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Firm Behavior and Labor Market Dynamics

Margolin, Simon

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Firm Behavior and Labor Market Dynamics

Simon Margolin

A Dissertation

Presented to the Faculty

of Princeton University

in Candidacy for the Degree

of Doctor of Philosophy

Recommended for Acceptance

by the Department of Economics

Advisers: Professor Gianluca Violante & Professor John Grigsby

May 2025

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Abstract

This dissertation studies how firm behavior affects the design of tax policy and labor market institutions. Chapter 1 investigates the optimal design of unemployment insurance (UI) and its effects on job seekers. Using a directed search model with endogenous search effort and asymmetric information between workers and recruiters, I show that higher UI benefits can worsen adverse selection by encouraging low-productivity workers to apply for high-wage jobs, crowding out more productive applicants. However, higher UI also reduces applications from low-productivity workers, partially offsetting this inefficiency. Calibrating the model with data from the Survey of Consumer Expectations and the Current Population Survey, I find that current UI benefits in the U.S. are close to the welfare-maximizing level. Chapter 2 examines the unequal incidence of corporate taxes across firms and its macroeconomic implications. I develop a dynamic general equilibrium model with heterogeneous firms and show that corporate tax cuts lead to larger wage gains at capital-intensive firms. This heterogeneity, combined with equilibrium effects, helps reconcile differences between micro and macro estimates of corporate tax incidence. Using French employer-employee administrative data and multiple tax reforms, I estimate firm-level responses, calibrate the model, and quantify the short- and long-run effects of corporate tax changes. The results suggest that, once firm heterogeneity and equilibrium dynamics are accounted for, workers bear a small share of the aggregate corporate tax burden. Chapter 3 (joint with Maxime Gravoueille and Thomas Zuber) analyzes worker flows around bankruptcies using new data covering 148,000 filings in France from 2008 to 2017. We find that layoffs begin, on average, two years before a firm files for bankruptcy, while job-to-job transitions rise only one year before. This suggests that workers rely on layoff patterns to detect financial distress and face delays in securing new jobs. We also document heterogeneity in exit timing: high-tenure and older workers exit later; high-wage workers quit earlier and are less likely to be laid off.

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Chapter 1

Unemployment Insurance and the Quality of Job Seekers

1.1 Introduction

Unemployment insurance (UI) plays a critical role in modern labor market policies. A well-established literature has examined the optimal design of unemployment insurance, identifying a key trade-off: while UI helps workers smooth consumption during periods of unemployment, it also introduces inefficiencies by distorting their job search effort. Prior studies have primarily focused on the quantitative aspect of this distortion, showing that job seekers tend to search less when they are more generously insured. This paper introduces an equilibrium search model that extends this discussion by exploring a new dimension: how unemployment insurance distorts the quality of the pool of job seekers.

This new distortion arises from two distinctive features of the model. First, job seekers choose both the number and the type of jobs they apply to. Second, worker productivity is private information, making it difficult for employers to separate out high- and low-productivity applicants. These two elements interact, as applications from low-productivity workers may crowd out the productive ones if the former send too many of them or send

them too high. Unemployment insurance distorts both margins, and therefore the extent to which productive workers are crowded out of the market.

This paper argues that higher levels of unemployment insurance can improve matching efficiency through a previously unexplored channel. By reducing the intensity of search effort among low-productivity workers and limiting their excessive applications, unemployment insurance can mitigate employers' informational constraints and alleviate the adverse selection force that drives high-productivity workers out of the market.

I develop a dynamic directed search model in which firms post wages, and unemployed workers choose both the number and the directions of their job applications. Employers targeting high-productivity workers face the challenge of distinguishing them from low-productivity applicants, as productivity is not directly observable. They attract the best applicants by leveraging the greater patience of high-productivity workers, who have better outside options. To do so, they post jobs in markets with low job-finding rates, creating conditions that deter more impatient, low-productivity workers from applying.

This difference in patience or, equivalently, in tolerance for unemployment risk, is affected by the level of unemployment insurance. As UI increases for low-productivity workers, they become more willing to tolerate risk in their applications and apply to markets with lower job-finding rates, thereby crowding out high-productivity workers and forcing them to accept even lower job-finding rates to signal their type.

Yet, this higher level of unemployment insurance has an additional, opposite effect on high-productivity workers. As low-productivity job seekers become more willing to tolerate unemployment risk, they reduce the number of applications they send, thereby decreasing the likelihood that their applications will reach high-productivity markets. This channel mitigates adverse selection and its crowding-out effect on high-productivity applicants.

I characterize these different forces and show how they transform the traditional trade-off of unemployment insurance design. To do so, I solve the problem of a Ramsey planner who chooses the level of unemployment benefits in the decentralized equilibrium, subject to the

UI budget constraint. I examine the new mechanisms by extending the decomposition of welfare gains from UI introduced by Baily (1978) and Chetty (2006). New terms appear in this decomposition, highlighting the direct impact of insuring low-productivity workers on high-productivity applicants, as well as its indirect externality on the fiscal burden of the unemployment system.

The ultimate impact of these forces on the optimal design of unemployment insurance is a quantitative question. To address it, I extend the model to incorporate aggregate productivity shocks, a key driver of unemployment risk. I show that the block recursivity of the directed search framework (Menzio and Shi, 2010, 2011) generalizes to simultaneous search, i.e. to a directed search equilibrium in which workers are allowed to visit multiple markets. This property allows me to solve for the equilibrium with aggregate risk relatively quickly. Interestingly, the interaction of endogenous search effort and adverse selection produces large unemployment fluctuations in response to aggregate productivity shocks. This is an important aspect of this framework given the difficulty for search models to replicate the employment dynamics observed in aggregate data (Shimer, 2005).

I calibrate the model using data from the Survey of Consumer Expectations Job Search Supplement (SCE-JS) (Faberman et al., 2022) and the Current Population Survey (CPS), and assess the welfare effects of unemployment insurance on workers. The quantitative exercise demonstrates that the two forces introduced in the model—adverse selection and endogenous search intensity—significantly affect the design of optimal unemployment insurance. While adverse selection and endogenous search intensity each independently push for less generous unemployment insurance, their interaction counteracts these effects by discouraging low-productivity workers from over-applying. I find an optimal level of unemployment benefits equal to 47.4% of workers' average wage, which is close to the replacement income observed in most US states, although slightly above the average.

This paper contributes to the literature on optimal unemployment insurance. Baily (1978) and Chetty (2006) derive a key trade-off for this insurance at the microeconomic level:

consumption-smoothing benefits vs. moral hazard costs. These forces have been described in equilibrium frameworks with random search (Gautier et al., 2016; Landais et al., 2018) and directed search Acemoglu and Shimer (1999, 2000); Schmieder and Von Wachter (2016); Chaumont and Shi (2022); Cai and Heathcote (2023), which capture the congestion effect of job seekers' behavior. I contribute to this literature by examining how unemployment insurance affects both the quality of the job seeker pool and the informational constraints faced by recruiters. This framework incorporates the traditional moral hazard and congestion effects of UI, allowing for a comparison with the new externalities. Additionally, I quantify these channels in an economy characterized by an endogenous number of applications, asymmetric information, and aggregate risk.

This paper also builds on the literature on adverse selection in the labor market. Blanchard and Diamond (1994) and Engbom (2021) demonstrate the importance of asymmetric information between job seekers and employers for unemployment dynamics. Guerrieri (2008), Guerrieri et al. (2010), Guerrieri and Shimer (2014) and Chang (2018) lay the foundations for directed search models with private information. Davoodalhosseini (2019) analyzes optimal tax policies in a similar environment in which applicants can only visit one market at a time. The framework developed in this paper builds on Auster et al. (2025) who introduce multiple applications, or simultaneous search (Burdett and Judd, 1983; Chade and Smith, 2006; Albrecht et al., 2006; Gautier and Wolthoff, 2009; Kircher, 2009; Galenianos and Kircher, 2009; Wolthoff, 2018; Albrecht et al., 2020), and extends it by incorporating an endogenous number of applications, dynamics, aggregate risk, and by exploring the distortions associated with the unemployment insurance in this type of economies.

The paper is organized as follows. Section 3.2 describes a steady-state version of the model. Section 1.3 characterizes the effects of unemployment insurance on workers' behavior and welfare, and the problem of a planner choosing the optimal level of unemployment benefits. Section 1.4 extends the model to a dynamic environment with aggregate productivity shocks and calibrates the model using data from the SCE-JS and the CPS. Finally, section

1.5 solves for the optimal level of insurance under multiple scenarios about the tools available to the government.

1.2 Model

This section develops an equilibrium directed search model in which unemployed workers choose the number and type of jobs to apply for. Firms do not observe directly whether applicants' productivity but post truth-revealing contracts to separate out good and bad candidates. The model is described in steady state, although section 1.4.1 extends it to an environment with aggregate risk.

1.2.1 Environment

Time is discrete and all agents discount future payoffs at rate β. The labor market consists of three types of agents: homogeneous firms owned by a representative entrepreneur, low-productivity workers (L) and high-productivity workers (H). There is mass of workers of size one, among which a share m^H is of type H and a share $1 - m^H$ of type L. A match between an employer and a low-productivity worker produces z units of output in every period of activity, while a match with a high-productivity worker produces $z(1 + \xi)$. The parameter $\xi > 0$ governs the difference in productivity between types. I assume that the goods produced by these matches are sold on a competitive market with a price normalized to one, such that each firm's output is also its stream of revenue.

Employers seek workers by creating vacancies, at cost κ. Each of these vacancies has a posted wage which is constant throughout the duration of a match. The set of posted wages is denoted by $\mathcal{W}$. Every posted wage w defines a market in which vacancies and applications meet through a matching function that will be described in the next section. Unemployed workers look for jobs by sending applications to these markets. They can send as many

applications as they want, and each of their applications can be directed towards a different type of job.

1.2.2 Matching

Every period, employers post vacancies and their associated wages, and unemployed workers direct their applications towards these different jobs. A market w is defined by all the vacancies that offer this wage and all the applications directed towards such postings.

Unemployed workers can send multiple applications *simultaneously*, to different types of jobs. Consequently, when a worker gets an offer from a job to which she applied, she may simultaneously obtain a better offer from another job to which she applied. As is common in the simultaneous search literature[1], I assume that two employers that make an offer to the same worker cannot compete ex post and commit to the wage they posted. Hence, a worker with multiple offers in hand accepts the one with the best wage and turns down the others.

As in Kircher (2009), an employer whose offer is turned down can immediately contact its next applicant. This assumption is named *perfect recall*[2]. *Effective* applications in the market for jobs offering a wage w are the ones from workers who were unsuccessful in their applications to better wages. With a large number of workers, the effective queue in the market for jobs of type w is its ratio of effective applications to vacancies, or

$$q(w) = \underbrace{\frac{\#\text{ applicants}}{\text{vacancies}}}_{\text{gross queue length}} \times Pr[\text{no better offer}]$$

Within a market, workers and firms cannot coordinate their actions and are matched through the matching function $m(q(w))$. This function is continuous, increasing and concave

[1]Notable exceptions include Albrecht et al. (2006) and Gautier and Wolthoff (2009) who introduce ex-post competition between firms that match with the same worker.

[2]Galenianos and Kircher (2009) build a model in which employers make at most one offer every period, and are thus left without a valid candidate as soon as their offer is turned down. Wolthoff (2018) develops a framework that nests these two extreme cases, i.e. perfect recall of applicants and no recall at all.

in $q \in \mathbb{R}$. I assume that $m(0) = 0$. The probability that a vacancy offering wage w meets an applicant willing to accept the job is

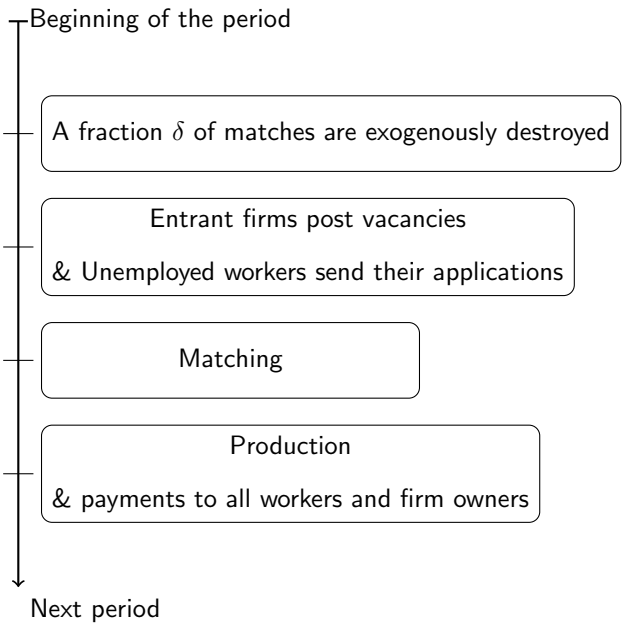
$$\mu\Big(q(w)\Big) = m\Big(q(w)\Big)$$

The probability that an unemployed applicant to market w gets an offer from this market is

$$\psi\Big(q(w)\Big) = \frac{m\Big(q(w)\Big)}{q(w)}$$

1.2.3 Timing

In every period, a fraction $\delta \in (0, 1)$ of existing matches is exogenously destroyed. Workers who lose their jobs must wait for the next period to be able to search for a new one. Firms losing their worker exit the market. Then, entrant firms post vacancies and their associated wages, and unemployed workers who lost their jobs in previous periods send their applications to the markets defined by these vacancies. The matching process described in the previous section occurs. The newly formed matches, as well as the incumbent matches that were not destroyed at the beginning of the period, produce, pay the promised wage to their worker, and give the remaining revenues to the representative firm owner. Finally, all unemployed workers receive their unemployment benefits.



1.2.4 Workers

Workers are hand-to-mouth and consume their entire disposable income every period. A worker of type $i \in \{L, H\}$, employed at wage w at the production stage (end of the period), has a lifetime utility

$$W^i(w) = v\Big((1-\tau)w\Big) + \beta\Big[\delta U^i + (1-\delta)W^i(w)\Big]$$

where $v(.)$ is a continuous and twice differentiable utility function such that $v'(.) \geq 0, v''(.) \leq 0$.

At the production stage, a worker is paid wage w, as prescribed by her contract, from which a fraction τ is taxed to fund the unemployment insurance system. Future payoffs are discounted at rate β. At the beginning of the next period, this job is exogenously destroyed with probability δ, in which case she obtains the value of unemployment corresponding to her type, U^i. If the match survives, she gets the value of this job next period.

An unemployed worker of type i has a lifetime utility, at the production stage, equal to

$$U^i = v\Big(b^i + b_0^i\Big) + \beta \max_a \Big\{S^i(a) - c(a)\Big\}$$

The government provides an unemployment benefit b^i, potentially specific to each type. The assumption of a type-specific unemployment benefit relies on the idea that the unemployment insurance system has more information about workers' employment history than recruiters and can therefore better identify their type. In the quantitative part of this paper, I compare results with and without this assumption, i.e. with type-specific and common benefits. In addition to this unemployment benefit, a worker receives an exogenous income b_0^i, $i \in \{L, H\}$, which is specific to each type[3].

In the next period, this unemployed worker will be able to search for a job. She will choose a discrete number a of applications to send simultaneously in order to maximize the net gains from searching. $c(a)$ is a convex cost function that satisfies $c(0) = 0$. $S^i(a)$ denotes the value of the optimal portfolio of a applications chosen by a worker of type i. It is the utility derived from the expected outcome of this strategy. Workers observe the posted wages $w \in \mathcal{W}$ and their associated queues $q(w)$, and choose the markets to which they send each of their a applications.

Without loss of generality, I order these applications from the one that offers the lowest wage to the one that offers the highest, that is $w_1 \leq w_2 \leq ... \leq w_a$. Once recruiters respond to these applications, a worker first looks at the result of her preferred application, w_a, which turns into a job offer with probability $\psi(q(w_a))$. If she does not get an offer from this preferred market, she goes to her second preferred application, w_{a-1}, which is successful with probability $\psi(q(w_{a-1}))$. Thus, the unconditional probability that this worker will end up in a job posted in market $a-1$ is $(1-\psi(q(w_a)))\psi(q(w_{a-1}))$. More generally, the probability that a worker accepts an offer responding to its k-th, $k \in \{1, ..., a\}$, application

[3]This exogenous income is meant to capture the fact that high-productivity workers may benefit from other sources of replacement income, on top of the government-provided benefits.

is $\prod_{j=k+1}^{a}\Big[1-\psi(q(w_j))\Big]\psi(q(w_k))$. If none of her a applications is successful, this worker remains unemployed. This outcome occurs with probability $\prod_{k=1}^{a}\Big[1-\psi(q(w_k))\Big]$. Hence the value of the optimal portfolio of a applications sent by a worker of type i is

$$S^i(a) = \max_{(w_1,\dots,w_a)\in\mathcal{W}^a} \left[\sum_{k=1}^{a} \underbrace{\left(\prod_{j=k+1}^{a} \Big[1-\psi(q(w_j))\Big] \right) \psi(q(w_k))}_{\Pr\left[k\text{-th lowest app = first success}\right]} W^i(w_k) \; + \; \underbrace{\prod_{k=1}^{a} \Big[1-\psi(q(w_k))\Big]}_{\Pr\left[\text{no job offer}\right]} U^i \right]$$

Following Kircher (2009) and Galenianos and Kircher (2009), one can formulate this portfolio choice recursively as

$$S^i(k) = \max_{w\in\mathcal{W}} \quad \psi(q(w))W^i(w) + \Big[1-\psi(q(w))\Big]S^i(k-1) \tag{1.1}$$

where $S^i(0) = U^i$. When choosing the direction of her k-th application, a worker maximizes the value of its expected outcome. With probability $\psi(q(w))$, this application provides this worker with a job in the target market, which yields a lifetime utility $W^i(w)$. With complementary probability $1-\psi(q(w))$, this k-th application is unsuccessful and the worker gets her effective outside option, $S^i(k-1)$, which is the utility derived from her lower ranked applications. One can already notice that, in general, each application is directed to a different market because the fallback option $S^i(k-1)$ varies across k.

1.2.5 Firms

All firms are owned by a risk-neutral representative entrepreneur and post vacancies to maximize the discounted sum of expected profits. Firms make two choices: whether to post a vacancy and with what wage.

At the production stage, the discounted sum of expected profits generated by a job filled with a worker of type i is

$$J^i(w) = z(1+\xi\cdot\mathbb{1}[i=H]) - w + \beta(1-\delta)J^i(w)$$

The flow profits from this match are equal to its output $z(1+\xi \cdot \mathbb{1}[i = H])$ minus its labor cost w. At the beginning of the next period, the match is destroyed exogenously with probability δ. In this case, the job's value to the employer becomes null. If the match survives this exogenous shock, the firm obtains the value of next period's discounted profits, $J^i(w)$.

An entrant firm creates a vacancy at cost κ and chooses a wage w to solve

$$V = \max_{w} \quad \mu(q(w)) \cdot \left[\gamma(w)J^L(w) + (1-\gamma(w))J^H(w)\right] - \kappa \tag{1.2}$$

where V denote the value of an unfilled vacancy, $\mu(q(w))$ is the probability that this vacancy is filled, and $J^i(w)$ is the employer's discounted sum of profits once the job is filled with a worker of type $i \in \{L, H\}$. Vacancies that are not filled in the period of their creation exit the market.

$\gamma(w) \in [0, 1]$ denotes the share of low-productivity workers in the pool of applicants for jobs offering a wage w. Recruiters know $\gamma(w)$ when they decide whether or not to post on market w. However, they cannot directly observe the productivity of the workers they meet. Consequently, they cannot condition their hiring and the wage they offer on the type of applicant they face.

1.2.6 Government

The government taxes all labor income at rate τ to pay for the benefits b^H and b^L paid to each H-type and L-type workers in every period of unemployment. I assume that the government budget is balanced, such that we can write the steady-state government budget constraint as

$$m^H \mathtt{u}^H b^H + (1-m^H)\mathtt{u}^L b^L = \tau\Big(m^H(1-\mathtt{u}^H)\mathbb{E}\left[w^H\right] + (1-m^H)(1-\mathtt{u}^L)\mathbb{E}\left[w^L\right]\Big) \tag{1.3}$$

where m^H is the share of workers of type H in the overall workforce, $\mathtt{u}^i$ denotes the unemployment rate for workers of type $i \in \{H, L\}$, and $\mathbb{E}\left[w^i\right]$ denotes the average wage of workers

of type $i \in \{H, L\}$. The left-hand side of equation (2.6) is the amount of benefits paid by the unemployment insurance every period. The right-hand side is the amount of revenues raised through the labor income tax.

1.2.7 Beliefs

For workers and firms to be able to make the choices described above, they must form beliefs about the size $q(w)$ and the composition of the pool $\gamma(w)$ of applicants they should expect for any potential wage, even if it is not posted in equilibrium, i.e. if $w \notin \mathcal{W}$.

First, these beliefs need to be consistent, as unemployed workers and entrant firms must expect the same application pool for any wage. Secondly, I follow the standard *market utility* approach (Wright et al., 2021) in the directed search literature, extended to frameworks with private information by Guerrieri et al. (2010) and Auster et al. (2025), for agents' out-of-equilibrium beliefs. When a firm considers the possibility of posting a wage $w \notin \mathcal{W}$, it expects the queue to be the one that requires the lowest job-finding probability capable of redirecting at least one application to this wage. More formally, the expected queue $q(w)$ is such that

$$S^i(k) \geq \psi(q(w))W^i(w) + \Big[1 - \psi(q(w))\Big] S^i_(k-1) \tag{1.4}$$

holds with equality for at least one type of worker i and one of her applications k, and with weak inequality for all $i \in \{H, L\}$ and $k \leq a^i$.

One way to understand this assumption is to consider it as a process of "tâtonnement", as described in Guerrieri et al. (2010). When a firm considers a deviation from equilibrium wages to $w \notin \mathcal{W}$, it first expects an infinitely long queue because it is the only firm in this hypothetical market and that many workers may prefer this wage to their equilibrium expected outcome. However, this long queue discourages job seekers, and they remove their applications from the queue up to the point where some of them are actually willing to continue applying to this market.

