries, I utilize the NAICS 6-digits code, which is the lowest level of aggregation available in the CO DLE data. For each industry, I calculate the median within-year standard deviation in employment over the period between 1998 and 2006 using the QCEW data. This approach allows me to calculate seasonality during a period sufficiently distant from the Great Recession. High-unemployment risk industries are defined as industries with a median within-year standard deviation in employment above 250 between 1998 and 2006. The findings are robust to using alternative cutoffs.

Figure OA.7 illustrates the β coefficients obtained by estimating Equation 19 separately for the subsamples of employers in low- and high- unemployment risk industries. Despite the large confidence intervals, the figure suggests that the decline in employment and wages documented for the full sample is mostly driven by high-unemployment risk industries, which exhibit larger increases in employment and wages despite a similar decline in the Tax Per Worker compared to low-risk industries. Notably, the average wage also increases for treated employers in high-risk industries, a pattern that does not emerge for treated employers in low-risk industries.

Table OA.5 reports the estimated γ coefficients from Equation 20:

$$Y_{i,t} = \alpha_i + \sum_{y=-8}^8 \beta_y 1_{y=t} Treat_i + \sum_{y=-8}^8 \gamma_y 1_{y=t} Treat_i \times \text{High Risk}_i + \epsilon_{i,t} \quad (20)$$

The γ coefficients attached to the interaction of time dummies, the indicator for treatment, and the indicator for high-risk industries, measure the heterogeneous effect of the reform on firm outcomes in low- and high-unemployment risk industries. The table shows that, despite treated employers in low- and high-risk industries experience the same reduction in their Tax Per Worker, treated employers in high-risk industries have 1.4-3.3 more employees, pay \$26,000-50,000 more in wages, and increase their average wage by \$2,400-3,900. Although the differential effects on employment and wages are statistically insignificant, the large increase in the magnitude of the coefficients at the time of the reform suggests that this analysis is underpowered.

Lastly, I calculate the elasticity of employment with respect to the unemployment tax per worker using the formula in Equation 18. To do this, I divide the reduced form effect of the reform on employment by the reduced form effect of the reform on the Unemployment Tax Per Worker τ . Then, I multiply this ratio by the ratio of the average Tax Per Worker to the average Employment of the treatment group in 2010.

$$\epsilon_{Employment,\tau} = \frac{\beta_{Employment}}{\beta_\tau} \frac{\tau_{t-1,Treat=1}}{Employment_{t-1,Treat=1}} \quad (21)$$

The reduced form effects employed in the calculation of the elasticity are obtained from estimating Equation 22, which pools together all the pre-period and post-period coefficients.

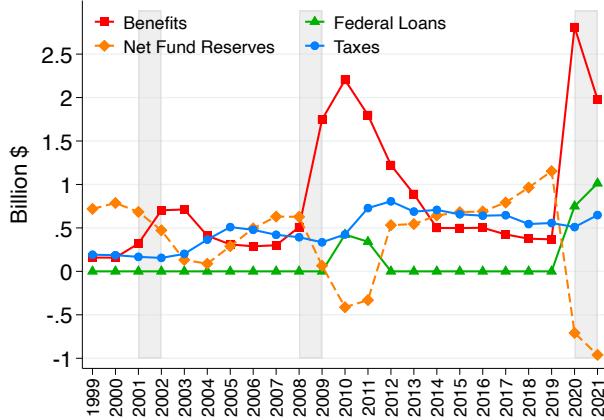
$$Y_{i,t} = \alpha_i + \beta 1_{y=t} Treat_i \times Post_t + \epsilon_{i,t} \quad (22)$$

Table 2 presents the components that contribute to the elasticity calculation and the corresponding estimated elasticities for the full sample and the subsamples of employers in low- and high-unemployment risk industries. The table shows that the increase in employment in high-unemployment risk industries is more than twice as large as that in low-risk industries. Given the similar pre-period employment and tax per worker, and given the similar reduction in the Tax Per Worker due to the reform, I find a higher elasticity for employers in high-risk industries. The elasticity of employment with respect to the Tax Per Worker, estimated at -1.348 in the full sample, is -1.354 for employers in low-risk industries and -2.452 for high-risk industries.

The patterns observed in the Colorado experiment confirm the findings obtained in the South Carolina experiment. The evidence indicates that the elasticity of employment with respect to the unemployment tax per worker is larger in high-unemployment risk industries. This suggests that industries with higher inherent unemployment risk are more responsive to changes in the unemployment tax, resulting in greater fluctuations in employment levels in response to tax policy reforms. The consistency between the two experiments strengthens the validity of the findings.

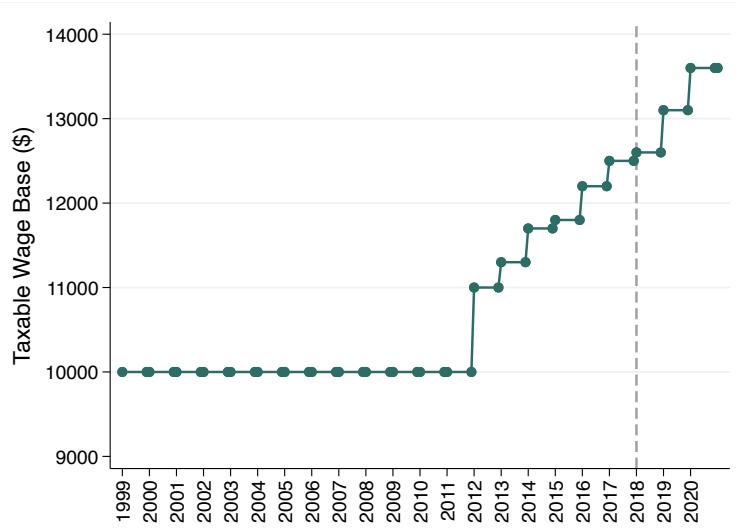
O.A.4 Colorado Tables and Figures

Figure OA.1: Recent Trends in Unemployment Benefits, Taxes, and Trust Fund Solvency in the United States



Notes: The figure illustrates the evolution over time of the total amount of unemployment benefits paid out to workers (regular, extended and emergency benefits), federal government loans, reserves in the Unemployment Trust Fund net of federal government loans, and unemployment taxes collected in Colorado (panel [c]). Gray areas correspond to economic recessions. Data sources: ET Financial Handbook 394 from the US Department of Labor and US Business Cycle Expansions and Contractions.

Figure OA.2: Taxable Wage Base in Colorado.