As explained by Guerrieri et al. (2010) and Auster et al. (2025), the *market utility* approach also determines the composition of the pool of applicants that firms expect for any out-of-equilibrium wage. The queue with the lowest job-finding probability needed to redirect an application can generally attract applications from a single type of worker. It only attracts workers of type L, $\gamma(w) = 1$, when condition (1.4) holds with equality for $i = L$ and for one $k \leq a^L$, and with strict inequality for $i = H$ and all $k \leq a^H$. Similarly, it only attracts workers of type H, $\gamma(w) = 0$, when it holds with equality for $i = H$ and for one $k \leq a^H$, and with strict inequality for $i = L$ and all $k \leq a^L$.

1.2.8 Separating equilibrium

Definition

A separating equilibrium is defined as a set of wages $\mathcal{W}$, a queue function $q(w)$, a market composition function $\gamma(w)$, numbers of applications a^i and values of unemployment U^i for $i \in \{H, L\}$, application portfolio values $S^i(k)$ for $i \in \{H, L\}$ and $k \in \{1, ..., a^i\}$ such that

1. *Worker optimization*: workers choose a number of applications a^i that maximizes their net value of searching, and a subset of the posted wages towards which they direct their a^i applications to solve (1.1).

2. *Firm optimization*: firms post wages that solve (1.2).

3. *Free entry*: firms enter in each market w until $V(w) = 0$.

4. *Incentive compatibility*: firms post wages that attract a single type of worker, i.e. such that $\gamma(w) \in \{0, 1\}$, by posting cream-skimming wages as defined below.

5. *Beliefs*: Workers and firms have beliefs consistent beliefs about the equilibrium functions $q(w)$ and $\gamma(w)$.

6. *Lemons condition*: unemployment delivers a higher lifetime utility to high-productivity workers than the highest wage that can be offered to low-productivity workers, or $U^H > W^H(z - \kappa(1 - \beta(1 - \delta))$.

Construction

In a separating equilibrium, each vacancy targets a specific type of worker. The *lemons condition* ensures that, in equilibrium, high-productivity workers are not willing to apply to vacancies that target low-productivity workers[4]. The wages posted for L-type workers and their associated queues are therefore those that satisfy the first-order condition of L-type workers' application problem (1.1) and set the value of a vacancy (1.2) with $\gamma(w) = 1$ equal to zero (due to free entry). These conditions define the optimal portfolio $(w_1^L, ..., w_{a^L}^L)$, its associated queues $(q(w_1^L), ..., q(w_{a^L}^L))$, and the value of this portfolio $S_{a^L}^L$ for any $a^L \geq 0$. The number of applications sent by low-productivity workers is the one that maximizes the net gains from searching $S_{a^L}^L - c(a^L)$.

However, the markets that target H-type workers must propose wage-queue combinations that are unattractive to L-type applicants. Nothing prevents a low-productivity worker to send one of her applications to the H-type market. First, a firm that targets H-type workers chooses a wage that does not attract any of the existing applications sent by L-type workers, that is, a w such that the following incentive compatibility constraint is satisfied

$$\psi(q(w))W^L(w) + [1 - \psi(q(w))]S_{a^L-k}^L \leq S_{a^L-k+1}^L \quad \text{for any } k \in \{1, ..., a^L - 1\}$$

The left-hand side of this inequality represents the value for a worker of type L of redirecting her $a^L - k + 1$-th application to the considered posting w. This worker would receive an offer from this market with probability $\psi(q(w))$ and would fall back on her $a^L - k$ lower

[4]In practice, the estimated values of b_0^H and ξ ensure that the *lemons condition* holds with strict inequality. Auster et al. (2025) show that pooling equilibria exist when this condition is relaxed. It would be interesting to understand the impact of the unemployment insurance in this type of equilibrium, although this is beyond the scope of the present paper.

applications with complementary probability $1 - \psi(q(w))$. The latter event would provide a lifetime utility $S^L_{a^L-k}$. The right-hand side of this equation represents the value of the equilibrium strategy of a L-type worker when sending $a^L - k + 1$ applications.

As shown by Auster et al. (2025), checking this condition for the highest application sent by L-type workers is sufficient. The reason for this is that this condition exploits L-type workers' aversion to unemployment risk in their application targets. Due to the lemons condition, firms targeting H-type workers post wages that are higher than any wage posted on L-type markets. These jobs are thus more attractive than all the ones L-type workers apply for. However, these postings generate such high queues that L-type workers are not willing to take the risk on redirecting one of their applications to these markets with relatively low job-finding probabilities. H-type workers are still willing to apply because they have a higher value of unemployment and have more tolerance to risk in their application portfolio.

Through the same mechanism, L-type workers tolerate more risk in their highest application than in any other application. The fallback option for application $a^L - k$ is the value associated with the $a^L - k - 1$ lower applications. This fallback option increases with k, such that the highest application, indexed by a^L, is also the one that has the highest outside option, and the highest risk tolerance. If the incentive compatibility constraint is satisfied for this highest application, it means that L-type workers find the posted wage w and its associated queue $q(w)$ too risky for it to be worth redirecting this application. Following this reasoning, the fact that they are even more risk averse for their lower applications implies that this wage would not be attractive for any of these lower applications neither. Hence, if the incentive compatibility constraint is satisfied for $k = 1$, it is satisfied for any $k \in \{1, ..., a^L - 1\}$.

This incentive compatibility constraint can be reformulated as

$$\psi(q(w))W^L(w) + [1 - \psi(q(w))]S^L_{a^L-1} \leq S^L_{a^L} \tag{IC1}$$

A second incentive compatibility constraint emerges from workers' endogenous number of applications. Even if they do not have any incentive to redirect their current applications to one of the H-type markets, L-type workers could still decide to send an additional application, indexed by $a^L + 1$, to one of these markets. To ensure that L-type workers do not make such a decision, firms targeting high-productivity workers post wages that satisfy

$$\psi(q(w)) \left[W^L(w) - S^L_{a^L} \right] \leq c(a^L + 1) - c(a^L) \tag{IC2}$$

The left-hand side of this constraint is the additional utility derived by L-type workers from an additional application to market w, while the right-hand side is its cost.

1.3 Optimal unemployment insurance

1.3.1 Ramsey problem

I follow the tradition of the optimal unemployment insurance literature (Acemoglu and Shimer, 1999; Schmieder and Von Wachter, 2016; Cai and Heathcote, 2023; Le Barbanchon et al., 2024) in considering the problem of a constrained planner who maximizes the expected utility of a worker starting unmatched before the search and matching stage. The social welfare function is

$$SWF = m^H(S^H(a^H) - c(a^H)) + m^L(S^L(a^L) - c(a^L)) \tag{1.5}$$

I assume that the Ramsey planner is constrained by the decentralized equilibrium described in the previous section, but can choose type-specific and time-invariant unemployment benefits b^H and b^L satisfying the long-run government budget constraint defined in 1.2.6.

1.3.2 Exogenous number of applications: an extended Baily-Chetty formula

With an exogenous number of applications, i.e. fixed a^L and a^H, we can differentiate the social welfare function with respect to the policy instruments b^H and b^L. Search in still endogenous through the directions workers choose for their applications. However, the intensity margin is shut down.

The planner's first order condition with respect to the unemployment benefit for workers of type L, b^L, is

$$\underbrace{m^L\left[\frac{\partial S^L}{\partial b^L}+\frac{\partial S^L}{\partial \tau}\frac{\partial \tau}{\partial b^L}\right]}_{\text{Insurance}}+\underbrace{m^L\frac{\partial S^L}{\partial \tau}\left(\sum_{k=1}^{a^L}\frac{\partial \tau}{\partial w_k^L}\frac{dw_k^L}{db^L}\right)+m^H\frac{\partial S^H}{\partial \tau}\left[\frac{\partial \tau}{\partial b^L}+\sum_{k=1}^{a^L}\frac{\partial \tau}{\partial w_k^L}\frac{dw_k^L}{db^L}\right]}_{\text{Moral hazard fiscal externality}}$$
$$+\underbrace{m^H\frac{\partial S^H}{\partial \underline{w}^H}\frac{d\underline{w}^H}{db^L}}_{\text{Adverse selection direct effect}}+\underbrace{\left(m^L\frac{\partial S^L}{\partial \tau}+m^H\frac{\partial S^H}{\partial \tau}\right)\frac{\partial \tau}{\partial \underline{w}^H}\frac{d\underline{w}^H}{db^L}}_{\text{Adverse selection fiscal externality}}=0 \quad (1.6)$$

The planner balances consumption-smoothing benefits from the unemployment insurance with efficiency costs which arise from the distortions it introduces. Insurance benefits are the gains L-type workers get from transferring a marginal unit of income from employed workers to unemployed workers at constant aggregate revenues, and correspond to the first term in brackets in (1.6).

Moral hazard and the traditional cost of unemployment insurance

A first distortion results from the fact that unemployment benefits cannot be conditioned on the effort job seekers put into their search. Unemployed workers are effectively more tolerant to idiosyncratic risks associated with the search for a job when they are better insured. As a result, workers of type L target higher wages when they are better insured, as b^L increases. The other side of the market tailors its vacancies to respond to this shift by offering contracts that feature higher wages and a higher unemployment risk, in the form of longer queues.

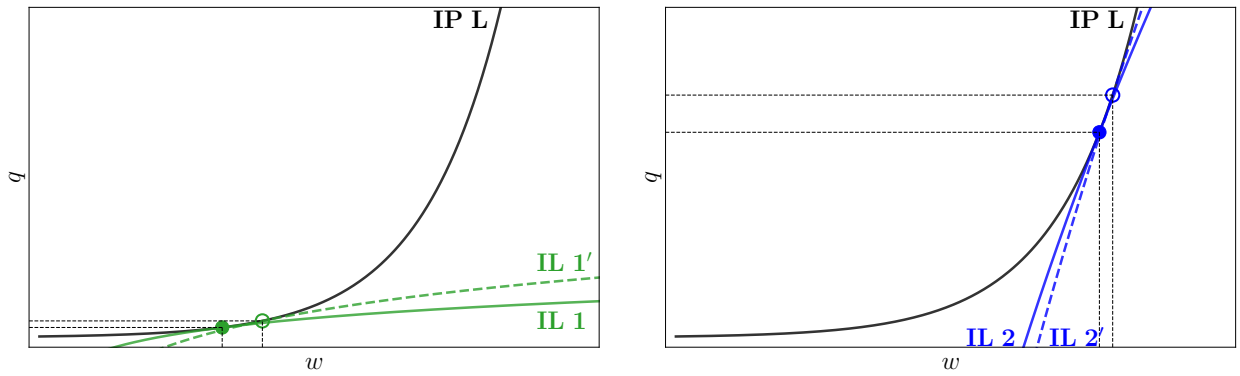
This moral hazard is what Acemoglu and Shimer (1999) coined "*market-generated moral hazard*".

The second and third terms of the first line of equation (1.6) generalize this efficiency cost to an economy with heterogeneous agents and multiple applications. The *moral hazard fiscal externality* can be decomposed into an externality within type L (second term), affecting the workers that are better insured, and an externality across types (third term), affecting workers who do not experience any change in their unemployment benefits but pay higher taxes as they contribute to the same system.

Increasing the unemployment benefit for L-type workers makes the overall unemployment insurance more costly first through a direct effect $\partial\tau/\partial b^L$, as every incumbent job seeker of type L receives higher benefits. Moreover, each of the a^L applications sent by unemployed workers of type L targets a market with higher wages and a lower employment probability. Thus, for each $k \in \{1, ..., a^L\}$, $dw_k^L/db^L > 0$. The fact that workers target higher wages has two effects on the cost of the unemployment insurance: it reduces the job finding rate, which increases the number of workers who claim benefits and decreases the number of workers who contribute through the labor income tax, and it increases the amount of taxes paid per job, as tax revenues are proportional to the level of wages. The first effect, on the mass of unemployed workers, makes the unemployment insurance more costly. The second effect makes it cheaper. The relative strength of these effects depends on which of the wages or queues is more sensitive to a marginal change in the level of unemployment benefits.

Figure 1.1 represents the equilibrium wage w and queue q for a given application sent by L-type unemployed workers. In this (w, q) space, the solid black line represents the isoprofit curve that satisfies the free entry condition for L-type markets. This isoprofit curve is defined by all the pairs (w, q) that give zero expected profits to a firm that posts a vacancy on a market that attracts L-type workers, i.e.

$$(w, q) \in \mathbb{R}^2 : \mu(q)J^L(w) = \kappa$$



(a) Low insurance

(b) High insurance

Figure 1.1: Wage and queue elasticities depend on the level of insurance

The solid green curve (IL1) on the left panel represents the indifference curve that corresponds to L-type workers market utility for their first application. This indifference curve is defined as all the pairs of wages and queues that deliver a lifetime utility of S_1^L, when the outside option is unemployment, i.e.

$$(w, q) \in \mathbb{R}^2 : \psi(q)W^L(w) + [1 - \psi(q)]U^L = S_1^L$$

In this framework, the equilibrium wage-queue combination for L-type workers' first application is the tangent point between the isoprofit curve and this indifference curve. Note that this solid green indifference curve (IL 1) is relatively flat. This is due to the low level of insurance assumed in the left panel. A low unemployment benefit b^L yields a low value of unemployment U^L, which makes job seekers relatively averse to job finding risk for this lowest application. This aversion translates into a flat indifference curve, which means that they need a large increase in the offered wage to accept a slightly higher queue, i.e. a lower job-finding rate.

Suppose a reform marginally increases the level of unemployment benefits for low-productivity workers b^L. Unemployed workers tolerate more job-finding risk in their application and, in equilibrium, firms cater to this change by posting a higher wage, associated with a higher queue. Panel (a) in Figure 1.1 shows that, at a low level of insurance, this

marginal increase in workers' risk tolerance has a large effect on the equilibrium wage and a relatively small effect on the equilibrium queue. Workers' indifference curve moves from (IL1) to (IL1'), the dashed green line, which drives the equilibrium wage-queue combination to the green circle. This equilibrium movement along the isoprofit curve generates a large change in the wage and a small change in the queue. At this low level of insurance, the queue is initially low and firms do not need a much longer queue to be compensated for an increase in the wage. The elasticity of wages with respect to unemployment benefits exceeds that of queue lengths.

Hence, at low levels of insurance, a marginal increase in unemployment benefits does not generate a large fiscal externality because it pushes workers towards higher wages, and therefore higher taxes, without a large increase in unemployment.

However, Panel (b) shows that a higher initial level of insurance is associated with steeper indifference curves. The resulting application strategy of job seekers places the equilibrium towards longer queues, as represented by the solid blue dot, because they tolerate more unemployment risk in order to reach higher wages. On this part of the isoprofit curve, firms need a larger increase in the queue and in their hiring probability to offset an increase in the wage they post. Therefore, a marginal increase in unemployment benefits has a small impact on the equilibrium wage and a large one on its associated queue. The fiscal externality is large because the employment effect, which reduces tax revenues, is large while the wage effect, which increases tax revenues, is small.

In practice, I calibrate unemployment benefits b^H and b^L to be 46.5% of their expected income when employed, the average replacement ratio in the US (Landais et al., 2018). In addition, both types of workers benefit from other source of replacement income, represented by b_0^H and b_0^L in the model. Therefore, the replacement income of unemployed workers is at least 46.5% of their expected income when employed. This value is high enough for job seekers to be relatively tolerant to long queues for every job they apply to. The endogenous distribution of posted contracts is located on the steeper part of the isoprofit curve repre-

sented in Figure 1.1, and queue lengths are much more sensitive than wages to changes in unemployment benefits.

These observations imply that $\sum_{k=1}^{a^L} \frac{\partial \tau}{\partial w_k^L} \frac{dw_k^L}{db^L}$, in equation (1.6), is positive. Higher benefits for unemployed workers of type L drive them to look for jobs offering higher, but less attainable, wages. This moral hazard effect makes unemployment insurance more expensive and requires a higher tax rate on labor income. This higher tax rate affects both types of workers negatively, i.e. $\partial S^H/\partial \tau < 0$ and $\partial S^H/\partial \tau < 0$.

The fiscal externality which emerges from moral hazard, represented by the second and third terms in equation (1.6), is negative, and reduces the planner's incentives to increase the unemployment benefits of workers of type L. This externality nests the fiscal cost depicted in Acemoglu and Shimer (1999). The latter corresponds to the case were $a^L = 1$ and $m^H = 0$.

Adverse selection: the new cost of unemployment insurance

With asymmetric information between applicants and recruiters, a new negative externality appears. The two terms of the second line of equation (1.6) represent this cost. A change in the level of insurance provided to workers of type L not only affects their search strategy, but also the set of incentive compatible contracts offered to workers of type H. The following proposition shows that an increase in unemployment benefits for workers of type L tightens the incentive compatibility constraint on markets of type H.

Proposition 1. *Suppose workers of type L and H send respectively a^L and a^H applications, and that $(\underline{w}_1^H, \underline{q}_1^H)$ denotes the lowest incentive compatible contract that can attract applications from H-type workers without receiving any application from a worker of type L, and that satisfies the zero-profit condition. Then, a budget-balanced increase in unemployment benefits provided to workers of type L, b^L, drives up the lowest incentive compatible wage and queue length. That is,*

$$\frac{d\underline{w}^H}{db^L} > 0 \quad \textit{and} \quad \frac{d\underline{q}^H}{db^L} > 0$$

With a higher level of insurance, L-type workers are willing to take more risk in their application portfolio. H-type markets, which offer high wages and small employment probabilities, become more attractive. Hence, firms that target H-type workers have to post contracts that provide even higher returns, with even higher risk, to avoid low-productivity workers. A complete proof of proposition 1 is provided in Appendix A.2.1.

Figure 1.2 shows the effect of an increase in unemployment benefits for low-productivity workers on the first incentive compatibility constraint that affects the wages posted for high-productivity workers. (IPL) and (IPH) are the isoprofit curves that satisfy the zero-profit condition for firms recruiting low-productivity workers and high-productivity workers. Both are increasing because firms accept to post a higher wage only if they are compensated by a longer queue, that is, a higher probability of filling their vacancy. (IPH) stands on the right of (IPL) because, for every queue q, a firm is willing to post a higher wage for H-type workers because they generate more revenue.

In this figure, I assume that both types of worker send two applications. In Panel (a), (IL1) and (IL2) represent the pairs of wage w and queue q that provide low-productivity workers with their "market utility", i.e. the equilibrium values of a portfolio of one application $S^L(1)$ and two applications $S^L(2)$. More formally, (IL1) is defined as

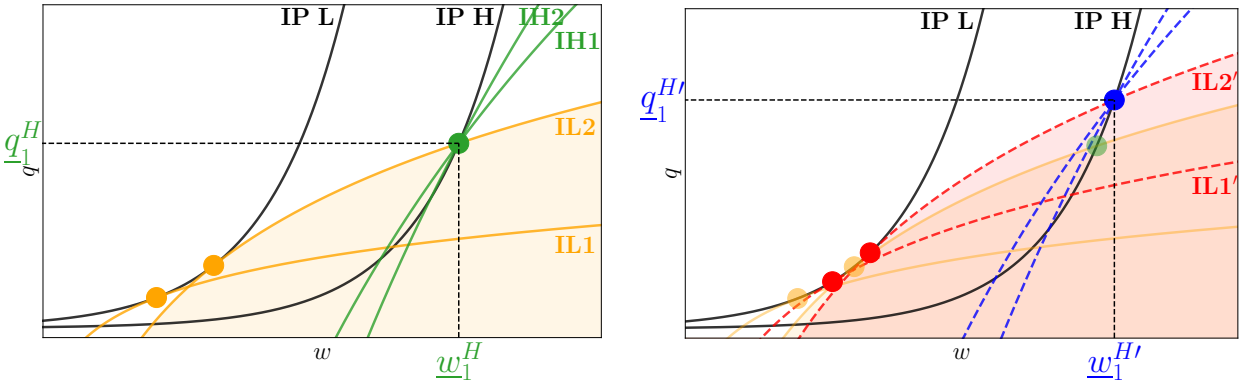
$$(w, q) \in \mathbb{R}^2 : \psi(q)W^L(w) + [1 - \psi(q)]U^L = S^L(1)$$

and (IL2) is defined as

$$(w, q) \in \mathbb{R}^2 : \psi(q)W^L(w) + [1 - \psi(q)]S^L(1) = S^L(2)$$

These two indifference curves have different slopes because each application has a different fallback option. The fallback of the lowest application, indexed by 1, is unemployment, while the fallback option of the second application also includes the expected outcome from the lowest application. Consequently, job seekers of type L are more willing to take some risk in

their second-lowest application than in their lowest one. Indifference curve (IL2) is steeper than (IL1), and the corresponding applications are sent to different markets in equilibrium, represented by the two orange dots on Panel (a).



(a) Equilibrium with Asymmetric Information

(b) After an increase in UI benefits for low-productivity workers

Figure 1.2: Higher insurance for low-productivity workers tightens the constraint on high-productivity workers

The shaded area under the curve (IL2) shows all the combinations of wage and queue that would be preferred by low-productivity workers compared to the one targeted by their highest application. As a result, any market that attracts H-type applications must be outside of this area. Otherwise, it would violate incentive compatibility. Moreover, because of free entry, we know that its wage-queue pair would be on (IPH), the isoprofit curve for high-productivity workers. Therefore, in equilibrium, any wage targeting H-type workers needs to be higher than w_1^H, the lowest incentive compatible wage. This wage is pinned down by the intersection of (IPH) and low-productivity workers' highest indifference curve (IL2).

I assume in this plot that this constraint is binding, i.e. that high-productivity workers would prefer to apply for jobs with lower wages and lower queues (down the isoprofit curve). Therefore, firms post the lowest incentive compatible wage w_1^H, and high-productivity workers send both of their applications to this type of job. Hence, low-productivity workers' ability to redirect their applications towards H-type markets, due to the unobservability of

their type, constrains H-type workers and forces them to apply to higher wages, at a higher risk.

Panel (b) shows how this constraint responds to an increase in unemployment benefits for low-productivity workers b^L. As explained in the previous subsection, job seekers tolerate more risk in their application portfolio when they are better insured. As a result, firms cater to these preferences by posting higher wages, which entail a higher risk of unemployment. When the incentive compatibility constraint is binding, this change in low-productivity workers' strategy drives up wages and queues on H-type markets. L-type workers' indifference curves become steeper and move to (IL1') and (IL2'). This upward movement constrains the set of incentive compatible wages and leads firms targeting high-productivity workers to post an even higher wage, $\underline{w}_1^{H'}$, with an even longer queue, $\underline{q}_1^{H'}$.

This upward movement in posted wages has a direct effect on the expected utility of high-productivity workers. This direct negative externality of unemployment insurance for low-productivity workers corresponds to the first term of the second line of equation (1.6). When the incentive compatibility constraint is binding, H-type workers would prefer to apply to jobs with lower wages and lower queues, but they are constrained to take more risk to reveal their type to recruiters.

In addition to this direct externality, the stronger adverse creates a negative fiscal externality on all workers. This new fiscal externality is characterized by the last term of the left-hand side of equation (1.6). By forcing high-productivity workers to accept lower job-finding rates, this adverse selection channel increases the mass of unemployed workers receiving benefits and reduces the mass of employed workers contributing to the system. Therefore, the balance of the unemployment insurance system requires a higher tax rate τ on all employed workers, which is detrimental to their lifetime utility S^L and S^H.

1.3.3 Endogenous search intensity: moral hazard costs vs. moral hazard benefits

The previous subsection showed that a new cost of unemployment insurance springs from the distortion of the directions of job search. In this subsection, I study the effect of unemployment insurance on another dimension of endogenous search: job seekers choose the number of applications they send, or their search intensity.

As for the directional aspect of job search, this intensity margin is distorted by the fact that an increase in unemployment insurance makes workers tolerate more risk in their application strategy. This higher tolerance for job-finding risk leads unemployed workers to send fewer applications.

However, this reduced intensity alleviates the adverse selection friction that the directional aspect of job search was reinforcing. When low-productivity workers send fewer applications, they are less likely to send one of them to a very high wage, associated with a very high queue. Figure 1.3 shows how the equilibrium responds to an increase in unemployment benefits for low-productivity workers now that they control the intensity of their search effort.

Before this increase in unemployment benefits, low-productivity workers were sending two applications to the markets represented by the orange dots. Now that they are better insured, they send each application to a higher target, but they send only one application. They are willing to take more risk in this application than in their previous lowest application, which explains the movement along the isoprofit curve (IPL) from the lowest orange dot to the red one. This is the new wage-queue combination characterizing the market to which low-productivity job seekers apply.

This change in low-productivity workers' search effort affects high-productivity markets in the following way. As they reach for higher targets, all their indifference curve shift towards riskier applications, crowding out high-productivity workers. On the other hand, they send one less application, which shifts their highest indifference curve to the one corresponding to

their lowest, and now only, application. This movement relaxes the incentive compatibility constraint on high-productivity markets and reduces the crowding out of their workers. Figure 1.3 shows an example in which this second force dominates the first one. The wage posted for high-productivity workers goes down to $\underline{w}_1^{H\prime}$, together with its associated queue $\underline{q}_1^{H\prime}$. These unemployed workers prefer this wage-queue pair (blue dot) to the previous equilibrium (green dot), as shown by the fact that H-type workers' new indifference curves lie to the south-east of the previous equilibrium.

A higher level of insurance for low-productivity workers may therefore alleviate the adverse selection friction which crowds out high-productivity workers.

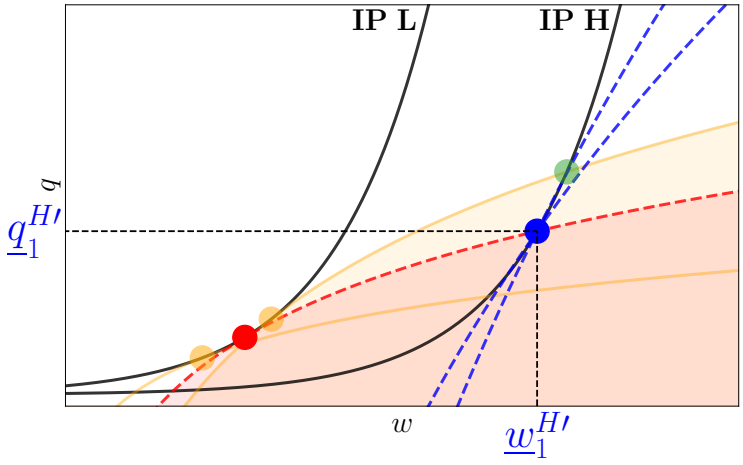


Figure 1.3: A higher level of insurance relaxes the constraint on high-productivity workers

Moreover, endogenous search intensity introduces an additional incentive compatibility constraint, described in section 3.2 as (IC2), which ensures that low-productivity workers do not have an incentive to send an extra application to the posted vacancies that try to hire high-productivity workers. The following proposition demonstrates that this constraint is relaxed when unemployment benefits increase for low-productivity workers.

Proposition 2. *Suppose workers of type L and H send respectively a^L and a^H applications, and that $(\underline{w}_2^H, \underline{q}_2^H)$ denotes the lowest contract that can attract applications from H-type workers without receiving any application from a worker of type L, and that satisfies the zero-profit condition. Then, a budget-balanced increase in unemployment benefits provided to workers*

of type L, b^L, drives down the lowest wage and queue length that satisfy the constraint (IC2). That is,

$$\frac{d\underline{w}_2^H}{db^L} < 0 \quad \textit{and} \quad \frac{d\underline{q}_2^H}{db^L} < 0$$

The reason for this relaxation of (IC2) is similar to the one described above for the first incentive compatibility constraint (IC1). When low-productivity workers are better insured, they are willing to take more risk in their application portfolio which, in terms of search intensity, implies that they are willing to send fewer applications. This effect reduces the desirability of an additional application reaching for high-productivity markets.

Endogenous search embeds a directional margin and an intensity margin. When workers are better insured, they aim for higher but fewer targets. Both margins yield the traditional cost of unemployment insurance: workers respond to a higher level of insurance by choosing a search strategy that features a higher risk of unemployment. However, the interaction of these two margins of endegenous search with asymmetric information work in opposite directions. Workers' directional response to a higher level of insurance reinforces adverse selection and crowds high-productivity workers out of the market. This channel increases the cost of unemployment insurance. On the other hand, the lower search intensity generated by an increase in unemployment insurance alleviates adverse selection by reducing low-productivity workers' incentive to send too many applications and crowding out high-productivity workers. This channel reduces the cost of unemployment insurance.

1.4 Calibration

I calibrate the model in two steps. First, I set some parameters exogenously. In a second step, I jointly estimate the remaining parameters to minimize the distance between moments generated by the model and moments taken from the Survey of Consumer Expectations Job Search Supplement (SCE-JS) and the Current Population Survey (CPS). The former

contains a lot of information about workers' search behavior, and more particularly about their application strategies. I use the CPS to measure aggregate worker flows.

One of the moments used to estimate the model is the standard deviation of the unemployment rate over the cycle. In order to generate such fluctuations in the model, I introduce aggregate risk in the form of labor productivity shocks common to all matches, as in Shimer (2005) and Hagedorn and Manovskii (2008). This extension of the model contributes to the literature on unemployment fluctuations by being, to the best of my knowledge, the first model of simultaneous search with aggregate risk. Aggregate risk is important in particular for the design of an optimal unemployment insurance, as a large part of workers' unemployment risk results from aggregate shocks. The next subsection explains what these labor productivity shocks change to the model and how they translate into labor market fluctuations.

1.4.1 Aggregate risk

I introduce aggregate shocks by assuming that the common component of labor productivity, z_t, is indexed by t and follows an AR(1) process

$$z_t = \rho_z z_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma_z)$$

where ρ_z is the persistence parameter of this process and σ_z is its volatility.

Firms post contracts stipulating a fixed wage over the duration of the match. Following Rudanko (2009), I show in Appendix A.2.3 that, under two-sided commitment, it is the type of contract that firms optimally choose to post even when they are allowed to choose any sequence of wages. Risk-neutral firms maximize profits by offering relatively low wages that are attractive for risk-averse workers due to their insurance properties. Fixed-wage contracts protect employed workers against aggregate shocks that occur throughout the duration of the match. However, these workers are still subject to aggregate risk once their match is

destroyed and they have to deal with the aggregate state of the labor market to find a new job.

All equilibrium outcomes are now functions of the aggregate state and are therefore indexed by t. The aggregate state includes the level of productivity z_t and the distribution of workers across employment states and wages. Given that the distribution of posted wages is potentially different in each period, keeping track of the overall distribution of wages is computationally difficult. However, I show, with the following proposition, that the equilibrium is block recursive (Menzio and Shi, 2010, 2011). The only aggregate variable one needs to forecast to compute the value functions and policy functions of workers and firms is labor productivity z_t.

Proposition 3. *The equilibrium is block recursive. One can construct an equilibrium in which value functions, posted wages and queues do not depend on the distribution of workers across employment states and wages.*

See Appendix A.2.4 for a proof. This useful property is common in directed search frameworks (Menzio and Shi, 2011; Schaal, 2017; Wright et al., 2021). This proposition shows that it extends to simultaneous search environments, which allow workers to search in multiple directions.

Fixed wages imply that the flow of profits generated by a match varies along the cycle. Some firms can make losses if they commited to a high wage in the past and labor productivity undergoes a sufficiently negative shock. These losses are paid by the risk-neutral representative entrepreneur who owns all firms and can borrow from an external fund at a fixed rate r if its net aggregate revenue is negative. In other words, I assume that this is a small open economy.

Similarly, the unemployment insurance system may now suffer deficits during bad times. When a negative shock hits, unemployment rises, which imposes large expenses in benefits and smaller revenues from labor income taxation. The government finances its deficits by issuing one-period bonds at the interest rate r. Let B_t denote the amount of bonds issued

in period t. Following the small open economy assumption, these bonds are held by agents outside of the economy. The government budget constraint in each period is

$$m^H \mathtt{u}_t^H b^H + (1-m^H)\mathtt{u}_t^L b^L + (1+r)B_{t-1} \\ = \tau\Big(m^H(1-\mathtt{u}_t^H)\mathbb{E}\left[w_t^H\right] + (1-m^H)(1-\mathtt{u}_t^L)\mathbb{E}\left[w_t^L\right]\Big) + B_t \quad (1.7)$$

Every period, the government provides unemployment benefits and pays for the outstanding debt by collecting taxes on labor income and issuing new bonds. I assume that the economy starts from period 0 with no debt, i.e. $B_{-1} = 0$. The intertemporal budget constraint is

$$\sum_{t=0}^{\infty} \frac{m^H \mathtt{u}_t^H b^H + (1-m^H)\mathtt{u}_t^L b^L}{(1+r)^t} = \tau \sum_{t=0}^{\infty} \frac{m^H(1-\mathtt{u}_t^H)\mathbb{E}\left[w_t^H\right] + (1-m^H)(1-\mathtt{u}_t^L)\mathbb{E}\left[w_t^L\right]}{(1+r)^t} \quad (1.8)$$

The unemployment insurance system can afford temporary deficits but needs to balance the discounted sum of benefit expenses with the discounted sum of tax revenues.

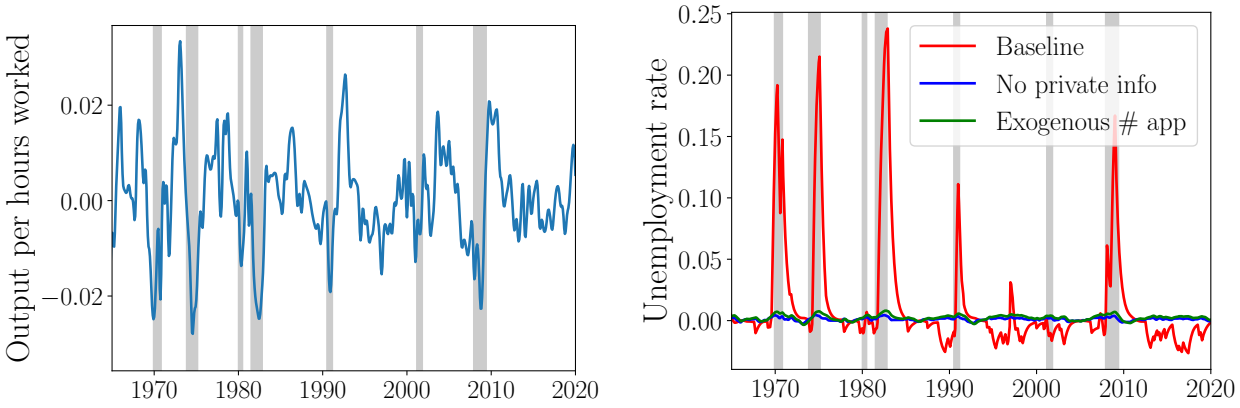
Amplification of productivity shocks

A long literature has documented the relative difficulty to generate the large unemployment fluctuations observed in the data from the small volatility of labour productivity using traditional search models (Shimer, 2005). The combination of endogenous search intensity with asymmetric information helps amplifying the effect of productivity shocks on unemployment fluctuations.

Figure 1.4 compares fluctuations in the unemployment rate generated by the business cycle movements in labor productivity in the US in the baseline model with endogenous applications and private information and in the same model without these elements. Panel (a) shows the log-deviations from trend of output per hours worked, as measured by the BLS. The grey bands highlight the recession periods defined by the NBER. Panel (b) shows

the resulting deviations in the unemployment rate once these productivity shocks are fed into the model.

In the baseline model (red line on Panel (b)), unemployment peaks during recessions and slowly transitions back to its steady-state level afterward[5]. However, removing endogenous search intensity (green line) or asymmetric information between applicants and recruiters (blue line) reduces significantly the unemployment fluctuations generated by the model.



(a) Productivity (b) Unemployment

Figure 1.4: Unemployment fluctuations generated by the US labor productivity series
Note: All variables are expressed in log-deviations from trend.

When a negative shock hits, firms offer lower wages and the marginal benefits from each application unemployed workers send decrease. Job seekers become more risk averse and are ready to accept lower wages to limit the shock on their job-finding rate. Because of incentive compatibility constraints, high-productivity workers are hampered in their ability to do so. Firms that target these workers do not want to cut their posted wages too much, otherwise they would not be able to identify their type. Consequently, high-productivity markets offer bundles of wages and queues that are still relatively high and which become less attractive in times of crisis. The marginal benefits from each application decreases more for high-productivity job seekers than for low-productivity ones. This effect leads them to send fewer applications and increases their unemployment rate significantly.

[5]This effect is not observed during the 2001 recession because the output per hours worked, which is the source of aggregate fluctuations in the model, fell only slightly in this period, as shown on Panel (a).

Hence, high-productivity workers are the ones who experience these large fluctuations in unemployment. When the number of applications they send is set exogenously the value of their portfolio of applications falls, but they cannot cut on their search intensity as they do in the baseline model. On the other hand, when there is no private information, they have more margins of adjustment, in particular the wages they target, which limit the fall in the value of their portfolio of application. Therefore, they have lower incentives to reduce their search intensity. It is the interaction of asymmetric information and endogenous search intensity that amplifies the fluctuations of unemployment for high-productivity workers.

1.4.2 Exogenous parameterization and functional forms

I set the length of a period to one month because it is the standard time frame for data frequency in the CPS and the SCE-JS. It is short enough for workers to send multiple applications simultaneously, i.e. without being able to wait for the result of each application before sending the next one.

I calibrate the persistence ρ_z and volatility σ_z of labor productivity shocks using the series of aggregate output per hour worked provided by the Bureau of Labor Statistics (BLS) from 1948 to 2020[6]. I measure an autocorrelation of 0.9625 and an unconditional standard deviation of 0.0104 for the log-deviations from trend of the HP filtered series with a smoothing parameter of 129,600.

Workers value the consumption of their disposable income through a CRRA utility function $v(w(1-\tau)) = [w(1-\tau)]^{1-\eta}/(1-\eta)$. I set the risk aversion parameter to a conventional value in the literature (Hornstein et al., 2011; Chaumont and Shi, 2022), that is $\eta = 2$. Workers and the representative entrepreneur who owns all the firms discount future payoffs at rate $\beta = 0.96^{1/12}$. The matching function is an urn-ball matching function (Burdett et al., 2001), $m(q) = 1 - e^{-\alpha q}$, with a parameter $\alpha \in (0, 1]$ that represents the share of suitable

[6]The BLS measures output per hour worked at a quarterly frequency. I use a linear interpolation to extend it to a monthly frequency.

candidates in each pool of applicants (Petrongolo and Pissarides, 2001). I use a quadratic application cost function $c(a) = k_a \cdot a^2$ with a cost parameter $k_a > 0$.

For the exogenous separation rate δ, I use the average transition rate from employment to unemployment (EU rate) from 1990 to 2020, which I measure using data from the BLS. The interest rate of this small open economy is set to $r = 0.04$.

1.4.3 Estimated parameters

I jointly estimate the remaining six parameters $\{\kappa, k_a, m^H, \xi, b_0^H, b_0^L, \alpha\}$ using the method of moments. I minimize the squared percentage deviations between moments simulated from the model and their empirical counterparts,

$$\boldsymbol{p}^* = \arg\min_{\boldsymbol{p}\in\mathcal{P}} \sum_{m\in\mathcal{M}} \left(\frac{m^{model} - m^{data}}{m^{data}} \right)^2, \qquad \boldsymbol{p} = \{\kappa, k_a, m^H, \xi, b_0^H, b_0^L, \alpha\}$$

Although these parameters are jointly estimated, each of them is particularly informed by one of the targeted moments. Cross-sectional moments are simulated from an initial state corresponding to the median of the aggregate productivity grid and the steady-state distribution of workers across employment states and wages. However, all agents are subject to aggregate risk looking forward. Time series moments are computed over a simulated path of 300 periods.

The cost of creating a vacancy, κ, targets the average unemployment rate. The target is 0.057, the average unemployment rate over the 1948-2020 time frame in the CPS. The application cost parameter, k_a, targets the average number of applications that unemployed workers send, measured in the SCE-JS. The standard deviation of unemployment[7] informs the share of high-productivity workers. As explained in section 1.4.1, the job-finding rate of unemployed workers of type H fluctuates much more with the cycle than for workers

[7]Where unemployment is measured as the log-deviations from a trend estimated with a HP filter with smoothing parameter 129,600.

Table 1.1: Calibrated parameters

External calibration					
Parameter	Description	Value	Source		
β	Discount factor	0.99			
σ_z	Std. dev. of z	0.01	Output/hours (BLS)		
ρ_z	Autocorrelation of z	0.96	Output/hours (BLS)		
δ	Separation rate	0.02	EU rate (BLS)		
r	Interest rate	0.04			
Internal calibration					
Parameter	Description	Value	Target	Model	Data
κ	Vacancy creation cost	0.14	Unemployment rate	0.06	0.06
k_a	Application cost	0.04	Avg. nb. of applications	4.0	6.3
m^H	Share of H-type workers	0.31	St.dev(unemployment)	0.07	0.16
ξ	Productivity of H-type workers	0.44	Mean-min ratio of wages	1.20	1.5
b_0^H	Private replacement inc. (H)	0.18	Avg. nb. of offers	0.39	0.34
b_0^L	Private replacement inc. (L)	0.01	Acceptance rate	0.56	0.49
α	Matching parameter	0.45	Mismatch unemployment rate	0.01	0.01

of type L. Therefore, a larger share of high-productivity workers amplifies the response of unemployment to productivity shocks.

The difference in productivity between the two types of workers targets the mean-min ratio of residualized wages from Hornstein et al. (2011). This index is a relevant measure of wage dispersion in this context since the model focuses on the wage differences due to unobserved characteristics, i.e. the differences in residualized wages. Workers' exogenous replacement income, b_0^H and b_0^L, are informed by the average number of offers that workers receive, and their average acceptance rate. These two parameters determine workers' outside option, and therefore the level of wages and queues that they target in their search, as well as their probability to decline an offer because they have a better one in hand. These two targets are taken from Faberman et al. (2022). Finally, parameter α can be interpreted as the share of job seekers who are mismatched (Petrongolo and Pissarides, 2001), i.e. who are looking for jobs in the wrong labor market. The target is the mismatch unemployment measured by Şahin et al. (2014), that is the difference between the observed unemployment rate and the unemployment rate without any mismatch of workers and vacancies across labor markets. The counterpart of this moment in the model is the difference in unemployment rate between the simulated economy and its equivalent with a value of $\alpha = 1$, which corresponds to an

absence of mismatch. Table 2.2 presents the estimated parameters and the corresponding moments.

1.5 Quantitative results

I use the calibrated model to solve for the optimal level of unemployment insurance. I start from a benchmark model with no private information and an exogenous number of applications, which is similar to Acemoglu and Shimer (1999, 2000). Then, I add the key ingredients of this model one by one: an endogenous number of applications and asymmetric information between workers and recruiters.

I solve for the optimal unemployment benefits b^L and b^H, but I express them as a percentage of type-specific average wages in order to make them more easily comparable to the current US unemployment system, which is based on a replacement ratio. In a second exercise, I assume that government has less flexibility in its policies and has to pick a common replacement ratio for all workers.

1.5.1 Type-specific replacement ratio

Table 1.2 shows the optimal type-specific replacement ratios in the different benchmark models. The bottom right corner shows the results from a model without private information and with an exogenous number of applications[8]. The optimal replacement ratios are quite high, because unemployment insurance does not distort much workers' incentives in this benchmark. Insurance affects the wages posted in equilibrium and their associated queues, but it does not reduce workers' search intensity nor drives high-productivity workers out of the market through adverse selection. The optimal level of insurance is higher for low-productivity workers because they have a lower private replacement income, b_0^L, than their high-productivity counterparts.