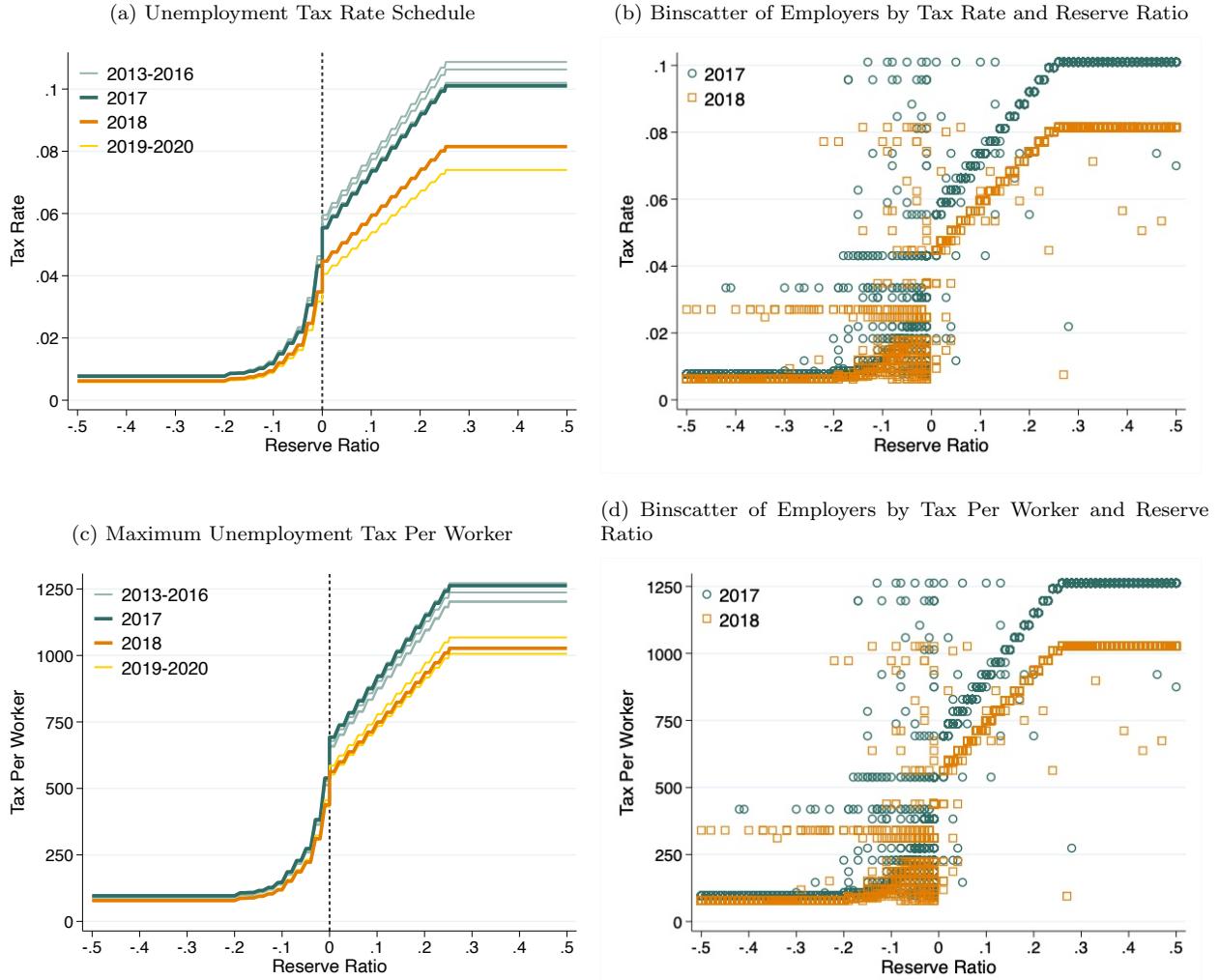
Notes: The figure illustrates the evolution of the taxable wage base in Colorado between 1999 and 2021 as reported in the Unemployment Insurance Financial Data Handbook (ET Financial Handbook 394) redacted by the US Department of Labor.

Table OA.1: Surcharges in Colorado between 2013 and 2019

Year	2013	2014	2015	2016	2017	2018	2019
Surcharge	19.39%	22.19%	25.20%	24.47%	23.94%	0	0

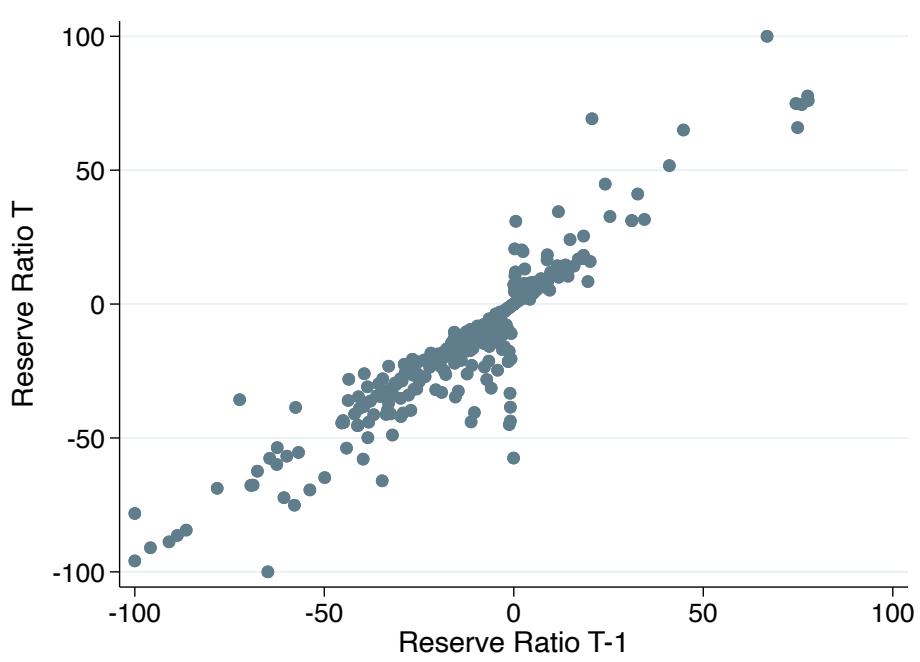
Notes: The table reports the surcharges in effect in Colorado between 2013 and 2019. The surcharge represents the percent amount by which the unemployment tax rates in the schedule in effect in each year had to be incremented to obtain the final effective tax rates.

Figure OA.3: Unemployment Financing Rules in Colorado



Notes: The figure illustrates the unemployment financing rules in effect in Colorado between 2013 and 2020. Panel (a) illustrates the tax rate schedule in effect in each year, assigning tax rates to each level of Reserve Ratio. Panel (b) plots Colorado employers by their tax rates and Reserve Ratios in 2017 and 2018. Panel (c) illustrates the Maximum Unemployment Tax Per Worker associated by law to each level of Reserve Ratio in each year. The tax associated to each level of Reserve Ratio is obtained by multiplying the corresponding tax rate by the Taxable Wage Base in effect in each year. Panel (d) plots Colorado employers by their Tax Per Worker and Reserve Ratios in 2017 and 2018.

Figure OA.4: Correlation in Employers' Reserve Ratio Over Time



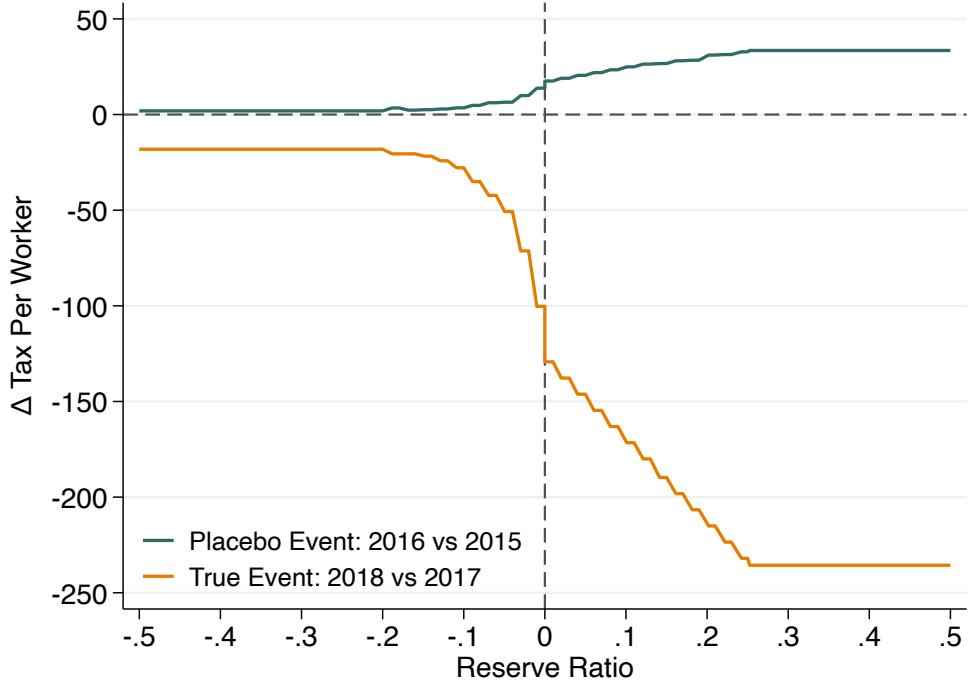
Notes: This figure plots Colorado employers by their Reserve Ratio in year T and Reserve Ratio in year T-1, with T=2014, 2015, 2016, 2017, 2018. The Reserve Ratio in year T has been rounded to the first decimal place. Each marker corresponds to the average of the Reserve Ratio in year T-1 for employers in that bin of Reserve Ratio in year T.

Table OA.2: Classification of Colorado Employers into Treatment and Control Cohorts

	2013	2014	2015	2016	2017	2018	2019
Treated cohort			RR < 0		RR > 0	True Event	
Control cohort	RR < 0		RR > 0	Placebo Event			

Notes: This table illustrates the conditions I use to classify employers into treatment and control groups. Treated employers have positive Reserve Ratio in 2017, the year before the reduction in the Tax Per Worker. Control employers have positive Reserve Ratio in 2015, the year before a placebo event. The *non-overlapping condition* between the two cohorts requires that treated employers have negative Reserve Ratio in 2015. The *similarity condition* requires that control employers also have positive Reserve Ratio three years before the placebo-event year, in 2013.

Figure OA.5: Variation in Unemployment Tax Per Worker by Reserve Ratio in True and Placebo Year



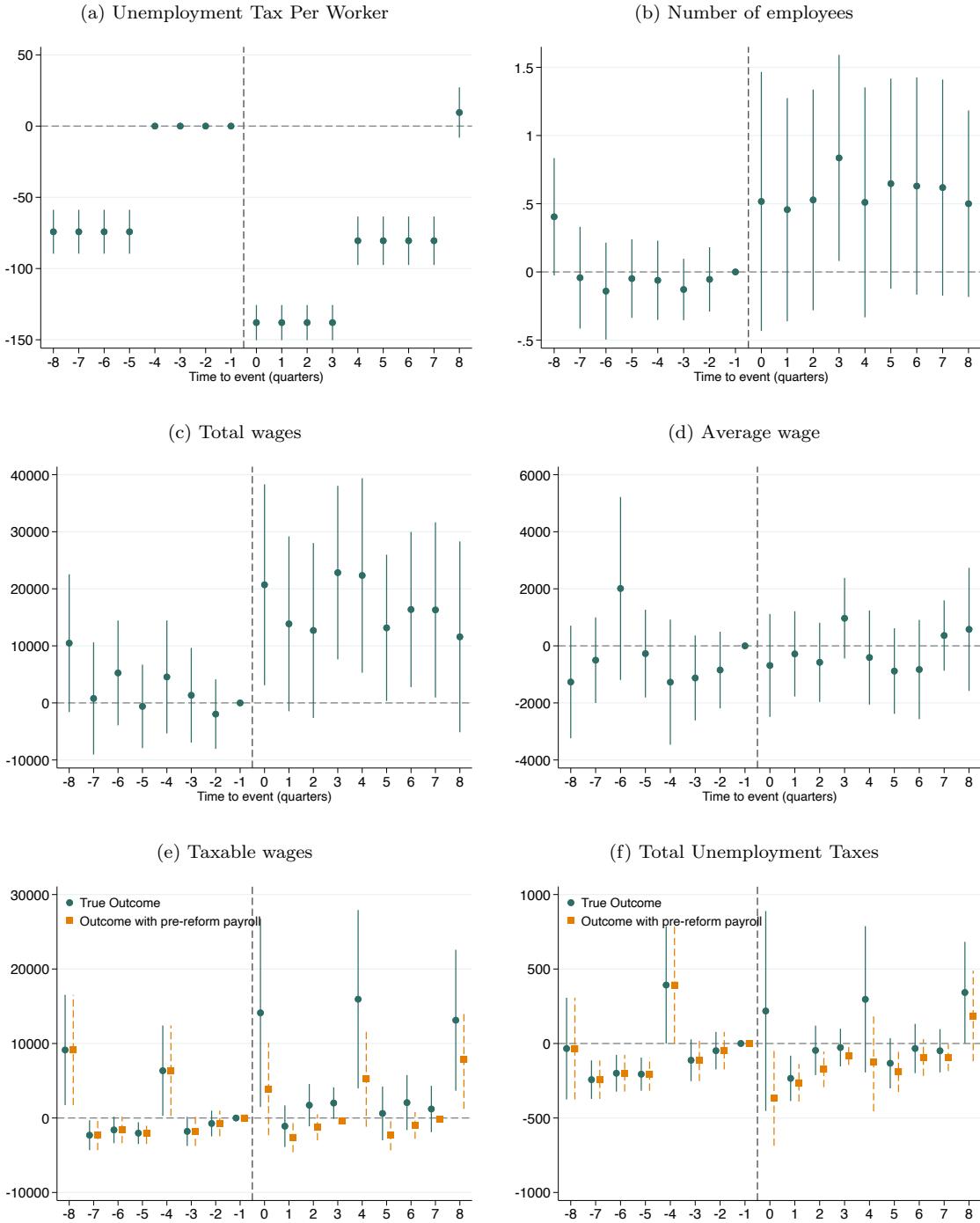
Notes: This figure illustrates the variation in the Unemployment Tax Per Worker associated to each level of Reserve Ratio between 2017 and 2018 (the true event year) and between 2015 and 2016 (the placebo event year).