[8]This exogenous number of applications is set to the number of applications they send in steady state in the baseline model.

Table 1.2: Optimal replacement ratios

	Private information	No private information
Endogenous number of applications	$R^H = 44.3\%$ $R^L = 46.2\%$	$R^H = 44.2\%$ $R^L = 65.3\%$
Exogenous number of applications	$R^H = 50.0\%$ $R^L = 26.2\%$	$R^H = 53.8\%$ $R^L = 80.1\%$

Introducing an endogenous number of applications in this benchmark without private information reduces both levels of insurance. This is what can be seen in the top right corner of Table 1.2. This reduction in the optimal level of insurance springs from the traditional moral hazard cost: job seekers look for jobs with a lower intensity when they are better insured, which creates a negative fiscal externality forcing the government to raise the labor income tax rate. Both types of workers are subject to moral hazard and generating this fiscal externality, which explains why the planner decides to reduce both replacement ratios.

The bottom left corner of Table 1.2 introduces private information without endogenous search intensity. Compared to the first benchmark, in the bottom-right corner, this new element generates an adverse selection externality on high-productivity workers, which worsens with the risks low-productivity workers are wiling to take in their applications. Unemployment insurance pushes them towards higher targets, compounding this crowding-out of productive job seekers. This new externality comes from low-productivity workers' incentives to redirect their applications. As such the planner reduces their insurance significantly (from 80.1% in the first benchmark to 26.2% in this economy), while the optimal level of insurance for high-productivity workers remains approximately unchanged. The optimal unemployment insurance in this bottom-left economy with private information and an exogenous number of applications is regressive. It provides a higher replacement ratio to high-productivity workers than to low-productivity ones even though the former earn a higher income than the latter.

Finally, the upper left corner of Table 1.2 combines private information with an endogenous number of applications. It describes the main economy studied throughout this

paper. Compared to the previous benchmark (bottom-left), it rebalances the optimal levels of insurance and provides similar replacement ratios to both types of workers. The reason for this is the new force, described in section 1.3, created by the interaction of endogenous search intensity with adverse selection. As low-productivity workers benefit from a higher level of insurance, they send fewer applications, which makes them less likely to reach high-productivity markets and alleviates the adverse selection constraints on these markets. This new channel leads the planner to insure low-productivity workers at a higher level, 46.2%.

This exercise highlights an important finding: the optimal level of insurance for low-productivity workers increases to reduce their job search effort, which is typically seen as a drawback of unemployment insurance.

1.5.2 Common replacement ratio

In practice, most states in the US use a common replacement ratio for all workers. Therefore, restricting the planner's policies to a unique replacement ratio for all workers is a relevant exercise to make the results more comparable with the current US system.

Table 1.3: Optimal common replacement ratio

	Private information	No private information
Endogenous number of applications	$R = 47.4\%$	$R = 64.6\%$
Exogenous number of applications	$R = 38.1\%$	$R = 79.7\%$

Table 1.3 shows the result of the same exercise as the one conducted in the previous subsection, but with a common replacement ratio for all workers. Similar patterns appear. A model with no private information and an exogenous number of applications (bottom-right corner) yields a high level of insurance. Adverse selection externalities are shut down, and the traditional moral hazard cost of unemployment insurance is relatively small given that workers can only adapt the directions of their applications and not their number. In this

scenario, consumption-smoothing benefits are large while the fiscal cost from moral hazard is relatively low. Thus, the planner picks a high replacement ratio, namely 79.7%.

The introduction of a new margin of endogenous search (top right corner) generates an additional moral hazard cost, which makes optimal unemployment insurance less generous. The introduction of private information (bottom left corner) creates the adverse selection channel through which better insured low-productivity workers crowd out high-productive applicants. This new externality makes optimal unemployment insurance less generous. Although these two ingredients separately create incentives for the planner to make the unemployment insurance less generous, their interaction has a more nuanced result.

The model that includes both asymmetric information and endogenous search intensity (top left corner) yields an optimal replacement ratio of 47.4%. Both elements generate additional insurance costs, but their interaction mitigates the crowding-out of high-productivity workers by discouraging low-productivity job seekers to over-apply. The fact that workers search less intensely for a job when they are better insured may therefore be efficiency-enhancing.

The combination of the traditional forces that affect the design of unemployment insurance, consumption-smoothing and moral hazard, with new externalities resulting from adverse selection and an endogenous number of applications, produce an optimal replacement ratio of 47.4%, which is slightly higher than the current average ratio applied in the US.

Figure A.4 shows the replacement income provided by states' unemployment insurance, as a percentage of the average wage, and the tax rate on labor income used to finance it. The relationship between these two variables is positive, as expected from the UI budget constraint. The orange circle represents the average across states along both dimensions. The average replacement ratio is 43.4%, which is slightly below the optimal level found through the quantitative exercise. This figure also shows that a large group of states provide a replacement income that is very close to the optimal one. A second important group

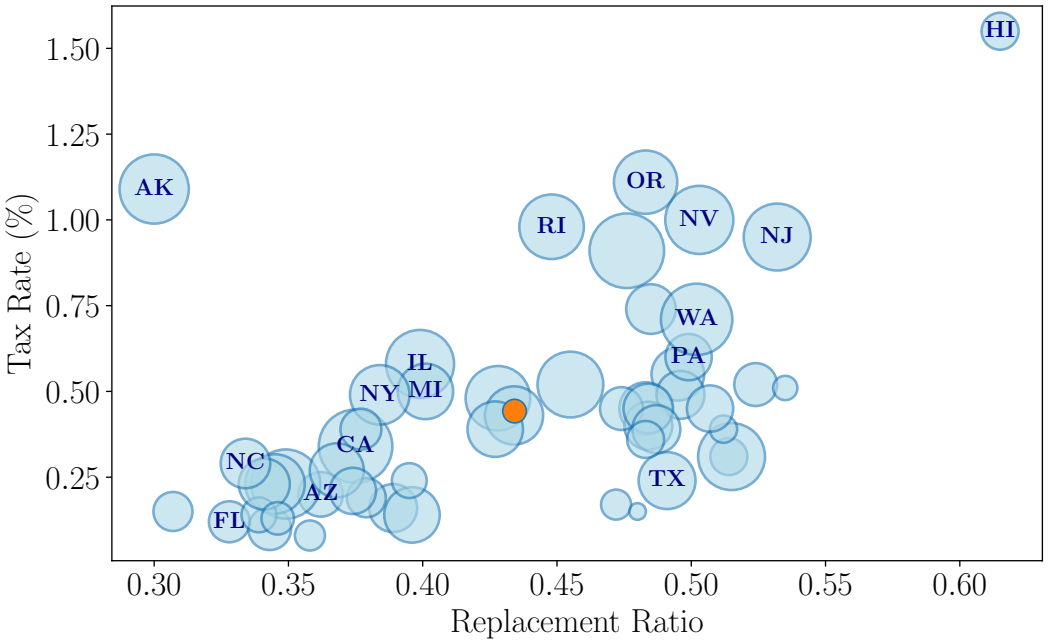


Figure 1.5: Replacement ratio and UI tax rate by state

Note: The replacement ratio for each state is measured as the average ratio of weekly benefits over wages. The tax rate is computed as the amount of taxes collected by the state's insurance system over the sum of its wages (not restricted to the taxable portion). The size of each circle represents the states' unemployment rates, and the orange circle corresponds to the average of both axes. All variables come from the Department of Labor's report on the UI system and are measured in the first quarter of 2024.

provides replacement ratios between 0.3 and 0.4 which, according to the present findings, may be suboptimal.

1.6 Conclusion

This paper develops a framework in which workers' search behavior affects recruiters' cost of acquiring information about applicants. The resulting adverse selection alters the composition of the pool of job seekers by crowding out high-productivity workers. I show that this channel matters for the design of unemployment insurance, as it distorts workers' incentives to search and, therefore, the strength of adverse selection in the labor market.

I analyze these forces theoretically and quantify their impact in an extended model incorporating aggregate risk. The results reveal that the costs and benefits of these new ex-

ternalities are significant, leading to an optimal unemployment benefit level of 47.4% of the average wage. This figure is slightly higher than the current average replacement ratio in the US, as it accounts for the fact that providing higher insurance discourages low-productivity workers from over-applying and crowding out high-productivity workers.

These findings are particularly relevant given new evidence that job application costs are decreasing (Martellini and Menzio, 2020), and job seekers are submitting more applications than in previous decades (Birinci et al., 2024). This shift in search technologies may alter governments' incentives to provide unemployment insurance and increase the importance of alternative labor market policies, such as those aimed at redirecting workers' search efforts (Behaghel et al., 2024).

Chapter 2

Micro vs. Macro Corporate Tax Incidence

2.1 Introduction

The steady decline in corporate tax rates in the OECD since 1980 (Figure 2.1) has motivated renewed interest in the question of how corporate tax reforms affect workers. Recent work on this issue has led to controversy and a lack of consensus: whereas studies dating back to Harberger (1962) using aggregate data find relatively little impact on workers, recent work using micro data has argued that there are large effects on workers (see, e.g., Fuest et al., 2018; Carbonnier et al., 2022; Kennedy et al., 2022). The goal of this paper is to understand the reason for these differing estimates and to assess the consequences of corporate tax reforms on workers' income and welfare.

To study this question, I build a dynamic Harberger model with a monopsonistic labor market that incorporates firm heterogeneity along two key dimensions: productivity and capital intensity. Because of its rich heterogeneity, the model can replicate the wide dispersion of size and labor share observed at the firm level and identify heterogeneous and common components of wage responses that are missing from average micro elasticities that control

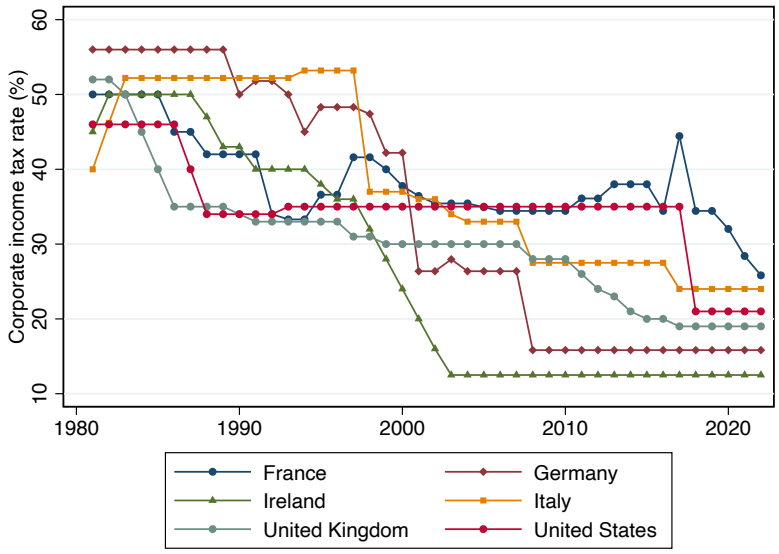


Figure 2.1: Top statutory corporate income tax rates (Source: OECD)

for common trends. My main finding is that, following a corporate tax cut, the relative wage increase captured by micro estimates is substantial, whereas the general increase in wages, the so-called "missing intercept", is much smaller. As a result, I estimate that changes in corporate taxes have a relatively limited impact on workers at the aggregate level.

Two key factors shape the aggregate effects of corporate tax reforms on workers' income and welfare. First, the distribution of technologies across firms plays a crucial role in determining workers' wage gains. Unlike the traditional Harberger model, all firms are subject to the corporate income tax. However, its distortion is more pronounced at capital-intensive firms. This unequal distortion generates greater wage and employment responses to corporate tax cuts at capital-intensive firms. Because these firms are typically larger and pay higher wages, firms' heterogeneous responses amplify the aggregate effects of corporate taxes on wages. Second, equilibrium price dynamics influence the timing of wage adjustments. If wages respond slowly to a reform, a significant portion of workers' gains (or losses) in the labor market would be discounted, leading them to bear a smaller share of the corporate tax burden. The calibrated model quantifies these different channels and the role they play for the pass-through of corporate taxes to wages.

I derive closed-form solutions for the key elasticities that determine the incidence of corporate taxes at both the firm and aggregate levels. The results indicate that most of the cross-sectional heterogeneity can be captured by firms' labor share. At the aggregate level, the explicit expressions for macro elasticities reveal that they can be estimated with simple sufficient statistics which are based on the covariance between labor shares and firm size.

I validate the core predictions of the model using reduced-form evidence from French tax returns, covering all corporations and employees between 2009 and 2019. I leverage all corporate income tax changes in France during the sample period, and use the instrumental variable method developed by Gruber and Saez (2002) to estimate the elasticity of wages and wage bills with respect to the net-of-tax rate across the labor share distribution. The results reveal a significantly stronger response from capital-intensive firms.

I calibrate the model using these empirical elasticities, which I match by estimating the same reduced-form moments on data generated by the model. Moreover, I construct a model inversion technique inspired by the spatial economics literature (Redding and Rossi-Hansberg, 2017) to recover the non-parametric distribution of firm-level TFP and capital intensity. This method relies on the mapping between observable firm size and labor share and unobservable TFP and capital intensity derived from firm optimization.

Finally, I simulate a one percentage point cut in the corporate income tax rate and quantify its impact on the consumption and welfare of workers, shareholders, and capital owners. While using micro elasticities into a standard incidence formula suggests that workers bear 29% of the tax burden, accounting for firm heterogeneity and general equilibrium dynamics cuts this share by half. The quantitative results show that a significant average pass-through of corporate taxes to wages at the microeconomic level does not necessarily imply that workers bear a large portion of the overall corporate tax burden.

This paper is related to the theoretical literature that studies the incidence of corporate taxes. Following the seminal work of Harberger (1962), several papers (see Gravelle (2013) and Auerbach (2018) for comprehensive surveys) have developed general equilibrium models

with a representative firm subject to the corporate income tax, and outside firms which represent either the non-corporate sector (Batra, 1975; Shoven, 1976; Ratti and Shome, 1977a,b; Baron and Forsythe, 1981; Atkinson and Stiglitz, 2015), or the rest of the world (Mutti and Grubert, 1985; Kotlikoff and Summers, 1987; Randolph, 2006). I also build on the literature that studies the role of capital accumulation and dynamics for the welfare consequences of capital taxation (Feldstein, 1974; Boadway, 1979; Turnovsky, 1982; Judd, 1985). Compared to these papers, this analysis examines the importance of firm and worker heterogeneity for corporate tax incidence and its estimation.

More recently, Suárez-Serrato and Zidar (2016) have built a static equilibrium model which combines heterogeneous firm and location-specific productivity with corporate taxation. I investigate the role of another source of firm heterogeneity, capital intensity, within a dynamic equilibrium framework. This paper is also closely related to Swonder and Vergara (2024), who introduce a similar dimension of heterogeneity. This framework introduces a monopsonistic labor market that allows me to match the wage responses observed at the micro level and to quantify the discrepancy between micro and macro wage elasticities.

This paper also pertains to the empirical literature that has used reduced-form evidence to measure the incidence of corporate taxes on various agents. An early literature has used time-series data to look at the response in factors' income and prices to corporate tax reforms (Krzyzaniak and Musgrave, 1963; Gordon, 1967; Cragg et al., 1967). Cragg et al. (1967) concluded that time-series data were not well suited for measuring such elasticities: "*We remain impressed by the difficulties of making inferences concerning tax incidence from time-series data*". More recent analyses have exploited cross-sectional tax rate variations across jurisdictions (Fuest et al., 2018; Giroud and Rauh, 2019), and microeconomic variations in exposure to corporate taxation (Arulampalam et al., 2012; Devereux et al., 2014; Carbonnier et al., 2022; Kennedy et al., 2022; Risch, 2024) to estimate the key elasticities that determine the share of the corporate tax burden borne by workers. I show in this paper that these high-quality micro estimates do not, on their own, summarize the incidence of corporate

tax changes at the aggregate level. I derive analytically and quantify the gap between these micro elasticities and their macroeconomic counterpart.

Finally, this paper is related to the literature that explores the effect of firm heterogeneity on the aggregate consequences of fiscal reforms. Zwick and Mahon (2017) and Winberry (2020) show the role of firm heterogeneity for the aggregate consequences of bonus depreciation policies. Gourio and Miao (2010) and Gourio and Miao (2011) demonstrate that firm heterogeneity matters for the aggregate response to dividend tax changes. Kaymak and Schott (2023) study the importance of the capital intensity distribution for the impact of corporate tax cuts on the labor share. I contribute to this literature by examining the role of firm heterogeneity for the incidence of corporate taxation and by deriving firm-level wage responses in the model which allows me to compare micro and macro estimates of the key elasticities.

The paper is organized as follows. Section 2.2 describes the model. Section 2.3 starts from a standard incidence formula and derives the sufficient statistics needed to estimate workers' share of the corporate tax burden. Section 2.4 characterizes the equilibrium response to a tax reform and shows analytically how heterogeneous firm responses aggregate into the sufficient statistics derived in 2.3. Section 2.5 confirms the main mechanism with reduced-form evidence. Section 2.6 calibrates the model. Section 2.7 presents the response of this calibrated model to a corporate tax cut.

2.2 Model

The economy consists of a mass of workers of measure one, a representative capital owner, and a representative firm owner. Workers and the firm owner are hand-to-mouth and consume their current income. The capital owner invests in the aggregate capital stock and lends it to firms. Time is discrete, and there is no uncertainty. All agents are infinitely lived and apply a discount factor $\beta \in (0, 1)$ on future utility.

The labor market is imperfectly competitive. Workers have idiosyncratic preferences over all firms, which set their wages without observing these preferences, as in Berger et al. (2022). Firms use different technologies to produce a homogeneous final consumption goods, which is sold in a competitive market. The final good serves as the numeraire.

2.2.1 Workers

Each worker supplies inelastically one unit of labor every period. While equally productive, workers differ in their preferences for employers[1]. They move freely across firms each period to solve

$$\max_{j} \quad \ln\left((1-\tau_t^w)w_{j,t}\right) + \varepsilon_{i,j} \tag{2.1}$$

where i and $j \in \mathcal{J} = \{1, ..., N\}$ index workers and firms, $w_{j,t}$ is firm j's wage in period t, τ_t^w is the labor income tax rate, and $\varepsilon_{i,j}$ is worker i's idiosyncratic taste for firm j, drawn from a T1EV distribution and constant across time. Although workers may switch employers as relative wages change over time, their preferences remain constant and determine the extent to which they respond to wage differentials. These random tastes can be interpreted as different location choices or different valuations of firms' amenities. Their cumulative distribution function is

$$F(\{\varepsilon_{i,j}\}_{j=1}^N) = \exp\left[-\left(\sum_j e^{-\gamma\varepsilon_{i,j}}\right)^{\frac{1}{\gamma}}\right]$$

where γ governs the dispersion of idiosyncratic tastes.

An important assumption is that firms do not observe their workers' preferences, and therefore cannot condition wages on these preferences. This is why wages are not indexed by i (the individual index). As in Card et al. (2018) and Berger et al. (2022), the solution

[1]The assumption of equal productivity can be relaxed by introducing an additional idiosyncratic shock that determines the amount of efficiency units of labor each worker can provide to different employers.

to this discrete choice problem results in a mass of workers who choose to work for firm j equal to

$$l_{j,t} = \frac{w_{j,t}^{\gamma}}{\boldsymbol{w_t}} \tag{2.2}$$

where $\boldsymbol{w_t} = \sum_j w_{j,t}^{\gamma}$ is the labor market wage index. I further assume that N is large, such that firms consider themselves as atomistic and take the wage index as given. Therefore, Equation (2.2) shows that γ can be interpreted as the labor supply elasticity at the firm level. As γ increases, workers' idiosyncratic tastes over different firms become less dispersed, which means that workers are more responsive to wage differentials and that firms face more elastic supply curves. With $\gamma \in [0, +\infty)$, firms face upward-sloping labor supply curves and benefit from some degree of monopsony power over their workers.

Importantly, the labor income tax rate, τ_t^w, does not appear in equation (2.2), showing that this tax is not distortionary. Two main features of the model generate this result: (i) the labor income tax rate is flat, so that it does not affect the relative after-tax wage that a worker derives from different employers; (ii) workers do not make intensive margin decisions, so that the labor income tax does not distort the amount of labor they supply.

2.2.2 Firms

Each period t, a firm $j \in \mathcal{J}$, with technology (z_j, α_j), rents k units of capital at price r_t and posts a wage $w_{j,t}$, which attracts $l_t(w_{j,t})$ workers. The function $l_t(w)$ is defined by equation

(2.2). Firm j takes the labor market wage index $\boldsymbol{w_t}$ as given and chooses its inputs to maximize after-tax profits

$$\begin{aligned} \max_{k,w} \quad & (1-\tau)\left[f(k, l_t(w), \alpha_j, z_j) - w l_t(w)\right] - (1-\lambda\tau) r_t k \\ \text{s.t.} \quad & f(k, l_t(w), \alpha_j, z_j) = z_j \left(\alpha_j k^{\frac{\sigma-1}{\sigma}} + (1-\alpha_j) l_t(w)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}} \\ & l_t(w) = \frac{w^{\gamma}}{\boldsymbol{w_t}} \end{aligned} \tag{2.3}$$

where z_j is the firm's total factor productivity (TFP) and $\alpha_j \in (0,1)$ represents its capital intensity. Returns to scale, ξ, the firm-level elasticity of substitution between capital and labor, σ, and the firm-level labor supply elasticity, γ, are common across firms.

The tax system is summarized by two parameters: a corporate income tax rate, τ, and λ, the share of capital costs that firms can deduct from their tax base. This last parameter is generally interpreted as the present discounted value of depreciation allowances, which may vary across firms based on their capital structure and maturity (Zwick and Mahon, 2017). Since this model assumes that firms are capital renters facing a static problem, λ is a reduced-form way to capture the imperfect deductibility of capital costs. I assume that τ and λ are constant across firms, and that the latter do not expect any change in the tax system in the future.

Let $u_t = \frac{1-\lambda\tau}{1-\tau} r_t$ denote the user cost of capital. One can divide the objective function by $(1-\tau)$ to reformulate the maximization problem in a more traditional way, with the following objective function: $f(k, l, \alpha_j, z_j) - w l_t(w) - u_t k$.

2.2.3 Capital owner

A representative capital owner chooses, in each period t, a level of consumption of goods $\{c_{jt}^K\}_{j=1}^N$, which are perfect substitutes, and the amount of capital for the next period K_{t+1} to maximize utility

$$V_k = \max_{\{c_{jt}, K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \ln(C_t^K) \quad , \quad C_t^K = \int_0^N c_{jt}^K dj \tag{2.4}$$
$$\text{s.t. } C_t^K + [K_{t+1} - (1-\delta)K_t] + \phi\left(K_t, K_{t+1}\right) = r_t K_t$$

where $\phi(.)$ is a capital adjustment cost function.

2.2.4 Shareholder

A representative shareholder collects after-tax profits from all firms and consumes this income each period. This agent is not important for the equilibrium allocation, as it does not make any choice. However, including a representative shareholder is useful to study the distributional consequences of corporate tax changes across agents that correspond to different types of income. Moreover, it makes the distribution of the corporate tax burden more comparable to the previous literature.

I assume that the representative shareholder has log-utility to maintain consistency with other agents in the economy and align with the recent literature on corporate tax incidence (Suárez-Serrato and Zidar, 2016). Hence, its present value of utility is

$$V_f = \sum_{t=0}^{\infty} \beta^t \ln(\widehat{\Pi}_t) \tag{2.5}$$

where $\widehat{\Pi}_t$ denotes the sum of firms' after-tax profits.

2.2.5 Government

The government finances expenditures G_t through two sources of fiscal revenue: corporate tax revenue collected from all firms, given by

$$T_t = \tau_t \sum_{j \in \mathcal{J}} \Big[y_{j,t} - w_{j,t} l_{j,t} - \lambda r_t k_{j,t} \Big]$$

where $y_{j,t} = f(k_{j,t}, l_{j,t}, \alpha_j, z_j)$, and revenue from the labor income tax $\tau_t^w W_t$, where $W_t = \sum_j w_{j,t} l_{j,t}$ denotes aggregate labor income. It sets τ_t^w each period to balance its budget, such that

$$T_t + \tau_t^w W_t = G_t \quad \forall t \tag{2.6}$$

All agents in this economy, including the government, take the corporate income tax rate τ as given and expect it to remain constant in the future. The quantitative exercises in Section 2.7 simulate the response of this economy to unexpected and permanent shock to τ.

2.2.6 Equilibrium

An equilibrium is a path of prices $\{\{w_{j,t}\}_{j \in \mathcal{J}}\}_{t=0}^{\infty}$, $\{\boldsymbol{w_t}\}_{t=0}^{\infty}$, $\{r_t\}_{t=0}^{\infty}$, quantities $\{K_t\}_{t=0}^{\infty}$, $\{\{k_{j,t}\}_{j \in \mathcal{J}}\}_{t=0}^{\infty}$, $\{\{l_{j,t}\}_{j \in \mathcal{J}}\}_{t=0}^{\infty}$, $\{C_t^K\}_{t=0}^{\infty}$, $\{\widehat{\Pi}_t\}_{t=0}^{\infty}$, and labor income tax rates $\{\tau_t^w\}_{t=0}^{\infty}$ such that:

1. Taking prices $\{r_t\}_{t=0}^{\infty}$ as given, the representative capital owner chooses $\{C_t^K, K_{t+1}\}_{t=0}^{\infty}$ to solve (2.4).

2. Taking prices r_t and $\boldsymbol{w}_t$ as given in each period t, firms $j \in \mathcal{J}$ choose capital $k_{j,t}$, wages $w_{j,t}$ and employment $l_{j,t}$ to solve (2.3).

3. The government budget constraint (2.6) is satisfied.

4. Markets clear in each period t:

- Capital market: $\sum_{j\in\mathcal{J}} k_{j,t} = K_t$
- Labor market: $\sum_{j\in\mathcal{J}} l_{j,t} = 1$
- Goods market:

$$\sum_{j\in\mathcal{J}} y_{j,t} = \sum_i c_{i,t} + C_t^K + K_{t+1} - (1-\delta)K_t + \phi\left(K_t, K_{t+1}\right) + \widehat{\Pi}_t + G_t$$

where $c_{i,t}$ denotes the consumption of worker $i \in [0,1]$ in period t, such that $\sum_i c_{i,t} = \sum_{j\in\mathcal{J}}(1-\tau_t^w)w_{j,t}l_{j,t}$, the wage index is defined as $\boldsymbol{w_t} = \sum_j w_{j,t}^{\gamma}$, and $\widehat{\Pi}_t$ is the consumption of the representative shareholder.

2.2.7 Discussion of the assumptions

Closed economy. Following the literature interested in the incidence of corporate income and capital taxation in a dynamic setting (Feldstein, 1974; Boadway, 1979; Turnovsky, 1982; Judd, 1985), I assume that the baseline economy is closed, and that investment in the capital stock has to be financed by private savings. This assumption is useful to study the impact of capital accumulation on the incidence of corporate taxes, and to estimate the share of the tax burden that capital owners bear.

Imperfect competition in the labor market. This assumption is essential to generate heterogeneous wage responses at the firm level, which is one of the empirical findings of Section 2.5. Imperfect competition is introduced in the form of what Berger et al. (2024) name "*heterogeneous worker-firm-specific preferences*", which generate upward-sloping labor supply curves at the firm level. These non-wage amenities are an important feature of labor markets (Berger et al., 2022, 2024), and they allow me to connect the aggregate elasticities that govern the macro incidence of corporate taxes to the the typical elasticities that one would estimate with micro data. This link between micro and macro wage elasticities is examined in Section 2.4.

Government budget constraint. The assumption that there are only two sources of revenue, corporate and labor income taxation, implies that the path of public expenditures G_t determines the extent to which lower corporate income tax revenues must be offset by higher labor income tax revenues.

If G_t directly follows the path of corporate tax revenues, labor income taxes remain unaffected by changes in corporate taxation. This assumption simplifies the analysis by abstracting from transfers when calculating the incidence of corporate taxes. Conversely, if $G_t = 0$ for all t, the revenues from the corporate income tax are directly transferred to workers, meaning that lower corporate tax revenue results in a reduced transfer. This second assumption captures the redistributive motive behind the introduction of a corporate income tax, despite its distortive effects. The primary reason workers would support a corporate income tax is that they benefit from associated transfers (or lower labor income taxation).[2]

In practice, the baseline model adopts the first assumption, excluding redistribution. Thus, the baseline incidence calculated in the quantitative Section reflects the pre-transfer incidence. However, Section 2.7 also explores the second assumption to assess the importance of redistribution in the aggregate incidence of corporate taxes.

2.3 A Sufficient Statistics Approach

The first objective of this Section is to formally clarify the definition of corporate tax incidence used in this paper. It then expresses the share of the corporate tax burden borne by workers in terms of key sufficient statistics and decomposes these macro elasticities into an aggregation of firm-level responses.

[2]Judd (1985) further argues that "*this is the only interesting case since there is no point in this model to taxing capital income and returning it to capitalists*".

2.3.1 Welfare Incidence

Following Suárez-Serrato and Zidar (2016) and Fuest et al. (2018), I focus on the incidence of the corporate income tax in terms of welfare. This tax creates a welfare cost, or burden, for the private part of the economy, which is distributed between its various components. The incidence on a given private agent is its share of the tax burden.

Moreover, the incidence is inherently tied to a tax reform a tax reform (which can be hypothetical). It is defined as the ratio of the change in this agent's welfare generated by the reform over the change in the overall tax burden, i.e. the change in aggregate welfare associated with this reform.

The incidence of a small tax reform $d\ln(1-\tau)$ on workers is defined as

$$I_W = \frac{\frac{dV_w}{d\ln(1-\tau)}}{\frac{dV_w}{d\ln(1-\tau)} + \frac{dV_k}{d\ln(1-\tau)} + \frac{dV_f}{d\ln(1-\tau)}} \tag{2.7}$$

where V_w denotes the discounted sum of workers' utility, and V_k and V_f denote the discounted sum of the representative capital owner's and shareholder's utility.

As in Feldstein (1974), these welfare changes are dynamic objects which account for utility changes along the transition path from one steady state to the other. All agents discount future utility at rate β, and value consumption through the same log-utility function. Workers' welfare is defined as

$$V_w = \sum_{t=0}^{\infty} \beta^t \sum_i \max_j [\ln((1-\tau_t^w) w_{j,t}) + \varepsilon_{i,j}]$$

This definition relies on a utilitarian aggregation of workers' welfare, treating all workers equally. Using the envelope theorem, we obtain

$$\frac{dV_w}{d\ln(1-\tau)} = \sum_{t=0}^{\infty} \beta^t \Bigg[\underbrace{\sum_j l_j \epsilon^j_{w_t,1-\tau}}_{\text{Wage effect}} + \underbrace{\epsilon_{1-\tau_t^w,1-\tau}}_{\text{Redistribution}} \Bigg] \tag{2.8}$$

where $\epsilon_{X,1-\tau} = d\log(X)/d\log(1-\tau)$ denotes the elasticity of X with respect to the net-of-tax rate $1-\tau$. The change in workers' welfare for each horizon t associated with a corporate tax reform can be decomposed into a wage effect resulting from an aggregate of firms' wage adjustments, and a redistribution effect stemming from the government's budget constraint.

The wage effect is a standard feature of incidence definitions. It is an employment-weighted average of microeconomic wage elasticities $\epsilon^j_{w_t,1-\tau} = d\ln w_{j,t}/d\ln(1-\tau)$. By the envelope theorem, changes in firms' employment dl_j disappear from this first-order effect. This is intuitive, as workers who change of employer following a tax reform are approximately indifferent between these employers.

We can further simplify this aggregate wage effect by noticing that it is equal to the elasticity of the labor market wage index $\boldsymbol{w}_t$ with respect to the net-of-corporate income tax rate divided by γ:

$$\sum_j l_j \epsilon^j_{w_t,1-\tau} = \frac{\sum_j w_{j,t}^{\gamma-1} \frac{dw_{j,t}}{d\ln(1-\tau)}}{\boldsymbol{w}_t} = \frac{\epsilon_{\boldsymbol{w}_t,1-\tau}}{\gamma}$$

The redistribution elasticity relies on the assumptions made about government's use of its fiscal revenue. Such assumptions are necessary for the general equilibrium model to be closed, but microeconomic incidence formulas generally abstract from it because the link between sources of fiscal revenue is less clear at the firm or local level. In Section 2.7, I assess the quantitative importance of the redistribution channel in workers' share of the post-transfer corporate tax burden.

The representative capital owner's welfare, V_k, is defined by (2.4). The envelope theorem yields

$$\frac{dV_k}{d\ln(1-\tau)} = \sum_{t=0}^{\infty} \beta^t \frac{K_t r_t}{C_t^K} \epsilon_{r_t,1-\tau}$$

where $\epsilon_{r_t,1-\tau}$ is the elasticity of the rental cost of capital with respect to the net-of-tax rate, and $C_t^K = r_t K_t - [K_{t+1} - (1-\delta)K_t] - \phi(K_t, K_{t+1})$ represents the capital owner's aggregate consumption. Finally, the change in the representative shareholder's welfare is

$$\frac{dV_f}{d\ln(1-\tau)} = \sum_{t=0}^{\infty} \beta^t \epsilon_{\widehat{\Pi}_t,1-\tau}$$

where $\epsilon_{\widehat{\Pi}_t,1-\tau}$ is the elasticity of aggregate after-tax profits with respect to the net-of-corporate income tax rate.

Combining these results allows us to express workers' share of the corporate tax burden as

$$I_W = \frac{\sum_{t=0}^{\infty} \beta^t \left[\epsilon_{\boldsymbol{w}_t,1-\tau}/\gamma + \epsilon_{1-\tau_t^w,1-\tau} \right]}{\sum_{t=0}^{\infty} \beta^t \left[\epsilon_{\boldsymbol{w}_t,1-\tau}/\gamma + \epsilon_{1-\tau_t^w,1-\tau} + \frac{r_t K_t}{C_t^K} \epsilon_{r_t,1-\tau} + \epsilon_{\widehat{\Pi}_t,1-\tau} \right]} \tag{2.9}$$

where $\epsilon_{\boldsymbol{w}_t,1-\tau}$ is the elasticity of the labor market wage index with respect to the net-of-corporate income tax rate. Equation (2.9) shows that, given measures of aggregate capital income net of investment costs C_t^K,we can estimate the share of the corporate tax burden borne by workers using four sufficient statistics: $\epsilon_{\boldsymbol{w}_t,1-\tau}$, $\epsilon_{1-\tau_t^w,1-\tau}$, $\epsilon_{r_t,1-\tau}$, and $\epsilon_{\widehat{\Pi}_t,1-\tau}$.

2.3.2 Micro-to-Macro Decomposition

A long literature has attempted to estimate these elasticities to assess the extent to which workers bear the burden of the corporate income tax. Recent articles leverage firm-level and local variations in tax rates and bases, combined with detailed firm data, to obtain micro-level estimates of the tax rate elasticities of wages (Fuest et al., 2018; Carbonnier et al., 2022; Kennedy et al., 2022; Risch, 2024).

However, the elasticities described in equation (2.9) are aggregate elasticities. When firms j are characterized by heterogeneous treatment effects, notably heterogeneous wage

elasticities $\epsilon^j_{w,1-\tau}$, the mapping between the distribution of firm-level responses and the aggregate sufficient statistics is not trivial.

Suppose we are interested in estimating the elasticity of the labor market wage index with respect to the net-of-corporate income tax rate, $\epsilon_{\boldsymbol{w}_t,1-\tau}$. This elasticity is a sufficient statistics for the numerator of our incidence equation (2.9) when we abstract from redistribution, which is why it has been the focus of an important empirical literature. An ideal experiment that would randomize tax rates across firms would aim to estimate the average firm-level treatment effect, $\mathbb{E}[\epsilon^j_{w,1-\tau}]$. Firm-level or local variations are generally necessary to rely on plausibly exogenous treatments and to interpret estimates as causal. Yet, such empirical designs cannot capture all the components of the macro elasticity we need, $\epsilon_{\boldsymbol{w}_t,1-\tau}$. To see this, one can decompose the latter as[3]

$$\frac{\epsilon_{\boldsymbol{w}_t,1-\tau}}{\gamma} = \underbrace{\mathbb{E}\left[\epsilon^j_{w_t,1-\tau}\right]}_{\text{Average micro response}} + N \underbrace{\mathbb{C}\text{ov}\left(l_j, \epsilon^j_{w_t,1-\tau}\right)}_{\text{Heterogeneous wage effects}} \tag{2.10}$$

where N denotes the number of firms in the economy, and l_j is firm j's initial employment share.

Equation (2.10) shows that the aggregate wage response is the sum of the average firm response and a covariance term that captures heterogeneity in wage responses across the firm size distribution. This second term may amplify (attenuate) the micro effect of corporate tax changes if larger firms are also the most (least) responsive.

One can further decompose our sufficient statistic by noting that firm-level elasticities $\epsilon^j_{w_t,1-\tau}$ consist of both partial equilibrium (or direct) effects and indirect equilibrium effects arising from price adjustments. Since most corporate tax reforms are macroeconomic shocks, the latter are likely to be a significant determinant of aggregate incidence.

Let $\mathbf{p}_t$ denote the vector of prices that firm j faces in period t. In the economy described in Section 2.2, $\mathbf{p}_t = (r_t, \boldsymbol{w}_t)^\top$, where r_t is the rental cost of capital, and $\boldsymbol{w}_t$ is the labor

[3]See Appendix B.3 for a proof.

market wage index. Its particular value $\mathbf{p_0}$ denotes the price vector just before the tax shock we consider occurs. We can rewrite the firm-level general equilibrium elasticity of wages with respect to the net-of-tax rate as

$$\epsilon^j_{w_t,1-\tau} = \underbrace{\epsilon^j_{w,1-\tau}\Big|_{\mathbf{p}=\mathbf{p_0}}}_{\text{Direct effect}} + \underbrace{(\epsilon^j_{w_t,\boldsymbol{p_t}})^\top \cdot \frac{d\ln(\mathbf{p_t})}{d\ln(1-\tau)}}_{\text{Indirect GE effect}} \tag{2.11}$$

where $\epsilon^j_{w_t,\boldsymbol{p_t}} = (\epsilon^j_{w_t,r_t}, \epsilon^j_{w_t,\boldsymbol{w}_t})^\top$ is the vector of elasticities of wages with respect to the price of capital and the labor market wage index, $\ln(\mathbf{p}_t) = (\ln(r_t), \ln(\boldsymbol{w}_t))^\top$, and $\epsilon^j_{w,1-\tau}\Big|_{\mathbf{p}=\mathbf{p_0}}$ is the partial equilibrium elasticity of firm j's wage with respect to the net-of-tax rate, i.e. holding other prices constant.

In this economy, dynamic responses to tax shocks are generated by the progressive build-up of the aggregate capital stock, which translates into price adjustments along the transition path. Therefore, partial equilibrium elasticities, which abstract from these price dynamics, are time-invariant objects. This is why the partial equilibrium firm-level wage elasticity is not indexed by t.

For simplicity, I rewrite equation (2.11) as

$$\epsilon^j_{w_t,1-\tau} = \underbrace{\epsilon^{j,PE}_{w,1-\tau}}_{\text{Direct effect}} + \underbrace{\epsilon^{j,GE}_{w_t,1-\tau}}_{\text{Indirect GE effect}}$$

where $\epsilon^{j,PE}_{w,1-\tau}$ denotes the partial equilibrium elasticity $\epsilon^j_{w,1-\tau}\Big|_{\mathbf{p}=\mathbf{p_0}}$ and $\epsilon^{j,GE}_{w_t,1-\tau}$ denotes the general equilibrium feedback from price adjustments $(\boldsymbol{\epsilon^j_{w_t,p}})^\top \cdot \frac{d\mathbf{p}_t}{d(1-\tau)}$.

Then, we can extend the decomposition in (2.10) to include the distinction between partial and general equilibrium effects, which gives

$$\underbrace{\frac{\epsilon_{\boldsymbol{w}_t,1-\tau}}{\gamma}}_{\text{Macro elasticity}} = \underbrace{\mathbb{E}\left[\epsilon^{j,PE}_{w,1-\tau}\right]}_{\text{Avg. micro elasticity}} + N \underbrace{\mathbb{C}\text{ov}\left(l_j, \epsilon^{j,PE}_{w,1-\tau}\right)}_{\text{Distribution of direct effects}} + \underbrace{\mathbb{E}\left[\epsilon^{j,GE}_{w_t,1-\tau}\right]}_{\text{Average indirect effect}} + N \underbrace{\mathbb{C}\text{ov}\left(l_j, \epsilon^{j,GE}_{w_t,1-\tau}\right)}_{\text{Distribution of indirect effects}} \tag{2.12}$$

Equation (2.12) shows that firm heterogeneity and general equilibrium effects create a discrepancy between the average partial equilibrium firm response to a tax change and its aggregate wage effect.

The first term on the right-hand side of this equation is the moment that an average treatment effect abstracting from general equilibrium would estimate. Micro empirical analyses often exploit local exogenous variations between firms, such as tax code thresholds, to define a treatment and a control group, and thus leave out general equilibrium adjustments that would affect both groups. This is why the first moment that one can estimate with local variations is an average firm-level partial equilibrium elasticity of wages.

A first discrepancy appears from heterogeneous responses across firms. As we will see more explicitly in the next section, various factors, starting with technological differences, can make the elasticity of wages with respect to the corporate income tax rate vary across firms. This heterogeneity gives rise to the second term of the right-hand side of equation (2.12), which is the covariance between firms' employment shares and partial equilibrium responses to a tax change. A second discrepancy springs from general equilibrium price adjustments, which can also be decomposed into an average effect across firms and a covariance term reflecting heterogeneous responses to these price movements.

Importantly, both covariance terms may be positive or negative, leading to an amplification or an attenuation of the average partial equilibrium response to a corporate income tax reform. Additionally, price adjustments are dynamic as the economy progressively reacts to

a tax shock and transitions to a new steady state. This is why the macro elasticity on the left-hand side of equation (2.12) and the last two terms on its right-hand side are indexed by t, which denotes the number of periods after a change in the tax rate. The elasticity of the aggregate wage effect with respect to the net-of-tax rate, and therefore its incidence on workers, are dynamic.

Finally, we have focused on the elasticity of labor income, but we can decompose the elasticity of aggregate profits with respect to the net-of-tax rate, in the denominator of equation (2.9), in exactly the same way. Heterogeneity across firms creates a gap between the micro and macro elasticities. The remaining two sufficient statistics, namely the elasticities of the rental cost of capital and the labor income tax rate with respect to the net-of-corporate income tax rate, can either be estimated with macroeconomic data, or through the general equilibrium model calibrated in Section 2.6.

The next Section uses the general equilibrium model described in 2.2 to explore the different components of the macro elasticity described in (2.12).

2.3.3 Consumption Incidence

Before deriving explicit expressions for these wage elasticities, I demonstrate that they are equally important for incidence when defined in terms of consumption rather than welfare.

Defining incidence in terms of consumption has the advantage of being less reliant on assumptions about utility functions. While these assumptions still influence the equilibrium allocation, they do not affect the definition of consumption incidence itself. In terms of consumption, the incidence of a corporate tax reform on workers is

$$I_W^C = \frac{\sum_{t=0}^{\infty} \beta^t \left[\epsilon_{\widehat{W}_t, 1-\tau} \widehat{W}_0 \right]}{\sum_{t=0}^{\infty} \beta^t \left[\epsilon_{\widehat{W}_t, 1-\tau} \widehat{W}_0 + \epsilon_{r_t K_t, 1-\tau} r_0 K_0 + \epsilon_{\widehat{\Pi}_t, 1-\tau} \widehat{\Pi}_0 \right]} \tag{2.13}$$

where $\widehat{W}_t$ is the after-tax and transfer aggregate labor income in period t, $r_t K_t$ is capital income, and $\widehat{\Pi}_t$ denotes aggregate after-tax profits.