Table OA.3: Summary Statistics and Balance Tests for Colorado Treated and Control Cohorts in Pre-Period

	Control Cohort			Treated Cohort			Diff C-T	P-value
	N	Mean	Std. Dev.	N	Mean	Std. dev.		
<i>Panel A: Main outcomes</i>								
Tax per worker	2435	848.597	188.540	1786	880.324	186.541	-31.727***	0.000
Employees	2435	11.970	53.162	1786	13.486	51.014	-1.517	0.352
Total wages	2435	196571.647	797855.771	1786	276538.280	1307746.230	-79966.633**	0.014
Average wage	2382	17943.359	19458.237	1742	20435.673	28746.423	-2492.314***	0.001
Taxable wages	2435	17087.057	105156.599	1786	23457.222	127418.331	-6370.166*	0.076
Total taxes	2435	1133.960	8014.412	1786	1492.809	7632.521	-358.849	0.143
<i>Panel B: Other employer characteristics</i>								
Year of establishment	2435	2002.430	9.860	1786	2003.057	9.785	-0.627**	0.041
Primary	2435	0.025	0.155	1786	0.061	0.239	-0.036***	0.000
Construction	2435	0.064	0.245	1786	0.066	0.247	-0.001	0.851
Manufacturing	2435	0.054	0.226	1786	0.054	0.226	0.000	0.948
Trade	2435	0.204	0.403	1786	0.204	0.403	-0.001	0.957
Transport	2435	0.099	0.299	1786	0.087	0.282	0.013	0.166
Services	2435	0.100	0.300	1786	0.073	0.260	0.027***	0.002
Reserve Ratio	2435	0.121	0.176	1786	0.114	0.174	0.007	0.175

Notes: This table shows summary statistics and tests for baseline differences between the treatment and control cohorts of Colorado employers in the quarter before the time of event. Time of event is set as 2018Q1 for the treated cohort, and 2016Q1 for the control cohort. Thus, these statistics refer to 2017Q4 for the treated cohort and 2015Q4 for the control cohort.

Figure OA.6: Reduced Form Effects of the Elimination of the Surcharge on Firm Outcomes



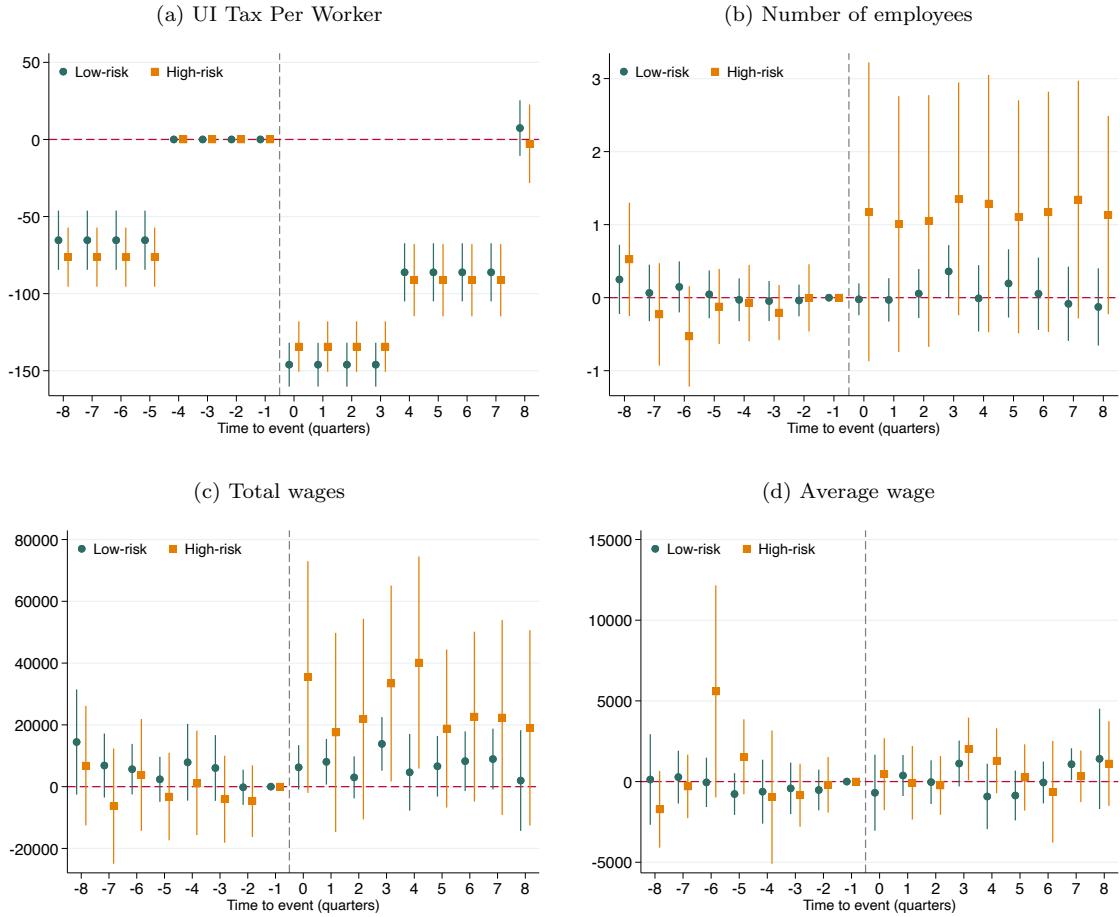
This figure illustrates the estimates of the β_y coefficients from Equation 19 for the sample of Colorado employers with positive Reserve Ratio. The treatment group includes employers with Positive Reserve Ratio in 2017. The control group includes employers with Positive Reserve Ratio in 2015. The outcomes are the unemployment tax per worker in panel (a) the quarterly average number of employees in panel (b), total wages in panel (c), the average wage in panel (d), the quarterly taxable wages in panel (e), and total unemployment taxes in panel (f). Non-behavioral unemployment taxes are equal to true unemployment taxes until time $t - 1$. From $t = 0$ on, they are the obtained by multiplying the tax rate by the taxable wages of that quarter in $t - 1$, rescaled by the percent increase in the Taxable Wage Base in that year relative to the pre-reform one (\$10,000). 95% robust confidence intervals are reported.

Table OA.4: Reduced Form Effects of the Elimination of the Surcharge on Firm Outcomes