The elasticity of aggregate labor income with respect to the net of tax rate can be expressed as a function of wage and transfer elasticities,

$$\begin{aligned}\epsilon_{\widehat{W}_t,1-\tau} = \mathbb{E}\left[\epsilon^{j,PE}_{w_t,1-\tau}\right] - N\gamma\mathbb{C}\text{ov}\left(l_j, \epsilon^{j,PE}_{w_t,1-\tau}\right) + \frac{N}{\widehat{W}_0}(1+\gamma)\mathbb{C}\text{ov}\left(l_j w_j, \epsilon^{j,PE}_{w_t,1-\tau}\right) \\ + \mathbb{E}\left[\epsilon^{j,GE}_{w_t,1-\tau}\right] - N\gamma\mathbb{C}\text{ov}\left(l_j, \epsilon^{j,GE}_{w_t,1-\tau}\right) + \frac{N}{\widehat{W}_0}(1+\gamma)\mathbb{C}\text{ov}\left(l_j w_j, \epsilon^{j,GE}_{w_t,1-\tau}\right) + \epsilon_{1-\tau^w_t,1-\tau} \quad (2.14)\end{aligned}$$

Thus, the elasticity of aggregate labor income with respect to the net-of-tax rate can be expressed as a function of average wage responses and covariance terms that capture the distribution of heterogeneous wage responses across firms. This formulation highlights that understanding the determinants of these firm-level wage responses, as explored in the next section, is crucial not only for assessing the incidence of corporate taxes on workers in terms of welfare but also in terms of consumption. In the quantitative Section of this paper, I will estimate the distribution of the corporate tax burden from both perspectives.

2.4 Micro and Macro Responses to a Tax Cut

2.4.1 Wage elasticity

We can use the model described in Section 2.2 to derive the elasticities that determine the incidence of corporate taxes. Given the focus of this paper on the incidence of corporate taxes on workers, this Section will be particularly interested in analyzing the elasticity of wages with respect to the net-of-tax rate at the firm level[4]:

$$\epsilon^j_{w_t,1-\tau} = \underbrace{-[1-\sigma(1-\xi)]\Lambda_r(s^j_{l,0})\epsilon_{u_t,1-\tau}}_{\text{Capital cost channel}} + \underbrace{\Lambda_w(s^j_{l,0})\epsilon_{\boldsymbol{w}_t,1-\tau}}_{\text{Labor cost channel}} \quad (2.15)$$

[4]See Appendix B.4.7

where $s^j_{l,t}$ denotes firm j's labor share in t,

$$s^j_{l,t} = \frac{w_{j,t} l_{j,t}}{y_{j,t}} = \xi \frac{\gamma}{1+\gamma} \frac{(1-\alpha_j)^\sigma \left(\frac{1+\gamma}{\gamma} w_{j,t}\right)^{1-\sigma}}{\alpha_j^\sigma u_t^{1-\sigma} + (1-\alpha_j)^\sigma \left(\frac{1+\gamma}{\gamma} w_{j,t}\right)^{1-\sigma}} \tag{2.16}$$

as derived in Appendix B.4.5, and where $\Lambda_r(s^j_{l,t})$ and $\Lambda_w(s^j_{l,t})$ are defined as

$$\Lambda_r(s^j_{l,t}) = \frac{\left(1 - \frac{1+\gamma}{\gamma}\frac{s^j_{l,t}}{\xi}\right)}{(1-\xi)(\gamma+\sigma) + [1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s^j_{l,t}}{\xi}}$$
$$\Lambda_w(s^j_{l,t}) = \frac{(1-\xi)}{(1-\xi)(\gamma+\sigma) + [1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s^j_{l,t}}{\xi}}$$

Equation (2.15) shows that firms' wage response to a corporate tax change is determined by two channels that arise from capital and labor costs. Let me now derive the results that will allow us to sign these channels.

First, we can derive the following lemma, which states that any firm j's labor share is bounded above by $\xi\frac{\gamma}{1+\gamma}$.

Lemma 1. *For all j and t, $s^j_{l,t} \leq \xi\frac{\gamma}{1+\gamma}$.*

Proof. From (2.16), we see that the labor share is the product of $\xi\frac{\gamma}{1+\gamma}$ and a positive and lower than one ratio. □

We can derive the following corollary from Lemma 1,

Corollary 1. *If $\sigma(1-\xi) < 1$, then for any j and t, $\Lambda_r(s^j_{l,t}) \geq 0$ and $\Lambda_w(s^j_{l,t}) \geq 0$, and both $\Lambda_r(s^j_{l,t})$ and $\Lambda_w(s^j_{l,t})$ are decreasing in firms' labor share $s^j_{l,t}$.*

These results produce the following relationship between the elasticities of the user cost of capital and the labor market wage index with respect to the net-of-corporate income tax rate,

Lemma 2. *If $\sigma(1-\xi) < 1$, then, for all t, the elasticity of the wage index with respect to the net-of-corporate income tax rate is positive, i.e. $\epsilon_{\boldsymbol{w}_t,1-\tau} \geq 0$, and the elasticity of the user-cost of capital with respect to this net-of-tax rate is negative, i.e. $\epsilon_{u_t,1-\tau} \leq 0$.*

Proof. See Appendix B.3.

Lemma 2 shows that, when the elasticity of substitution between capital and labor is small enough, the equilibrium wage index increases after a corporate tax cut. This result springs from the fact that the elasticity of substitution, σ, determines the relative strengths of substitution and scale effects at the firm level. When capital and labor are complements, the latter dominates the former, which yields an increase in labor demand when the user cost of capital falls.

In line with Oberfield and Raval (2021), I estimate, in Section 2.6, a firm-level elasticity of substitution σ lower than one, and $\xi \leq 1$ by definition of decreasing returns to scale. The premise of Lemma 2 is satisfied, so that a corporate income tax cut reduces the user cost of capital and boosts the wage index.

Corollary 1 and Lemma 2 pin down the signs of the capital cost and labor costs channels in equation (2.15). The first term on the right-hand-side of this equation represents the impact of a shock to the net-of-tax rate on a firm's wage policy which goes through a change in the user cost of capital u_t. As corporate tax cuts reduce the user-cost of capital, they generate two effects: a substitution effect, incentivizing firms to substitute away from labor, and a scale effect, driving firms to scale up production by renting more capital and hiring more workers. The substitution effect draws wages down, while the scale effect pushes wages up. An elasticity of substitution between capital and labor, σ, lower than one makes the latter dominate the former. Hence, the capital cost channel is positive.

The second term on the right-hand side of (2.15) represents the effect of a shock to the net-of-tax rate on a firm's wage policy which goes through a change in the labor market wage index $\boldsymbol{w}_t$. Following a corporate income tax cut, the demand for labor increases, notably through the capital cost channel just described, which pushes wages up. This general wage

increase feeds back to firms' wages as they compete for workers through their relative wage rates. Thus, the labor cost channel is positive.

These results imply that all wages rise after a corporate income tax cut. It is important to note, however, that it does not mean that all firms grow in size. Relative wage changes across firms determine the movement of workers across employers. Some firms raise wages more than others following a corporate tax cut, causing a reallocation of workers towards those firms.

We are interested in the heterogeneity of firm-level responses to tax changes. It is a source of discrepancy between the micro and macro elasticities presented in Section 2.3.2. Corollary 1 and Lemma 2 imply that the wage elasticity defined in (2.15) is decreasing in a firm's labor share, s_l^j. Capital-intensive firms benefit more from corporate tax cuts and workers are reallocated away from labor intensive firms. This heterogeneous response pattern arises from the fact that corporate income taxes distort input choices in favor of labor, which is fully deductible from firms' tax bases. Firms using capital-intensive technologies are more hindered by this distortion. As the distortion goes away, capital-intensive firms grow, while labor intensive firms are hit by the rising wage.

Following the method used in Section 2.3.2, one can decompose the elasticity from (2.15) into a partial equilibrium and a price component. We can isolate the partial equilibrium component by setting $dr_t = d\boldsymbol{w}_t = 0$:

$$\epsilon_{w,1-\tau}^{j,PE} = [1 - \sigma(1-\xi)]\Lambda_r(s_{l,0}^j)\frac{1-\lambda}{1-\lambda\tau} > 0 \tag{2.17}$$

Based on this expression and Corollary 1, we can state the following proposition

Proposition 4. *If $\sigma(1-\xi) < 1$, the direct effect of a corporate tax cut on wages, $\epsilon_{w,1-\tau}^{j,PE}$, is positive for all firms j and decreasing in their initial labor share $s_{l,0}^j$.*

Capital-intensive firms are more responsive to corporate tax cuts, a prediction I will test empirically in Section 2.5.

The indirect effect is summarized by the following elasticity:

$$\begin{aligned}\epsilon^{j,GE}_{w_t,1-\tau} &= \epsilon^{j}_{w_t,1-\tau} - \epsilon^{j,PE}_{w_t,1-\tau} \\ &= -[1-\sigma(1-\xi)]\Lambda_r(s^j_{l,0})\epsilon_{r_t,1-\tau} + \Lambda_r(s^j_{l,0})\epsilon_{\boldsymbol{w}_t,1-\tau} \end{aligned} \tag{2.18}$$

This general equilibrium effect results from capital and labor price adjustments. Following a corporate tax cut, the price of capital rises as demand shifts up while supply slowly adjusts. Therefore, we can expect $\epsilon_{r_t,1-\tau}$ to be positive after a corporate income tax cut, which will be confirmed in the quantitative exercise of Section 2.7. The sign of this indirect effect is ambiguous.

2.4.2 Aggregate Wage Effect

We can use the expressions derived in the previous Section to uncover the sign and magnitude of the last three terms of the right-hand side of our aggregate wage effect in (2.12), which represent the discrepancy between micro and macro wage elasticities,

$$\frac{\epsilon_{\boldsymbol{w}_t,1-\tau}}{\gamma} = \mathbb{E}\left[\epsilon^{j,PE}_{w,1-\tau}\right] + \underbrace{N\mathbb{C}\mathbb{o}\mathbb{v}\left(l_j, \epsilon^{j,PE}_{w,1-\tau}\right) + \mathbb{E}\left[\epsilon^{j,GE}_{w_t,1-\tau}\right] + N\mathbb{C}\mathbb{o}\mathbb{v}\left(l_j, \epsilon^{j,GE}_{w_t,1-\tau}\right)}_{\text{Gap between micro and macro elasticities}} \tag{2.19}$$

where t is the horizon we consider to evaluate this elasticity after a tax change.

The first covariance term springs from heterogeneous firm-level technologies, which determine the distribution of partial equilibrium elasticities[5]:

$$\mathbb{C}\mathbb{o}\mathbb{v}\left(l_j, \epsilon^{j,PE}_{w,1-\tau}\right) = [1-\sigma(1-\xi)]\frac{1-\lambda}{1-\lambda\tau}\mathbb{C}\mathbb{o}\mathbb{v}\left(l_j, \Lambda_r(s_l)\right) \tag{2.20}$$

where $\mathbb{C}\mathbb{o}\mathbb{v}\left(l_j, \Lambda_r(s^j_l)\right)$ is the covariance between initial employment shares l_j and a decreasing function of their initial labor shares s^j_l. If capital-intensive firms tend also to be the

[5]By definition, it abstracts from price movements, which are the source of dynamics in this framework. This is why this first covariance term does not require any horizon index t.

largest firms, this covariance is positive and the first component of the micro-macro gap amplifies the average firm-level effect.

The second element of the discrepancy between micro and macro wage responses is the average indirect effect across firms,

$$\mathbb{E}\left[\epsilon^{j,GE}_{w_t,1-\tau}\right] = -[1-\sigma(1-\xi)]\mathbb{E}\left[\Lambda_r(s_l^j)\right]\epsilon_{r_t,1-\tau} + \mathbb{E}\left[\Lambda_w(s_l^j)\right]\epsilon_{\boldsymbol{w}_t,1-\tau} \tag{2.21}$$

Importantly, the price elasticities $\epsilon_{r_t,1-\tau}$ and $\epsilon_{\boldsymbol{w}_t,1-\tau}$ are horizon-specific, which is why the average indirect effect is dynamic.

The last term on the right-hand-side of equation (2.12) can be rewritten as

$$\begin{aligned}\mathbb{C}\text{ov}\left(l_j, \epsilon^{j,GE}_{w_t,1-\tau}\right) = -[1-\sigma(1-\xi)]\mathbb{C}\text{ov}\left(l_j, \Lambda_r(s_l^j)\right)\epsilon_{r_t,1-\tau} \\ + \mathbb{C}\text{ov}\left(l_j, \Lambda_w(s_l^j)\right)\epsilon_{\boldsymbol{w}_t,1-\tau}\end{aligned} \tag{2.22}$$

As the first (partial equilibrium) covariance term, its sign depends on the covariance of employment and decreasing functions of labor shares across firms, $\mathbb{C}\text{ov}\left(l_j, \Lambda_r(s_l^j)\right)$ and $\mathbb{C}\text{ov}\left(l_j, \Lambda_w(s_l^j)\right)$.

Equations (2.20), (2.21) and (2.22) characterize the discrepancy between micro and macro, as well as between short and long run elasticities of wages with respect to the net-of tax rate. They highlight the fact that, given a set of parameters $\{\xi, \sigma, \lambda, \gamma\}$, one can estimate these differences using simple sufficient statistics.

Finally, we can collect these results to express the key elasticity for workers' welfare as

$$\frac{\epsilon_{\boldsymbol{w}_t,1-\tau}}{\gamma} = [1-\sigma(1-\xi)]\frac{N\mathbb{E}\left[l_j\Lambda_r(s_l^j)\right]}{1-\gamma N\mathbb{E}\left[l_j\Lambda_w(s_l^j)\right]}\left(\frac{1-\lambda}{1-\lambda\tau} - \epsilon_{r_t,1-\tau}\right) \tag{2.23}$$

One can estimate $\mathbb{E}\left[l_j\Lambda_r(s_l^j)\right]$ and $\mathbb{E}\left[l_j\Lambda_w(s_l^j)\right]$ directly from micro data. However, we generally need more structure to estimate the elasticity of the rental price of capital, $\epsilon_{r_t,1-\tau}$. One common assumption in the literature on local corporate tax incidence is the small open

economy, with which $\epsilon_{r_t,1-\tau}$ is set to zero. In the case of a national tax reform in a closed economy, which is the focus of this paper, we need to solve the general equilibrium model to recover the entire wage pass-through.

2.5 Reduced-form evidence

This Section estimates firm-level elasticities of wages and labor income with respect to the net-of-corporate income tax rate using French administrative data provided by the Ministry of Finance (DGFiP) and the National Institute of Statistics and Economic Studies (Insee). The goal is to validate the predictions of Proposition 5 and to provide micro-level moments that will be used in Section 2.6 to discipline the model. To achieve this, I exploit multiple reforms implemented in France between 2009 and 2019 that altered the corporate income tax schedule faced by firms.

The three main datasets—DADS, FARE, and BIC-RN—contain detailed information on all firms and employees in France, collected from tax returns. These datasets are linked using the unique administrative firm identifier common across data sources. Appendix B.2 provides a detailed description of the data, as well as the sample and variable definitions used in this analysis.

2.5.1 Empirical design

Each reform introduced during the sample period (2009-2019) modified the corporate income tax schedule for targeted groups of firms[6]. For example, a reform known as "exceptional contributions" increased the marginal tax rate for firms with sales above 2.5 million euros, targeting very large firms by French standards. A second reform, introduced in 2017, reduced all marginal tax rates above 38,120 euros of corporate income. The variety in scale and

[6]In practice, I build a tax function that I apply to firms' reported income, and which includes multiple rules and reforms on top of the standard rate ("taux normal"): the reduced rate for small firms ("taux réduit"), the "contribution sociale sur les bénéfices", the "contributions exceptionnelles", the sequential 2017 reform. See Bach et al. (2019) for more details.

targets of the reforms throughout the sample period is advantageous, as it allows me to leverage both tax cuts and hikes across firms with diverse characteristics to estimate the elasticities of interest.

I estimate the firm-level elasticity of average wages with respect to the net-of-tax rate described in equations (2.15) and (2.17) using the following specification:

$$\ln(w_{j,t}/w_{j,t-1}) = \delta_j + \delta_t + e \cdot \ln([1-\tau_{j,t}]/[1-\tau_{j,t-1}]) + \varepsilon_{j,t} \tag{2.24}$$

where $w_{j,t}$ denotes firm j's average wage in year t. δ_j and δ_t denote firm and year fixed effects, $\tau_{j,t}$ denotes the marginal corporate income tax rate that firm j faces in year t, and $\varepsilon_{j,t}$ is an error term.

Tax variations are measured using firms' marginal tax rate, rather than their average tax rate, because it is the relevant determinant of firms' choices in the model presented in Section 2.2.

The coefficient of interest, $\widehat{e}$, is an estimate of the corporate tax elasticity of average wages at the firm level. A well-known source of endogeneity in this type of settings comes from firms' behavioral response to changes in the tax schedule. Firm j's marginal tax rate, $\tau_{j,t}(\pi^b_{j,t})$, is a function of its tax base (or before-tax corporate income), $\pi^b_{j,t}$, which is determined by its production choices and thus correlated with its wages.

To address this endogeneity, I follow the framework developed by Gruber and Saez (2002) for individual income and instrument the change in corporate income tax rate by the predicted change if firms' tax bases had remained constant. More formally, $\ln([1-\tau_{j,t}(\pi^b_{j,t})]/[1-\tau_{j,t-1}(\pi^b_{j,t-1})])$ in equation (2.24) is instrumented by $\ln([1-\tau_{j,t}(\pi^b_{j,t-1})]/[1-\tau_{j,t-1}(\pi^b_{j,t-1})])$. This method isolates the mechanical response to tax rate changes, which is uncorrelated with simultaneous wage changes.

In the preferred specification, I use two-year differences rather than one in order to abstract from very short-run adjustment frictions like the time needed to change production

Table 2.1: Estimated micro elasticities

	Δ log(Average wage)			Δ log(Wage bill)		
	2-year diff		1-year diff	2-year diff		1-year diff
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Net-of-tax rate	.012	.030	.017	.074	.152	.095
	(.004)	(.004)	(.004)	(.008)	(.009)	(.008)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	Yes	No	Yes
Obs (millions)	1.3	1.4	1.6	1.4	1.4	1.6

plans. As a robustness check, I estimate the same specification with one-year differences and show that the estimates are very close.

2.5.2 Average micro elasticities

I first estimate the specification described in (2.24) on the whole sample of firms. Column (1) of Table 2.1 shows the estimated firm-level elasticity of wages with respect to the net-of-corporate income tax rate using two-year differences and controlling for time and firm fixed effects. As expected from Section 2.4, this elasticity is positive and significant. The average firm-level elasticity is 0.012, which means that a one percent increase in the net-of-tax rate increases average wages by .012%. This relatively small average effect hides heterogeneous wage responses across different firms, as explored in the next section.

Columns (2) and (3) estimate the wage elasticity using different versions of the specification described in (2.24), by removing firm fixed effects in (2) and using one-year differences in (3). The estimated elasticities are positive, significant, and close to the preferred estimate in (1). In the quantitative exercise of Section 2.7, I use these microeconomic estimates to assess the distribution of the corporate tax burden and compare the results to macroeconomic estimates computed through the general equilibrium model described in Section 2.2.

Columns (4)-(6) estimate the elasticity of firms' wage bill with respect to the net-of-tax rate. As expected, these estimates are positive, significant, and larger than their wage counterparts (in columns (1)-(3)). Indeed, since firms benefit from monopsony power in the

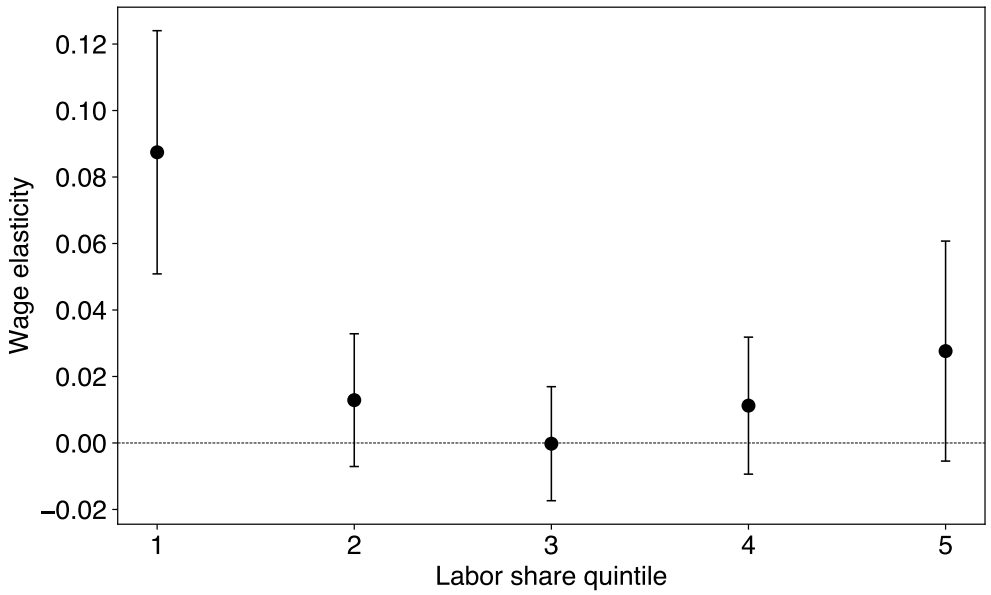


Figure 2.2: Firm-level elasticity of average wages w.r.t. the net-of-tax rate for different quintiles of labor share

labor market, an increase in their wage not only increases the labor cost associated with each of their incumbent employees on the intensive margin but also expands their workforce, thereby increasing labor costs at the extensive margin.