Outcome:	(1) Tax per worker	(2) Employees	(3) Total wages	(4) Avg wage	(5) Tax wages	(6) tTax wages (payroll -1)	(7) Tot taxes	(8) Tot taxes (payroll -1)
Treated × Time Event -7	-74.170*** (5.553)	-0.042 (0.190)	780.880 (5,010,572)	-502.067 (765,625)	-2,309.157** (1,020,746)	-2,309.157** (1,020,746)	-242.643*** (65,945)	-242.643*** (65,945)
Treated × Time Event -6	-74.170*** (5.553)	-0.141 (0.181)	5,256,345 (4,681,723)	2,011,565 (1,635,617)	-1,601,360* (907,916)	-1,601,360* (907,916)	-199.575*** (62,822)	-199.575*** (62,822)
Treated × Time Event -5	-74.170*** (5.553)	-0.049 (0.147)	-605,613 (3,730,643)	-271,399 (783,724)	-2,031.131*** (743,803)	-2,031.131*** (743,803)	-205.710*** (56,746)	-205.710*** (56,746)
Treated × Time Event -4	-0.000 (0.000)	-0.061 (0.148)	4,551,471 (5,047,063)	-1,272,757 (1,118,952)	6,348,528** (3,096,095)	6,348,528** (3,096,095)	392,535* (200,674)	392,535* (200,674)
Treated × Time Event -3	-0.000 (0.000)	-0.129 (0.115)	1,343,140 (4,229,319)	-1,125,463 (759,795)	-1,795,814* (999,585)	-1,795,814* (999,585)	-112.226 (71,532)	-112.226 (71,532)
Treated × Time Event -2	-0.000 (0.000)	-0.055 (0.120)	-1,959,303 (3,103,647)	-846,689 (684,844)	-736,837 (880,431)	-736,837 (880,431)	-48.226 (64,038)	-48.226 (64,038)
Treated × Time Event	-137.931*** (4.441)	0.517 (0.484)	20,699,545** (8,979,766)	-687,090 (919,934)	14,117,023** (6,444,497)	3,894,169 (3,165,377)	218.213 (342,139)	-366.714** (163,002)
Treated × Time Event +1	-137.931*** (4.441)	0.457 (0.417)	13,859,271* (7,816,478)	-281,527 (761,756)	-1,098,065 (1,423,879)	-2,601,310** (1,021,194)	-233.989*** (77,560)	-263.689*** (64,245)
Treated × Time Event +2	-137.931*** (4.441)	0.528 (0.413)	12,701,203 (7,817,753)	-577,271 (708,032)	1,723,298 (1,451,139)	-1,251,636 (895,102)	-46.166 (84,621)	-172.964*** (61,026)
Treated × Time Event +3	-137.931*** (4.441)	0.836** (0.385)	22,832,893*** (7,755,592)	967,837 (719,854)	2,007,980* (1,081,326)	-390,274*** (20,555)	-27.148 (64,344)	-84.090*** (30,650)
Treated × Time Event +4	-80.467*** (6.121)	0.510 (0.430)	22,337,083** (8,694,516)	-408,008 (840,957)	15,948,231*** (6,109,702)	5,251,370 (3,281,596)	296,574 (250,378)	-124.635 (168,442)
Treated × Time Event +5	-80.467*** (6.121)	0.647* (0.393)	13,157,465** (6,535,986)	-884,307 (764,184)	615,319 (1,837,183)	-2,278,433** (1,052,966)	-132,583 (85,930)	-188,393*** (69,828)
Treated × Time Event +6	-80.467*** (6.121)	0.629 (0.406)	16,369,790** (6,937,115)	-829,554 (886,859)	2,063,071 (1,884,058)	-1,003,068 (920,311)	-33,455 (84,275)	-93,971 (62,928)
Treated × Time Event +7	-80.467*** (6.121)	0.618 (0.404)	16,298,354** (7,831,682)	363,051 (628,578)	1,207,561 (1,583,987)	-161,273*** (48,856)	-48,963 (74,079)	-95,384** (45,565)
Treated × Time Event +8	9.544 (6.365)	0.500 (0.349)	11,583,325 (8,529,672)	578,978 (1,100,913)	13,124,311*** (4,826,137)	7,847,570** (3,377,565)	342,508** (173,614)	185,021 (154,974)
Observations	70,312	70,312	70,312	68,098	70,312	70,312	70,312	70,312
R-squared	0.605	0.748	0.757	0.456	0.466	0.567	0.441	0.513
Mean Outcome	862	12.45	216724	17544	49284	49284	3206	3206

This table reports the estimates of the β_y coefficients from Equation 19 for the sample of Colorado employers. The treatment group includes employers with Positive Reserve Ratio in 2017. The control group includes employers with Positive Reserve Ratio in 2015. The outcomes are the unemployment tax per worker in column (1) the quarterly average number of employees in column (2), quarterly total wages in column (3), the average wage in column (4), the quarterly taxable wages in column (5), quarterly total unemployment taxes in column (6), and quarterly non-behavioral total unemployment taxes in column (7). Non-behavioral unemployment taxes are equal to true unemployment taxes until time $t - 1$. From $t = 0$ on, they are obtained by multiplying the tax rate by the taxable wages of that quarter in $t - 1$, rescaled by the percent increase in the Taxable Wage Base in that year relative to the pre-reform one (\$10,000). Standard errors are robust to heteroskedasticity and clustered at the employer level. *** p<0.01, ** p<0.05, * p<0.1

Figure OA.7: Differential Reduced Form Effects in High- and Low-Unemployment Risk Industries



This figure illustrates the estimates of the β_y coefficients from Equation 19 estimated separately for the subsample of Colorado employers in low- and high-unemployment risk industries. High-unemployment risk industries have median within-year standard deviation in employment above 250 between 1998 and 2006 according to the Quarterly Census of Employment and Wages data for Colorado. Industries are defined using the NAICS-6 digits code. The treatment group includes employers with Positive Reserve Ratio in 2017. The control group includes employers with Positive Reserve Ratio in 2015. The outcomes are the unemployment tax per worker in panel (a) the quarterly average number of employees in panel (b), total wages in panel (c), and the average wage in panel (d). 95% robust confidence intervals are reported.

Table OA.5: Differential Reduced Form Effects in High- and Low-Unemployment Risk Industries