2.5.3 Heterogeneous firm-level elasticities

Since heterogeneous responses to corporate tax changes across the labor share distribution are central to the main mechanisms of the model, I validate this pattern by estimating equation (2.24) for different quintiles of labor share[7].

Figure 2.2 shows that the elasticity of wages with respect to the net-of-corporate income tax rate is weakly positive across all labor share quintiles, with a much larger effect for firms in the first quintile, i.e. with low labor shares. The point estimates decrease over the first three quintiles and then slightly increase for the last two, although these latter coefficients are not significantly different from zero.

[7]These quintiles are defined in the year prior to the tax rate changes, that is in $t-2$ when considering two-year differences.

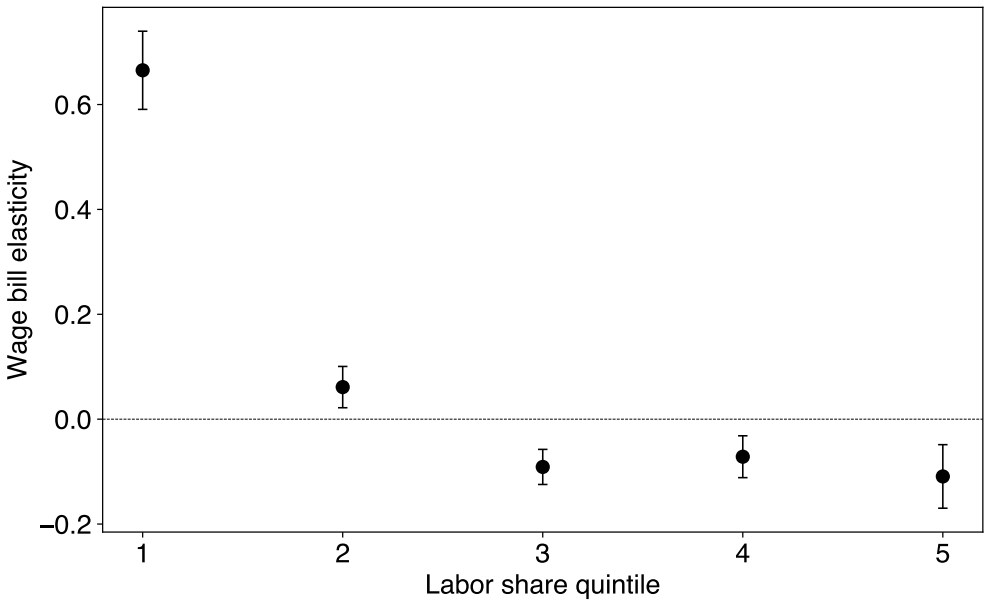


Figure 2.3: Firm-level elasticity of labor income w.r.t. the net-of-tax rate for different quintiles of labor share

These results confirm the prediction from Section 2.4 that wages increase following a corporate income tax cut, particularly for firms with low labor shares.

Figure 2.3 presents results from a version of (2.24) where the outcome variable is the log-change in wage bill. It shows that the effect of corporate tax cuts on wage bills decreases with firms' labor share. Labor income elasticities are positive and significant for the first two quintiles of labor share, and negative, significant, and relatively close for the last three quintiles. Firms that see substantial labor income growth following a corporate tax cut are concentrated at the top of the capital intensity distribution. On average, a 1% increase in the net-of-tax rate generates a .67% increase in labor income at firms in the first quintile of labor share. As corporate tax rates fall, workers reallocate from labor-intensive to capital-intensive employers, corroborating the findings of Section 2.4.

2.6 Parameterization

The parameterization strategy proceeds as follows. First, I calibrate multiple parameters using estimates from the recent literature and observable aggregates either as direct values or as targets. Secondly, I estimate the remaining economy-wide parameters by replicating the reduced-form regression from the previous Section and minimizing the distance between its results and the moments estimated from French administrative data. Finally, I recover the distribution of technologies across firms by inverting the model. Given a set of economy-wide parameters, there is a one-to-one mapping between observed pairs of (labor share, size) and unobserved pairs of technologies (α, z), which allows us to identify the non-parametric distribution of technologies.

2.6.1 External calibration

I use estimates from the literature as well as my own estimates (based on the micro data described in the previous section) to calibrate parameters $\{ \delta, \beta, \lambda, \psi, \tau_0, r_0 \}$. The last two parameters, τ_0 and r_0, denote the initial corporate income tax rate and return on capital. The exercise presented in the next Section simulates the response of this economy to an exogenous tax cut. This unanticipated reform is introduced while the economy is in an initial steady state. This is why we need to specify initial values for τ and r.

All agents' preferences are characterized by the annual discount factor β, set to 0.9615, and log utility derived from consumption. The capital depreciation rate δ is set to 0.05. I set the initial rate of return on capital r_0 to 0.08, which corresponds to the average rate of return on capital in the Euro area from 1990 to 2019 (Bank of France). Given $\{\beta, \delta, r_0\}$, the capital adjustment cost parameter ψ is pinned down by steady state necessary conditions, as derived in Appendix B.4.1.

The corporate income tax schedule is summarized by two parameters: the corporate income tax rate τ_0 and the present value of depreciation allowances λ. I set the former to

0.3333, which was the main statutory corporate income tax rate in France at the beginning of the sample used for the empirical analysis. I compute λ using tax returns data. As in the United States, each type of capital defined in the French tax code features a legal rate at which firms are required to formally depreciate their assets. Tax deductions are then inferred from these legal depreciation rates. Hence,

$$\lambda = \sum_{a \in A} \gamma_a \sum_{t=1}^{T_a} \frac{D_{a,t}}{(1+r)^t} \tag{2.25}$$

where $a \in A$ are asset categories defined in the tax code, γ_a is their share of total assets measured in the data, T_a is the number of years on which a firm is allowed to depreciate its asset of class a, and $D_{a,t}$ is the share of its value that can be depreciated and deducted from a firm's tax base t years after being purchased. Firms discount these future depreciation allowances with the initial rate of return on capital, i.e. $r = r_0$ in (2.25). Doing so yields a value of λ equal to 0.68.

I examine two scenarios regarding the use of public funds. In the benchmark scenario, I assume that tax revenues finance expenditures that do not impact any agent's income. This scenario follows the assumption that G_t directly tracks corporate tax revenues, resulting in outcomes that can be interpreted as the pre-transfer incidence—i.e., the effects of corporate tax changes without considering the allocation of tax revenues across agents. In the second scenario, I assume the government uses corporate income tax revenues as direct transfers to workers, implying that $G_t = 0$ for all t in equation (2.6).

2.6.2 Model inversion

What remains to be estimated is the set of parameters $\{\gamma, \sigma, \xi\}$, common to all firms, and the distribution of technologies $(\alpha_j, z_j)_{j \in \mathcal{J}}$ across firms. Conditional on parameters $\{\gamma, \sigma, \xi\}$ and an initial wage index $\boldsymbol{w}_0$, one can invert the model to recover the non-parametric distribution

of capital intensity and productivity (α, z) from observed pairs of labor and employment shares.

Hence, I use the actual distribution of (s_l, l) across firms in the data to jointly identify the full set of technologies $\{\alpha_j, z_j\}_{j\in\mathcal{J}}$. I set the number of firms in this economy to 300 and the initial wage index $\boldsymbol{w}_0$ to u_0, the initial user cost of capital. The distribution of labor and employment shares is generated from the 2010 data as follows. I group firms in the data into 300 quantiles of labor share. Each of these quantiles represents a firm, for which I compute its labor share as well as its share of total employment.

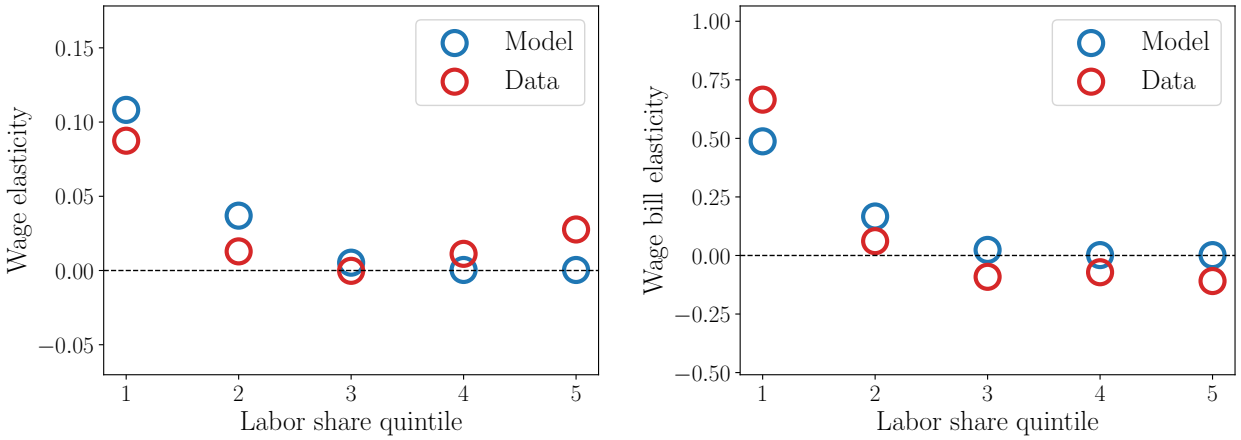
This method builds on the spatial economics literature, which uses model assumptions to recover the distribution of unobservable amenities across space (Redding and Rossi-Hansberg, 2017). It generates a non-parametric distribution of technologies that fits exactly the observed characteristics of firms, once considered through the lens of the model.

2.6.3 Indirect inference

This mapping between unobservable technologies and observable firm characteristics is conditional on the firm-level labor supply elasticity γ, the elasticity of substitution between capital and labor σ, and the parameter governing returns to scale ξ, which I estimate using the method of moments. I estimate reduced-form elasticities of wages and wage bills with respect to the net-of-tax rate on data generated by the model[8], using the same specification (2.24) as the one used on French administrative data. I calibrate parameters $\{\gamma, \sigma, \xi\}$ to minimize the mean squared errors between the empirical elasticities from Section 2.5 and their model counterparts

$$\boldsymbol{p}^* = \underset{\boldsymbol{p}\in\mathcal{P}}{\arg\min} \sum_{\epsilon\in\mathcal{E}} \left(\epsilon^{model} - \epsilon^{data}\right)^2, \qquad \boldsymbol{p} = \{\gamma, \sigma, \xi\}$$

[8]In practice, I randomize firm-level tax changes in the model in order to generate variation at the firm-level to identify the relevant elasticities.



(a) Wage elasticity

(b) Wage bill elasticity

Figure 2.4: Empirical elasticities vs. Model elasticities

where $\boldsymbol{p}^*$ denotes the resulting set of parameters, $\mathcal{P}$ denotes the domain on which these parameters are optimized, and $\mathcal{E}$ denotes the set of elasticities used as targets.

Figure 2.4 shows that the elasticities generated by the calibrated model (in blue) are very close to the corresponding empirical elasticities from Section 2.5 (in red). This method yields a firm-level labor supply elasticity γ equal to 3.5. This value is close to but lower than the labor supply elasticity estimated by Azar et al. (2022) in the US with application data (4.8). This gap is consistent with the fact that the French labor market is characterized by a lower mobility of workers. It implies that workers receive 78% of their marginal product in wages.

The resulting firm-level elasticity of substitution between capital and labor is 0.47, which is in the range of values estimated by Oberfield and Raval (2021). Finally, the returns to scale ξ are equal to 0.82. This value is consistent with the literature, which considers values from 0.60 (Gourio and Kashyap, 2007) to 0.92 (Khan and Thomas, 2008).

Figure B.1 plots the distributions of labor share and employment share across firms in the data (Panels (a) and (b)), and the resulting marginal distributions of technological parameters (α, z). Table B.1 summarizes the calibrated parameters.

Table 2.2: Calibrated parameters

External calibration					
Parameter	Description	Value	Source/Target		
δ	Capital depreciation	0.05	Data		
λ	PDV of deprec. allowances	0.68			
β	Discount factor	0.96			
Internal calibration					
Parameter	Description	Value	Target	Model	Data
ψ	Capital adjustment cost	0.02	Return on capital	0.08	0.08
σ	Elast. of substitution K-L	0.47	Reduced-form elast. (see 2.6.3)		
γ	Firm-level labor supply elast.	3.50	Reduced-form elast. (see 2.6.3)		
ξ	Returns to scale	0.82	Reduced-form elast. (see 2.6.3)		
$\mathbb{E}[\alpha]$	Average capital intensity	0.194	Avg. labor share	0.57	0.61
std(α)	Std. capital intensity	0.19	Std. labor share	0.10	0.15
$\mathbb{E}[z]$	Average TFP	0.06	Avg. empl. share	0.003	0.003
std(z)	Std. TFP	0.016	Std. empl. share	0.002	0.002
Corr(α, z)	Corr(cap. int., TFP)	0.64	Corr(labor share, empl. share)	-0.25	-0.24

2.7 Results

This Section describes the response of the calibrated economy to a one percentage point corporate income tax cut along multiple dimensions.

2.7.1 Dynamic corporate tax incidence

Figure 2.5 shows the paths of welfare gains for workers, the representative shareholder and the representative capital owner, expressed as shares of the total welfare gains, following a one percentage point corporate income tax cut. The fiscal assumption made in this first experiment is that the revenues from the corporate income tax are used for an external expenditure. Therefore, it abstracts from the distribution of public funds across agents.

The representative capital owner (red line in Figure 2.5) realizes large welfare gains in the short run, which slowly vanish along the transition path. As shown in Section 2.3.1, these first-order gains are generated by movements in the rental price of capital r_t. Figure 2.6 shows that this price jumps immediately when the tax cut is introduced, and then slowly returns to its steady-state level. The reform increases firms' demand for capital, but the supply of capital is relatively inelastic in the short run. The price of capital r_t rises and

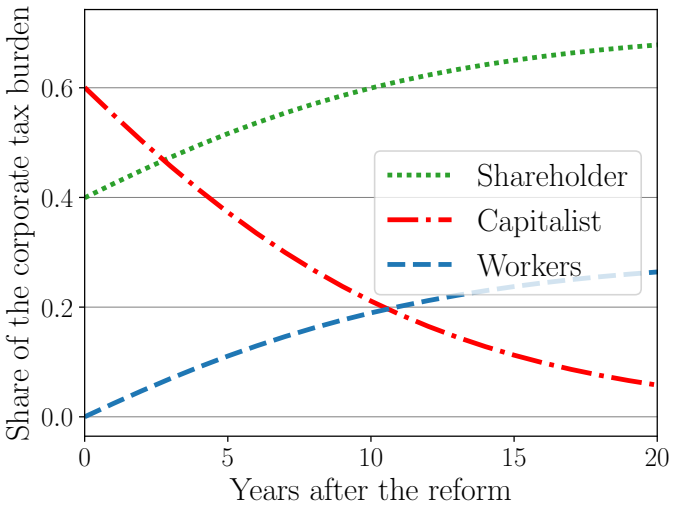


Figure 2.5: Corporate tax incidence

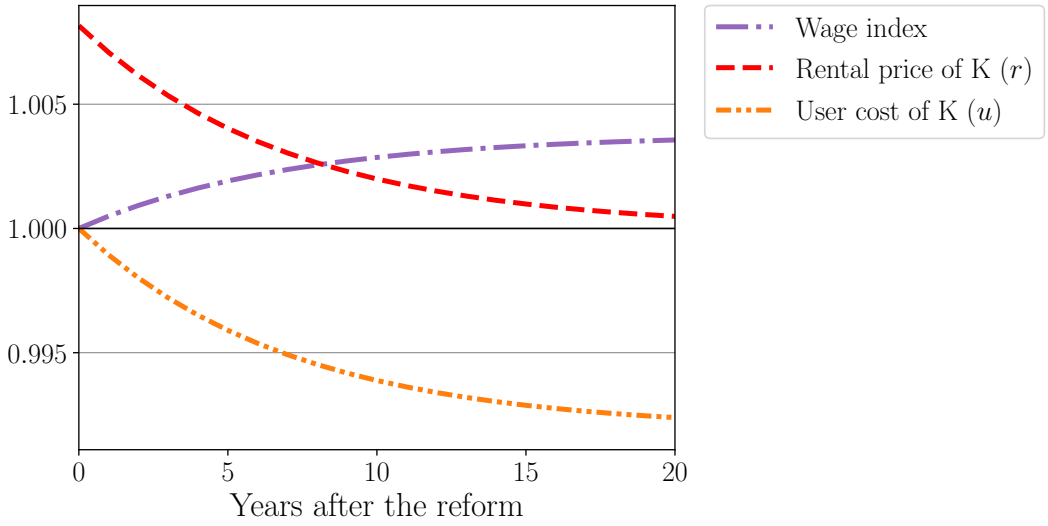


Figure 2.6: Aggregate price responses

offsets the exogenous reduction in the user cost resulting from the tax cut. As capital supply builds up, r_t falls and the user cost u_t with it. Capital is perfectly elastic in the long run, which is why its share of the burden converges to zero.

Capital and labor are complements at the firm level, implying a partial equilibrium increase in labor demand from all firms as the user cost of capital decreases, which drives up the aggregate wage index (purple line in Figure 2.6). The capital stock builds up progressively over time, which generates a slow movement in prices and firm behavior.

Finally, the representative shareholder (green line in Figure 2.5) derives utility from aggregate after-tax profits. These profits mechanically increase when the corporate tax cut is implemented and then grow along the transition path as the user cost of capital goes down. This is why the shareholder's share of the burden grows over time.

Following the definition of dynamic incidence shares presented in equation 2.7, I compute the net present value of welfare gains for workers, the representative shareholder, and the representative capital owner, and express them as shares of the total welfare gains generated by the corporate tax cut. These results are reported in column (2) of Table 2.3.

In the baseline model, workers experience a small increase in lifetime utility. The present value of their welfare gains is equal to 15% of the total welfare gains generated by the reform. The representative capital owner obtains 24% of the discounted welfare gains, although her share is close to 60% in the short run. In contrast, the representative shareholder experiences 61% of the total welfare gains, although her share is about 40% in the short run.

Overall, these findings indicate that workers bear a relatively small share of the corporate income tax burden, which can even become negative when considering that revenues from corporate tax changes may be transferred to workers. Shareholders, on the other hand, bear the majority of this burden. Moreover, the significant difference between the short-run and long-run distribution of the corporate tax burden highlights the importance of accounting for dynamics when assessing its incidence. These results are somewhat surprising given the recent literature on corporate tax incidence, which suggests that workers bear between 30% and 50% of the tax burden (Fuest et al., 2018; Carbonnier et al., 2022; Kennedy et al., 2022). Section 2.7.2 explains that this discrepancy arises from the macroeconomic perspective of this paper, as well as the underlying micro heterogeneity.

2.7.2 Micro vs. Macro estimates

To compare these results with micro estimates, I introduce common assumptions made at the micro level in frameworks interested in the incidence of corporate taxes. First, I use

Table 2.3: Micro vs. Macro estimates

	Share of the CIT burden				
	Micro estimate	Macro estimates			
		Baseline	w/o Firm het.	Redistribution	Consumption
	(1)	(2)	(3)	(4)	(5)
Workers	0.29	0.15	0.05	−0.05	0.09
Shareholder	0.71	0.61	0.80	0.77	0.73
Capital owner	-	0.24	0.15	0.28	0.18

Note: This table reports the estimated shares of the corporate income tax (CIT) burden borne by workers and the representative shareholder and capital owner. Column (1) uses the average elasticity estimated with (2.24). Column (2) reports the results from the baseline model. Column (3) removes firm heterogeneity. Column (4) introduces redistribution of the tax revenues to workers. Column (5) reports the consumption incidence shares in the baseline model.

the wage elasticity estimated from the micro-empirical specification (2.24) to account for wage effects of corporate taxes. This estimate is an average treatment effect and controls for general equilibrium effects that are common to all firms.

The second assumption is the absence of redistribution. The connection between corporate tax revenues and public expenditures is often unclear at local or regional levels, particularly when revenues are collected at the national level and subsequently redistributed among local entities. This observation provides a rationale for this assumption.

The third assumption is that the reform occurs in a small open economy. Microeconomic estimates typically adopt this assumption because firm-level or local variations in corporate tax rates do not influence the price of capital. The small open economy assumption abstracts from any welfare effect on capital owners, as capital prices are fixed. The corporate tax burden is only distributed between workers and shareholders.

Column (1) of Table 2.3 shows the distribution of the corporate tax burden under these micro-relevant assumptions. Workers bear 29% of the corporate tax burden, while the representative shareholder bears the remaining 71%. The present result is consistent with, though slightly below, the findings of the recent literature based on estimates of average microeconomic effects with the same underlying assumptions. This literature finds that workers' share of the corporate tax burden lies between 32.5% (Suárez-Serrato and Zidar, 2016) and

50% (Carbonnier et al., 2022). Figure B.2 makes a more extensive comparison between this paper's estimates and the recent literature.

Hence, the general equilibrium model estimate reduces workers' share of the corporate tax burden by half compared to the micro estimate.

The primary driver of this discrepancy between micro and macro incidence is the gap between wage elasticities at these two levels. Short-run price responses play a key role in general equilibrium as they drive down the macro elasticity. Wages increase following a corporate tax cut because firms demand more capital, which, in turn, raises the demand for labor as a complementary factor. In general equilibrium, the amount of capital that firms use slowly increases as the aggregate capital stock builds up. The associated wage gains take time to realize. Due to discounting, this dimension reduces the impact of corporate taxes on workers.