Outcome: Industry unempl. risk:	(1) Tax per worker		(2) Employees		(3) Low		(4) High		(5) Tot wages		(6) Low		(7) High		(8) Avg wage		(9) Low		(10) High		(11) Tax wages		(12) Low		(12) High	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High		
Treated \times Time Event -7	-65.351*** (8.120)	-76.328*** (8.106)	0.064 (0.197)	-0.229 (0.357)	6,839.637 (5,281.841)	-6,309.452 (9,508.846)	277.745 (834.497)	-299.623 (1,001.305)	-245.691 (1,322.057)	-4,638.028*** (1,736.712)	-106.381 (69.411)	-396.429*** (124.235)														
Treated \times Time Event -6	-65.351*** (8.120)	-76.328*** (8.106)	0.148 (0.178)	-0.530 (0.350)	5,650.153 (4,174.775)	3,796.609 (9,221.120)	-50.489 (780.031)	5,587.315* (3,350.178)	-439.684 (855.470)	-3,161.027* (1,787.852)	-85.657 (53.734)	-341.465*** (126.010)														
Treated \times Time Event -5	-65.351*** (8.120)	-76.328*** (8.106)	0.046 (0.167)	-0.121 (0.262)	2,371.989 (3,719.523)	-3,215.094 (7,218.785)	-772.553 (659.674)	1,535.215 (1,184.376)	-1,777.459** (748.920)	-2,177.790 (1,412.965)	-136.811*** (49.934)	-276.331** (111.732)														
Treated \times Time Event -4	-0.000 (0.000)	-0.000 (0.000)	-0.029 (0.149)	-0.074 (0.267)	7,876.477 (6,327.823)	1,228.969 (8,627.616)	-625.313 (1,009.621)	-961.419 (2,106.249)	5,080.812 (3,955.861)	6,429.211 (5,060.343)	338.898 (258.932)	365.657 (327.328)														
Treated \times Time Event -3	-0.000 (0.000)	-0.000 (0.000)	-0.046 (0.140)	-0.204 (0.193)	6,039.772 (5,425.555)	-4,071.251 (7,174.513)	-421.445 (814.592)	-848.960 (995.341)	-1,677.381 (1,185.386)	-1,798.237 (1,791.744)	-108.399 (75.658)	-108.321 (134.448)														
Treated \times Time Event -2	0.000 (0.000)	-0.000 (0.000)	-0.038 (0.111)	-0.003 (0.235)	-203.191 (2,902.398)	-4,713.430 (5,913.403)	-522.524 (642.738)	-202.222 (877.602)	-878.889 (770.290)	-454.638 (1,744.671)	-53.888 (47.755)	-38.159 (130.462)														
Treated \times Time Event	-146.066*** (6.017)	-134.328*** (6.916)	-0.023 (0.111)	1.175 (1.044)	6,259.152* (3,655.511)	35,474.547* (19,115.533)	-692.933 (1,200.526)	457.463 (1,137.710)	6,165.334 (4,140.543)	21,173.022 (13,267.460)	-193.586 (226.168)	548.575 (703.023)														
Treated \times Time Event +1	-146.066*** (6.017)	-134.328*** (6.916)	-0.030 (0.151)	1.008 (0.893)	8,044.529* (3,758.433)	17,546.204 (16,430.347)	375.049 (646.810)	-73.570 (1,162.467)	-1,734.353 (1,324.129)	-336.872 (2,762.643)	-219.997*** (67.454)	-268.316* (153.982)														
Treated \times Time Event +2	-146.066*** (6.017)	-134.328*** (6.916)	0.056 (0.171)	1.050 (0.879)	2,992.886 (3,474.201)	21,861.815 (16,546.956)	-33.220 (689.497)	-240.915 (928.407)	-445.600 (970.763)	4,063.815 (2,992.200)	-102.312* (58.134)	-9.992 (174.746)														
Treated \times Time Event +3	-146.066*** (6.017)	-134.328*** (6.916)	0.359* (0.184)	1.353* (0.813)	13,839.625*** (4,429.307)	33,394.526** (16,172.578)	1,118.710 (725.299)	2,023.775** (987.723)	800.737 (823.309)	3,227.674 (2,195.780)	-39.142 (50.150)	-30.356 (130.474)														
Treated \times Time Event +4	-86.171*** (7.969)	-91.274*** (9.899)	-0.009 (0.232)	1.288 (0.899)	4,645.345 (6,329.222)	40,167.666** (17,497.892)	-923.358 (1,033.636)	1,290.937 (1,023.353)	7,783.993 (4,848.091)	22,935.838* (12,163.159)	143.888 (241.358)	306.037 (479.432)														
Treated \times Time Event +5	-86.171*** (7.969)	-91.274*** (9.899)	0.195 (0.238)	1.108 (0.813)	6,607.720 (5,001.746)	18,819.582 (13,037.911)	-862.684 (787.237)	-257.495 (1,046.343)	-205.197 (1,482.703)	1,721.020 (3,685.394)	-104.119 (79.804)	-195.801 (166.896)														
Treated \times Time Event +6	-86.171*** (7.969)	-91.274*** (9.899)	0.054 (0.252)	1.176 (0.839)	8,251.472* (4,918.912)	22,666.295 (14,011.561)	-57.967 (661.780)	-633.079 (1,606.147)	-847.528 (1,001.170)	5,172.709 (3,976.950)	-46.149 (56.577)	-39.000 (174.698)														
Treated \times Time Event +7	-86.171*** (7.969)	-91.274*** (9.899)	-0.084 (0.259)	1.343 (0.829)	8,929.959* (5,019.833)	22,364.019 (16,093.049)	1,073.705** (504.477)	326.749 (816.461)	-757.729 (771.339)	3,435.659 (3,361.001)	-50.271 (45.573)	-57.075 (154.457)														
Treated \times Time Event +8	7.377 (7.618)	-2.808 (10.778)	-0.127 (0.270)	1.131 (0.692)	1,969.492 (8,312.643)	19,027.445 (16,128.452)	1,408.415 (1,584.706)	1,115.727 (1,336.287)	7,531.834 (5,411.154)	16,718.145* (8,565.987)	373.635* (207.084)	186.107 (301.509)														
Observations	36,074	30,311	36,074	30,311	36,074	30,311	35,260	29,048	36,074	30,311	36,074	30,311														
R-squared	0.615	0.597	0.877	0.685	0.805	0.733	0.590	0.344	0.544	0.433	0.514	0.407														
Mean Outcome	863.4	870.6	7.815	8.585	124741	155857	16905	18842	28648	35323	1874	2318														

This table reports the estimates of the γ_y coefficients from Equation 20 estimated for the sample of Colorado employers. High-unemployment risk industries have median within-year standard deviation in employment above 250 between 1998 and 2006 according to the Quarterly Census of Employment and Wages data for Colorado. Industries are defined using the NAICS-6 digits code. The treatment group includes employers with Positive Reserve Ratio in 2017. The control group includes employers with Positive Reserve Ratio in 2015. The outcomes are the unemployment tax per worker in column (1) the quarterly average number of employees in column (2), quarterly total wages in column (3), and the average wage in column (4). Standard errors are robust to heteroskedasticity and clustered at the employer level. *** p<0.01, ** p<0.05, * p<0.1

Table OA.6: Elasticities of Employment and Wages with respect to the Unemployment Tax Per Worker

	Full Sample	Low Risk	High Risk
<i>Panel A: Employees</i>			
Treated \times Time Event +3: β	0.836***	0.359	1.353**
Treated \times Time Event +3: <i>se</i>	(0.316)	(0.238)	(0.661)
Mean 2010 Treated	8.091	7.710	8.451
<i>Panel B: Average Wage</i>			
Treated \times Time Event +3: β	967.837	1118.710	2023.775
Treated \times Time Event +3: <i>se</i>	(901.992)	(1017.453)	(1672.155)
Mean 2010 Treated	18472.681	17824.092	19613.702
<i>Panel C: Tax Per Worker</i>			
Treated \times Time Event +3: β	-137.931***	-146.066***	-134.328***
Treated \times Time Event +3: <i>se</i>	(4.291)	(5.813)	(6.682)
Mean 2010 Treated	882.939	882.152	888.466
<i>Panel D: Elasticities</i>			
Employment Elasticity wrt Tax Per Worker	-0.661	-0.281	-1.059
Wage Elasticity wrt Tax Per Worker	-0.335	-0.379	-0.682

Notes: This table illustrates the components that contribute to the calculation of the elasticity of employment with respect to the unemployment tax per worker and the corresponding estimated elasticity. I calculate this elasticity in the full sample of Colorado employers and in the subsamples of employers in low- and high-unemployment risk industries. High-unemployment risk industries have median within-year standard deviation in employment above 250 between 1998 and 2006 according to the Quarterly Census of Employment and Wages data for Colorado. Industries are defined using the NAICS-6 digits code. The elasticity is calculated using the formula in Equation 21. The Treated \times Post coefficients are the estimated coefficients from Equation 22. The treatment group includes employers with Positive Reserve Ratio in 2017. The control group includes employers with Positive Reserve Ratio in 2015.

O.B Model Complete Derivation

This section contains the explicit derivation of the results presented in Section 2.

O.B.1 Cross-subsidization with complete and incomplete experience rating

Equations 24 and 23 show that the subsidies of the high- and low- risk employers, defined as the difference between the unemployment benefit costs that each of them generated and the unemployment taxes they pay, are equal to zero.

$$Subsidy_H^{ER} = \underbrace{bp_H l_H}_{\substack{\text{Benefit cost generated by} \\ \text{high-risk employer}}} - \underbrace{bp_H l_H}_{\substack{\text{UI taxes paid by} \\ \text{high-risk employer}}} = 0 \quad (23)$$

$$Subsidy_L^{ER} = \underbrace{0}_{\substack{\text{Benefit cost generated by} \\ \text{low-risk employer}}} - \underbrace{0}_{\substack{\text{UI taxes paid by} \\ \text{low-risk employer}}} = 0 \quad (24)$$

Consequently, if the government maintained a completely experience rated unemployment insurance system over time, the low- and the high-risk employers would cumulate zero unemployment insurance subsidies: $\sum_{t=0}^{\infty} Subsidy_{t,H}^{ER} = 0$ and $\sum_{t=0}^{\infty} Subsidy_{t,L}^{ER} = 0$.

Equations 26 and 25 show that unemployment insurance subsidies are non-zero when experience rating is incomplete.

$$Subsidy_H^{Pool} = \underbrace{bl_H \left(p_H + \frac{1}{m} \right) l_H}_{\substack{\text{Benefit cost generated by} \\ \text{high-risk employer}}} - \underbrace{ebl_H \left(p_H + \frac{1}{m} \right)}_{\substack{\text{UI taxes paid by} \\ \text{high-risk employer}}} = (1 - e)bl_H \left(p_H + \frac{1}{m} \right) > 0 = Subsidy_H^{ER} \quad (25)$$

$$Subsidy_L^{Pool} = \underbrace{0}_{\substack{\text{Benefit cost generated by} \\ \text{low-risk employer}}} - \underbrace{(1 - e)bl_H \left(p_H + \frac{1}{m} \right)}_{\substack{\text{UI taxes paid by} \\ \text{low-risk employer}}} = -(1 - e)bl_H \left(p_H + \frac{1}{m} \right) < 0 = Subsidy_L^{ER} \quad (26)$$

Crucially, if the employers' layoff rate were drawn from a random distribution in each period, unemployment insurance subsidies would cancel out over time. However, since layoff rates are permanent features of the industries, unemployment insurance subsidies cumulate period after period, generating systematic patterns of interindustry cross-subsidization: $\sum_{t=0}^{\infty} Subsidy_{H,t}^{Pool} = \sum_{t=0}^{\infty} (1 - \alpha)bl_H \left(p_H + \frac{1}{m} \right) = +\infty$ and $\sum_{t=0}^{\infty} Subsidy_{L,t}^{Pool} = \sum_{t=0}^{\infty} -(1 - \alpha)bl_H \left(p_H + \frac{1}{m} \right) = -\infty$.

O.B.2 Optimal labor demand as function of experience rating

The high-risk employer observes the government's choice of the degree of experience rating e , treats it as a fixed parameter, and chooses the labor demand that maximizes expected profits. By replacing $\tau_H l_H$ from Equation 5 in Equation 1, I express expected profits as function of the degree of experience rating e :

$$\begin{aligned}\Pi_H &= \left(1 - p_H - \frac{1}{m}\right) \left[\int_0^{l_H} f(i, k) di - w_H l_H - ebl_H \left(p_H + \frac{1}{m}\right) - jk \right] \\ &\quad + \left(p_H + \frac{1}{m}\right) \left[-eb \left(p_H + \frac{1}{m}\right) (1 + q) - (1 - 1_{e=1})\psi(m) \right]\end{aligned}\quad (27)$$

The privately optimal labor demand of the high-risk employer as a function of the degree of experience rating is determined by taking the derivative of their profits with respect to l_H and setting it equal to zero:

$$\frac{\partial \Pi_H}{\partial l_H} = \left(1 - p_H - \frac{1}{m}\right) \left[f(l_H, k_H) - w_H - eb \left(p_H + \frac{1}{m}\right) \right] - \left(p_H + \frac{1}{m}\right)^2 eb = 0 \quad (28)$$

Rearranging terms, I obtain Equation 7. To understand how labor demand changes with experience rating, I define the following function of l_H and e and use the Implicit Function Theorem to determine the derivative of labor demand with respect to experience rating, $\frac{\partial l_H}{\partial e}$:

$$G(l_H, e) = f_H(l_H, k) - \left[\frac{eb \left(p_H + \frac{1}{m}\right)}{(1 - p_H - \frac{1}{m})} + w_H \right] \quad (29)$$

$$\frac{\partial l_H}{\partial e} = -\frac{\frac{\partial G(l_H, e)}{\partial e}}{\frac{\partial G(l_H, e)}{\partial l_H}} = -\frac{\frac{b \left(p_H + \frac{1}{m}\right)}{(1 - p_H - \frac{1}{m})}}{f'_H(l_H, k_H)} < 0 \quad (30)$$

Since $f(i, k)$ is decreasing in i by assumption, $f'(l_H, k_H) < 0$, and $\frac{\partial l_H}{\partial e} < 0$.

O.B.3 Optimal effort as a function of experience rating

The high-risk employer observes the government's choice of the degree of experience rating e , treats it as a fixed parameter, and chooses the level of effort to avoid shocks that maximizes expected profits. To determine the privately optimal effort, I take the derivative of the employer's profits, shown in Equation 27, and set it to zero:

$$\frac{\partial \Pi_H}{\partial m} = \frac{1}{m^2} \left[\int_0^{l_H} f(i, k) di - w_H l_H - ebl_H \left(p_H + \frac{1}{m}\right) - kj + ebl_H + (1 - 1_{e=1})\psi(m) \right] - \left(p_H + \frac{1}{m}\right) \psi'(m)(1 - 1_{e=1}) \quad (31)$$

Rearranging terms and noticing that $\int_0^{l_H} f(i, k) di - w_H l_H - ebl_H \left(p_H + \frac{1}{m} \right) - kj + ebl_H + (1 - 1_{e=1})\psi(m) = \Pi_H^{good} - \Pi_H^{bad} + eq$, I obtain Equation 8.

To assess how the optimal level of effort changes with the degree of experience rating, it is useful to distinguish the two cases where $e = 1$ and $e < 1$. Equation 32 shows that with complete experience rating, when $e = 1$ and $(1 - 1_{e=1})\psi(m) = 0$, the derivative of expected profits with respect to effort is positive. Consequently, it is optimal for the high-risk employer to keep increasing effort: $m^{*,ER} \rightarrow \infty$. It follows that with complete experience rating the unemployment risk in the economy is minimized: $\lim_{m \rightarrow \infty} r_H = \lim_{m \rightarrow \infty} p_H + \frac{1}{m} = p_H$.

$$\frac{\partial \Pi_H}{\partial m} = \frac{1}{m^2} \left[\int_0^{l_H} f_H(i, k) di - w_H l_H - bl_H \left(p_H + \frac{1}{m} \right) - kj + bl_H \right] > 0 \quad (32)$$

With coinsurance, when $e < 1$, the high-risk employer faces positive costs of exerting effort: $(1 - 1_{e=1})\psi(m) = \psi(m)$. Equation 33 illustrates the derivative of expected profits with respect to effort in this scenario:

$$\frac{\partial \Pi_H}{\partial m} = \frac{1}{m^2} \left[\int_0^{l_H} f_H(i, k) di - w_H l_H - ebl_H - kj + \psi(m) \right] - \left(p_H + \frac{1}{m} \right) \psi'(m) = G(m, e) \quad (33)$$

To see how effort changes with the degree of experience rating, I define the implicit function $G(m, e)$ from the first order condition just derived. Using the Implicit Function Theorem, I determine the derivative of effort with respect to experience rating:

$$\frac{\partial m}{\partial e} = -\frac{\partial G(m, e)\partial e}{\frac{\partial G(m, e)}{\partial m}} = -\frac{bl_H}{-\frac{2}{m^3} [\int_0^{l_H} f_H(i, k) di - w_H l_H - ebl_H - kj + \psi(m)] + \frac{2\psi'(m)}{m} - p_H \psi''(m) - \frac{\psi'''(m)}{m}} \quad (34)$$

Since $\frac{\partial[G(m,e)m^2]}{\partial m} = \frac{\partial G(m,e)}{\partial m}m^2 + 2mG(m,e)$ and $G(m, e) = 0$ at the optimum, the sign of $\frac{\partial G(m,e)}{\partial m}$ and $\frac{\partial[G(m,e)m^2]}{\partial m}$ must be the same. Since ψ is convex, $\psi'(m) > 0$ and $\psi''(m) > 0$, and $\frac{\partial[G(m,e)m^2]}{\partial m}$ in Equation 35 is negative, implying that $\frac{\partial G(m,e)}{\partial m} < 0$ and $\frac{\partial m}{\partial e} > 0$. Effort is thus increasing in the degree of experience rating.

$$\frac{\partial G(m, e)m^2}{\partial m} = -p_H \psi''(m)m^2 - p_H 2m\psi'(m) - \psi''(m)m < 0 \quad (35)$$

O.B.4 Welfare maximization

The government chooses the degree of experience rating e to maximize the social welfare function in Equation 9, obtained as the sum of workers' and capitalists' utilities, subject to the government budget constraint, the tax burden allocation rules in Equations 5 and 6, labor market clearing, and the high-unemployment risk employer's effort defined in Equation 8:

$$\begin{aligned}
& \max_e \quad SWF \\
\text{s.t.} \quad & \tau_L l_L = (1 - e) b l_H \left(p_H + \frac{1}{m} \right), \\
& \tau_H l_H = e b l_H \left(p_H + \frac{1}{m} \right), \\
& l_L = 1 - l_H, \\
& f_H(l_H, k_H) = \frac{e b (p_H + \frac{1}{m})}{1 - p_H - \frac{1}{m}} + w_H, \\
& \left(p_H + \frac{1}{m} \right) \psi'(m)(1 - 1_{e=1}) = \frac{1}{m^2} \left[\int_0^{l_H} f_H(i, k) di - w_H l_H - k j + e b l_H + (1 - 1_{e=1}) \psi(m) \right]
\end{aligned}$$

After normalizing k to 1, the Lagrangean associated to the maximization problem is:

$$\begin{aligned}
\mathcal{L} = & (1 - l_H) u(w_L) + l_H \left[\left(1 - p_H - \frac{1}{m} \right) u(w_H) + \left(p_H + \frac{1}{m} \right) [u(b) + L] \right] + [\gamma(\Pi_L + \Pi_H) - 1] \\
= & (1 - l_H) u(w_L) + l_H \left[\left(1 - p_H - \frac{1}{m} \right) u(w_H) + \left(p_H + \frac{1}{m} \right) [u(b) + L] \right] + \gamma \left[\int_{l_H}^1 f_L(i, k) di - w_L(1 - l_H) - (1 - e) b l_H \left(p_H + \frac{1}{m} \right) - j k \right] \\
& + \gamma \left(1 - p_H - \frac{1}{m} \right) \left[\int_0^{l_H} f(i, k_H) di - w_H l_H - e b l_H \left(p_H + \frac{1}{m} \right) - j \right] + \gamma \left(p_H + \frac{1}{m} \right) \left[-e b l_H \left(p_H + \frac{1}{m} \right) (1 + q) - (1 - 1_{e=1}) \psi(m) \right] - 1
\end{aligned} \tag{36}$$

To determine the optimal degree of experience rating e^* , I take the derivative of the Lagrangean with respect to e , shown in Equation 37, and set it equal to zero. Since the high-risk employer is choosing l_H and m optimally after observing e , by the Envelope Theorem $\frac{\partial l_H^*}{\partial e} = \frac{\partial m^*}{\partial e} = 0$. When deriving the profit function of the high-risk employer with respect to e , I can thus disregard that m and l_H are functions of e . I further use the workers' indifference between jobs and within the high-risk job between unemployment and employment discussed in Section 2.1 and $r_H = p_H + \frac{1}{m}$ to obtain:

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial e} = & - \frac{\partial l_H}{\partial e} u(w_L) + \frac{\partial l_H}{\partial e} \left[\left(1 - p_H - \frac{1}{m} \right) u(w_H) + \left(p_H + \frac{1}{m} \right) [u(b) + L] \right] + l_H \left[\frac{1}{m^2} [u(w_H) - u(b) - L] \frac{\partial m}{\partial e} \right] \\
& + \left[-f_L(l_H, k) + w_L - (1 - e)b \left(p_H + \frac{1}{m} \right) \right] \frac{\partial l_H}{\partial e} + b l_H \left(p_H + \frac{1}{m} \right) + \frac{(1 - e)b l_H}{m^2} \frac{\partial m}{\partial e} \\
& + \left(1 - p_H - \frac{1}{m} \right) \left[-b l_H \left(p_H + \frac{1}{m} \right) \right] + \left(p_H + \frac{1}{m} \right) (-b l_H \left(p_H + \frac{1}{m} \right) (1 + q)) \\
= & -\epsilon_{l_H, e} \frac{l_H}{e r_H} [f_L(l_H) - w_L + (1 - e)b r_H] + \epsilon_{m, e} \frac{(1 - e)b l_H}{e m r_H} - r_H b l_H q = 0
\end{aligned} \tag{37}$$

I then notice that $r_H b l_H q = \Pi'_H^{good} - \Pi'_H^{bad}$, where Π'_H^{good} and Π'_H^{bad} are the partial derivatives of good- and bad-state profits respectively: $\Pi'_H^{good} = \frac{\partial \Pi_H^{good}}{\partial e}$ and $\Pi'_H^{bad} = \frac{\partial \Pi_H^{bad}}{\partial e}$. I then divide all factors of Equation 37 by $B = b l_H r_H$ to obtain:

$$-\epsilon_{l_H,e} \frac{1}{ebr_H^2} [f_L(l_H) - w_L + (1-e)br_H] + \epsilon_{m,e} \frac{(1-e)}{emr_H^2} = q \quad (38)$$

Using $\Pi_H^{good} = B$ the definitions for λ and μ in Equations 11 and 12, I obtain Equation 10, defining the optimal degree of experience rating.

O.B.5 Optimal degree of experience rating with flexible wages

Coming soon.

O.B.6 Optimal degree of experience rating with workers' preferences

Coming soon.

O.B.7 Optimal degree of experience rating with non-zero risk

Coming soon.

O.B.8 Effort elasticity and layoff elasticity

To calibrate the elasticity of effort with respect to the degree of experience rating, $\epsilon_{m,e}$ elasticity, I leverage the relationship between effort m and the unemployment risk r_H in the model. Since $r_H = p_H + \frac{1}{m}$, it is possible to express the elasticity of effort as a function of the elasticity of the unemployment risk, as shown in Equation 39:

$$\epsilon_{r_H,e} = \frac{dr_H}{de} \frac{e}{r_H} = \frac{\partial p_H}{\partial e} + \frac{d\frac{1}{m}}{de} = -\frac{1}{m^2} \frac{\partial m}{\partial e} \frac{e}{r_H} = -\frac{\epsilon_{m,e}}{mr_H} \quad (39)$$

It follows that $\epsilon_{m,e} = -mr_H \epsilon_{r_H,e}$.