Column (3) in Table 2.3 shows the result from an economy similar to baseline one except that all firms are the average firm, i.e. they all have the same technology ($\mathbb{E}[\alpha], \mathbb{E}[z]$). In this economy without firm heterogeneity, workers bear an even smaller share of the corporate tax burden. The reason for this outcome is that, when firms are heterogeneous, corporate income tax changes generate different wage effects across firms. We saw in Section 2.4 that capital-intensive firms respond more intensely to such changes. Given that they are also larger and pay higher wages on average, the wage effect of a corporate tax cut is amplified by these heterogeneous responses. In other words, the first covariance term in equation (2.12) is positive. Without firm heterogeneity, and without the amplification coming from this covariance term, corporate tax cuts generate lower wage gains for workers.

Column (4) adds redistribution to the baseline model by assuming that the revenues from the corporate income tax are used as transfers to workers. In this scenario, workers actually experience a welfare loss after a corporate tax cut. The sign and magnitude of this effect depend on the initial position of the economy on the corporate tax Laffer curve. This fiscal channel has a negative impact on workers' share of the tax burden because the economy is

on the increasing portion of the Laffer curve. At much higher tax rates, on the decreasing portion of the Laffer curve, this fiscal externality would have the opposite sign, increasing workers' share of the burden. Overall, these results indicate that the use of public funds is a significant determinant of incidence shares at the aggregate level.

Finally, column (5) shows the distribution of the corporate income tax burden in terms of consumption in the baseline model. The share of the change in aggregate consumption associated with the tax reform that workers represent is 9%, which is line with the welfare results of column (2).

Overall, these results highlight the importance of general equilibrium effects, firm heterogeneity and dynamics in shaping incidence outcomes at the aggregate level.

2.8 Conclusion

The incidence of corporate tax cuts on workers depends crucially on their impact on wages. While recent studies have leveraged micro data and cross-sectional variation to estimate average wage firm-level responses, I show in this paper that these high-quality micro estimates can only capture a fraction of the aggregate elasticity that determines the overall impact of corporate tax changes on workers' welfare.

Typical average treatment effect estimates focus on average relative wage responses across firms. Such estimates may miss the fact that large firms with relatively high wages are also the ones that increase their wages the most after a corporate tax cut. This consequence of firm heterogeneity creates a positive multiplier which amplifies the effect of a corporate tax cut on wages.

Moreover, these estimates miss equilibrium effects, often referred to as the "missing intercept", which dampen wage increases in the short run. The positive impact of corporate tax cuts on wages primarily arises through firms' investment, which, due to capital adjustment

costs, takes years to materialize. As a result, a significant share of workers' wage gains is delayed and discounted, diminishing the welfare benefits of corporate tax cuts for workers.

The model developed in this paper allows me to derive explicit expressions for the micro and macro elasticities of wages with respect to corporate tax changes, which shed light on the amplifying role of firm heterogeneity and the dampening role of equilibrium effects. I estimate the model using administrative data from French tax returns and quantify these channels. The results reveal that the short-run equilibrium dampening effect is substantial, reducing the welfare impact of corporate tax cuts relative to microeconomic estimates.

This analysis opens several avenues for further research. One promising direction would be to examine additional margins affecting the elasticity of capital and labor income to corporate tax rates, such as international mobility (Gordon and Hines Jr, 2002), income shifting, or the salience of tax incidence (Aghion et al., 2023). Extending the model to a multi-country framework could provide valuable insights into the welfare implications of the global minimum corporate tax rate agreed upon by over 130 countries in October 2021.

Chapter 3

The Anatomy of Worker Flows in Distressed Firms

Joint with Maxime Gravoueille (Monash University) and Thomas Zuber (Banque de France, Paris School of Economics).

3.1 Introduction

Firm bankruptcies are dramatic events with wide-ranging implications for both microeconomic and macroeconomic outcomes. At the firm level, bankruptcies involve substantial reallocation costs for displaced workers (Jacobson et al., 1993), the loss of firm-specific human capital, and sunk exit costs for capital owners. At the aggregate level, firm closures play a crucial role in enabling the reallocation of labor inputs from less productive to more productive firms, thereby enhancing overall productivity (Hopenhayn and Rogerson, 1993; Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009). This paper studies the timing and nature of worker-firm separations in the context of bankruptcies, focusing on the role of firm and worker characteristics in shaping this process.

When confronted with diminishing profits due to a faltering level of demand, negative productivity shocks, or an increase in competitive pressure, firms are bound to reorganize in

order to restore their profitability level. Under downward wage rigidity, this adjustment may increase the layoff risk faced by incumbent workers. While firing costs and institutional restrictions already constrain bankrupt firms away from their optimal downsizing strategy, the endogenous response of workers seeking to escape the costs of job displacement by increasing their job-search effort will exert a further drag on distressed firms' future prospects.[1] On workers' side, a change in job-search behavior could lead to poorer job matches for panicked workers transitioning to a new firm from a bankrupt one. Overall, bankruptcy filing events should see large increases in worker-firm separations, both on the layoff and quit margins. By studying the timing, determinants, and individual-level consequences of worker-firm separations occurring in bankrupt firms, this paper opens the black box of workers' reallocation flows originating in firms' downsizing events.

Using linked employer-employee data matched to unemployment records as well as bankruptcy filings from France, this paper asks whether and how job flows react to the prospect of an upcoming financial turmoil. A first contribution is that our rich data sources allow us to decompose firms' employees outflows between job-to-job transitions and laid-off workers registering with public employment services and/or receiving unemployment insurance benefits. At the firm level, we find that distressed firms' layoffs start to increase two years prior to the actual bankruptcy filing and are followed one year later by a surge in job-to-job moves from departing employees.

A second contribution of this paper is to study the individual determinants of worker-firm separations. We show that the timing and pattern of these separations are consistent with a simple model of quits and layoffs with heterogeneous workers and match specific stochastic productivity. We find that inherently productive individuals quit more frequently and sooner than less productive ones, that firm specific human capital decreases the probability of a

[1]Since Jacobson et al. (1993)'s seminal study of displacement events in Pennsylvania, a long and ongoing stream of subsequent research repeatedly confirmed that displaced workers' earnings fall by more than 50% on impact and never fully recover in subsequent years. Going beyond earnings, displaced workers trapped in economically distressed areas face worsened social outcomes, falling marital rates, have to cope with poorer health, live shorter lives and tend to shift their political allegiance to candidates who pledge to rein in the negative effects of globalization (Autor et al., 2013, 2014; Dorn et al., 2020; Adda and Fawaz, 2020).

layoff, and that firing costs play an important role in shaping bankrupt firms' layoff policy. Additionally, we find that workers departing from distressed firms are willing to accept substantial earnings losses to avoid the risk of layoff, and that these cuts are primarily driven by a reduction in hours worked at the destination firm. Finally, we use a change in severance payment eligibility rules which occurred in France in 2008 to assess the causal impact of firing costs on firms' downsizing strategy.

This paper relates to several strands of the literature. First, we follow the steps of a long series of papers studying the worker-level consequences of job displacement. Starting with Jacobson et al. (1993) and Farber et al. (1993), this literature has shown that the permanent loss of a long-term job results in substantial and durable earnings losses (Couch and Placzek, 2010; Davis and Von Wachter, 2011; Flaaen et al., 2019; Schmieder et al., 2020). These losses can be decomposed into a temporary reduction in work hours, which gradually recovers in the years following displacement, and a more durable decline in wages (Krolikowski, 2017; Lachowska et al., 2020; Jarosch, 2023). This permanent loss in wages can in turn be split into the destruction of valuable match effects (Lachowska et al., 2020) as well as an increased likelihood that displaced workers move to firms offering lower wage premia (Lachowska et al., 2020; Fackler et al., 2021; Brandily et al., 2020). Finally Schmieder et al. (2020) show that the cyclical pattern in earnings losses uncovered by Davis and Von Wachter (2011) can be traced back to these losses of firm premia experienced by displaced workers.

A common shortcoming of early papers studying the consequences of job loss for workers' earnings is that ultimately displaced workers may differ in important dimensions from workers leaving the firm prior to the displacement event. While more productive workers are valuable to a distressed firm, they also are the ones with better employment outside options and hence greater incentives to leave the firm before its final closure. From the firm's point of view, firing less productive workers may be seen as a preemptive strategy to forestall its own fall.

Among empirical studies accounting for the changing composition of worker flows around displacement events Lengermann and Vilhuber (2002) find that the composition of a firm's outgoing flows is tilted toward high-skill workers in the quarters leading up to displacement. They cannot, however, disentangle productive high-wage workers quitting their distressed firm from costly tenured workers being laid off. Schwerdt (2011) shows that, because of these composition changes, studies which exclude early leavers from their estimates of displacement effects will tend to overestimate the costs of job loss. These results, however, contrast with those of Fackler et al. (2014) who find that a failing firm's workforce tends to become increasingly skilled as the firm's exit date approaches. This finding is consistent with Pfann (2001) and Pfann and Hamermesh (2008), who study a failing Dutch aircraft manufacturer and show that high-skill workers remained on board longer than their low-skill counterparts.

A related literature has examined the specific role of employment protection on job flows. Empirical studies have shown that firms face important labor adjustment costs (Hamermesh, 1989; Caballero et al., 1997), and that separation costs were particularly high in France (Abowd and Kramarz, 2003; Kramarz and Michaud, 2010; Cahuc et al., 2019). Such costs are known to affect firms' hiring (Kugler and Saint-Paul, 2004), firing (Bentolila and Bertola, 1990; Saint-Paul, 1995) and restructuring (Aghion and Howitt, 1992; Dessaint et al., 2017) policies. All three become critical as firms get close to bankruptcy.

This paper is also related to the literature which studies bankruptcy filings as a special case of job displacement. Indeed, employment shrinks dramatically around bankruptcy filings (Hotchkiss, 1995), bond defaults (Agrawal and Matsa, 2013), and covenant violations (Falato and Liang, 2016). Anticipating this displacement risk, workers supply fewer labor (Brown and Matsa, 2016) and demand compensating differentials (Abowd and Ashenfelter, 1981; Topel, 1984; Hamermesh and Wolfe, 1990; Matsa, 2018; Graham et al., 2019) to employers with high financial leverage and thus higher risk of default. However, Agrawal and Matsa (2013) and Baghai et al. (2020) show that bankruptcy risk wage compensations

are less sensitive to corporate leverage in high-protection institutional environments. In the relatively well protected environment we study, such risk compensations are less of a concern.

The rest of the paper unfolds as follows: section 3.2 outlines a simple model of worker/firm separations; section B.2 presents our data sources as well as some descriptive results on French firms' bankruptcies; section 3.4 presents our main results on job flows by type of transitions; section 3.5 studies the individual determinants of these separations; section 3.7 show that firing costs are an important dimension shaping firms' layoff policies; and section 3.8 concludes.

3.2 A Simple Model of Quits and Layoffs in Distressed Firms

In order to understand the forces determining the nature and timing of worker/firm separations we layout a simple continuous time partial equilibrium model of quit and layoff decisions under uncertainty. This model is similar in spirit to the model of layoffs under uncertainty outlined in Pfann (2006). Contrary to Pfann (2006) who models only a layoff decision, we explicitly take into account the possibility of quits and the strategic nature of the worker/firm relationship.

3.2.1 Set-up

Environment Time is continuous. Workers and firms are risk neutral and discount future payoffs at the market rate ρ. Consider the case of a firm combining one worker and one unit of capital in order to produce some output.

Productivity In the spirit of Jovanovic (1979) the flow product of a worker-firm match is $y_t + \alpha$ where y is a match specific component evolving according to a geometric Brownian motion with match specific drift μ and variance σ^2:

$$\mathrm{d}y = \mu y \mathrm{d}t + \sigma y \mathrm{d}z$$

and $\alpha \geq 0$ is the worker's idiosyncratic productivity type.

Wage rule We assume that in all active matches a fixed share ϕ of the gross flow output $y + \alpha$ is paid to the worker by its firm. Under this particular sharing rule wages are given as the sum of a time invariant worker specific component and time varying match specific component:

$$w_t = \phi\alpha + \phi y_t$$

While the shares of worker and match specific productivity paid to the worker need not be the same, we take a single sharing parameter ϕ as our baseline case.[2] The fact that wages are negotiated out of the gross surplus $\alpha + y_t$ rather than the familiar net surplus as in Mortensen and Pissarides (1994) is fundamental to our approach. Indeed, because at each point in time wages share the gross surplus of a match, separations will in general be inefficient. This property, which may be undesirable in a general equilibrium setting, is crucial to the modelling exercise that we propose. When separations are efficient, worker/firm matches are dissolved if and only if the net surplus from the match falls from zero. At this point neither the firm nor the worker want to stay in the match and both willingly depart to look for better production opportunities. In this sense, efficient separations imply that all quits are desired by the firm while all layoffs are desired by the workers. While the efficient separation case is a very useful general equilibrium benchmark, one can cast some doubts on the empirical relevance of such a setting where no meaningful distinction can be drawn between quits and layoffs. For this reason, our model focuses on the partial equilibrium setting where workers' and firms' outside options are taken as given.

[2]Close to our paper but considering a one-sided version of this model where workers are homogeneous and do not quit Cahuc et al. (2019) show that wages will be adjusted according to some fixed sharing rule of gross match productivity.

Bankruptcy risk and exogenous separations Because we are modeling firms and workers operating under the threat of a bankruptcy procedure we assume that exogenous separations may arise at the Poisson rate δ.

Endogenous separations Productivity and worker types are observable by both parties and each side can decide to break off the match at any moment. A worker-initiated separation is a "quit" whereas a firm initiated one is a "layoff". Upon quitting, a worker receives utility $Q(\alpha)$, which we assume to be increasing in a worker's type and which may or may not include the payment of a sunk cost. When a worker is laid off, which can happen endogenously because its firm decides to fire him, or exogenously with Poisson probability δ if the firm is liquidated, he receives utility $U(\alpha)$, which we assume to be increasing in worker type α. If the worker is laid off endogenously, he also receives a severance payment F from the firm. On the opposite side of the market, firms may lay off workers, in which case they get $1/\rho$ in present discounted value out of their installed unit of capital but have to incur the severance payment F. If a worker quits, the firm recovers $1/\rho$. Finally, we assume that in case of liquidation, the firm loses its unit of capital.

Value functions To get a simple closed form solution of quit/layoff decisions we assume that re-entry costs are infinite for both agents. Under these assumptions each worker's quit and firm's layoff unilateral strategies are easily characterized along the lines of Dixit (1989). See Appendix C.2 for a detailed treatment. Let J and E denote the firm's and worker's respective value functions. While a match is still productive J and E verify the following Bellman equations:

$$(\rho + \delta)E(y) = \phi(y + \alpha) + \delta U(\alpha) + \mu y E'(y) + \frac{\sigma^2}{2} y^2 E''(y) \tag{3.1}$$

$$(\rho + \delta)J(y) = (1 - \phi)(y + \alpha) + \mu y J'(y) + \frac{\sigma^2}{2} y^2 J''(y) \tag{3.2}$$

These Bellman equations cease to characterize E and J as soon as one of the two parties decides to leave the match.

3.2.2 Separation Regimes

We distinguish two different regimes which may arise in equilibrium. In the first regime the worker quits at a level of match productivity y_Q at which the firm would prefer not to let him go. In the second regime, the opposite happens: the firm decides to lay off a worker when productivity reaches a level y_L at which the worker would rather stay on the job.

Quit regime In the quit regime, the worker freely chooses the quit threshold y_Q. This quit threshold and his value function E are simultaneously pinned down by (3.1) and the following value matching and smooth pasting conditions:

$$E(y_Q) = Q(\alpha) \quad \text{and} \quad E'(y_Q) = 0$$

In this case the firm's behavior is constrained and its value function J is pinned down by y_Q, the smooth Bellman equation (3.2), and the value matching condition:

$$J(y_Q) = \frac{1}{\rho}$$

Layoff regime In the layoff regime, the firm freely chooses the layoff threshold y_L. This layoff threshold and its value function J are simultaneously pinned down by (3.2) and the following value matching and smooth pasting conditions:

$$J(y_L) = \frac{1}{\rho} - F \quad \text{and} \quad J'(y_L) = 0$$

In this case, the worker's behavior is constrained and his value function E is pinned down by y_L, the smooth Bellman equation (3.1), and the value matching condition:

$$E(y_L) = U(\alpha) + F$$

Proposition 5 characterizes the two equilibrium thresholds y_Q and y_L.

Proposition 5. *Under the assumption of infinite re-entry costs the thresholds y_Q in the quit regime and y_L in the layoff regime are given by:*

$$y_L = \max\{\frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{1-\phi}[(\rho+\delta)(\frac{1}{\rho}-F)-(1-\phi)\alpha], 0\}$$

and

$$y_Q = \max\{\frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{\phi}[(\rho+\delta)Q(\alpha)-\phi\alpha-\delta U(\alpha)], 0\}$$

where

$$\gamma = -\frac{(1-\frac{2\mu}{\sigma^2})-\sqrt{(1-\frac{2\mu}{\sigma^2})^2+4\frac{2(\rho+\delta)}{\sigma^2}}}{2}$$

While proposition 5 characterizes each agent's optimal behavior in isolation, it does not, however, answer the question of knowing which (if any) of the two strategies will prevail in equilibrium. Knowing that firms are willing to lay off workers at some positive productivity level or that workers are willing to quit at some other productivity level does not guarantee, however, that either of the layoff or quit strategies are an equilibrium. For either of these strategies to be an equilibrium, we need to verify (i) in the layoff regime, that the worker will not quit before being laid off, and (ii), in the quit regime, that the worker will not be laid off before he decides to quit. Proposition 6 below characterizes the types of equilibria that may arise in this separation game according to the possible values of worker types α. Before addressing this question directly in Proposition 6, a simple inspection of the two thresholds y_Q and y_L already yield some insights into the conditions that are necessary for either outcome to arise as an equilibrium of the separation game.

Quit regime Under what conditions can the quit regime arise? Would it be possible that y_Q reaches 0 so that in some cases workers never quit? The answer to this question depends on the shape of workers' two outside options Q and U. More precisely, there may or may not exist a cutoff value $\alpha_Q > 0$ defined by

$$(\rho + \delta)Q(\alpha_Q) - \phi\alpha_Q - \delta U(\alpha_Q) = 0$$

such that workers of type $\alpha \leq \alpha_Q$ never quit. However, under the assumption that the value of work relative to unemployment is weakly increasing in worker productivity ($Q' - U' \leq 0$), that low type workers are at least indifferent between working and remaining unemployed, i.e. $Q(0) - U(0) = B \geq 0$ and that Q is bounded away from 0, then $\alpha_Q = 0$. All worker types may be willing to quit if match productivity is low enough. We maintain these baseline assumptions throughout the rest of the paper.

Layoff regime Under what conditions can the layoff regime arise? Inspection of y_Q shows that if the worker's type α is high enough

$$\alpha \geq \frac{\rho + \delta}{1 - \phi}(\frac{1}{\rho} - F)$$

then $y_L = 0$ and the worker will never be laid off.

Contrary to the quit case, however, where the constrained outside option of the firm is always higher than its unconstrained one ($1/\rho > 1/\rho - F$), in the layoff regime some workers may always have an incentive to quit before being laid-off. This will be the case if the outside value of quit $Q(\alpha)$ is preferable to how these workers fare upon getting fired, i.e. the value of unemployment $U(\alpha)$ plus the value of severance payments F. In other words, the layoff regime *cannot* arise for all workers such that $Q(\alpha) > U(\alpha) + F$.

In order for layoffs not be altogether ruled out in the model, we assume from now on that $Q(0) - U(0) = B \leq F$, so that workers with low enough productivity may have an incentive not to quit before they are laid off. This assumption is reasonable insofar as one

may plausibly think that lowest type workers have a value of work relative to unemployment close to zero ($B \sim 0$). Combining this assumption with the assumption that $Q-U$ is weakly increasing and further adding that $\lim_{\alpha \mapsto +\infty} Q(\alpha) - U(\alpha) > F$, then there exists a unique $\alpha_L > 0$ such that $Q(\alpha_L) = U(\alpha_L) + F$.

All in all, combining the conditions that $y_Q > 0$ and that $Q(\alpha) < U(\alpha) + F$ we have already shown that the layoff regime can only arise for workers of type:

$$\alpha \leq \min\{\frac{\rho+\delta}{1-\phi}(\frac{1}{\rho} - F), \alpha_L\} \tag{3.3}$$

where the first term of the minimum ensures that firms are willing to fire the worker at some low enough productivity level and the second term ensures that workers will not systematically quit well before reaching this low productivity level.

Separation equilibria Proposition 6 defines the different separation regions (quit or layoff).

Proposition 6. *What's more:*

- *under the assumption that gain from re-employment is high enough for productive workers in the sense that:*

$$\lim_{\alpha \mapsto \infty} \frac{(\rho+\delta)Q(\alpha) - \delta U(\alpha)}{\phi} > \frac{(\rho+\delta)}{1-\phi}\frac{1}{\rho}$$

  then there will exist a threshold $\underline{\alpha}$ such that the quit strategy is an equilibrium for matches involving a type α worker if and only if $\alpha > \underline{\alpha}$. The cutoff $\underline{\alpha}$ will verify $\underline{\alpha} \geq \alpha_Q$ where α_Q is such that $\phi\alpha + \delta U(\alpha) > (\rho+\delta)Q(\alpha)$ iff $\alpha \leq \alpha_Q$;

- *under the assumption that baseline unemployment benefits are not too high:*

$$\rho U(0) < \frac{\phi}{1-\phi}(\rho+\delta)\frac{1}{\rho} - (\frac{\phi}{1-\phi} + 1)(\rho+\delta)F$$

there will exist a threshold $\overline{\alpha}$ such that the layoff strategy is an equilibrium for matches involving a type α worker if and only if $\alpha < \overline{\alpha}$. The cutoff $\overline{\alpha}$ above which the layoff strategy is not an equilibrium must verify:

$$\overline{\alpha} \leq \min\{\frac{\rho+\delta}{1-\phi}(\frac{1}{\rho} - F), \alpha_L\}$$

where α_L is such that $Q(\alpha) \geq U(\alpha) + F$ iff $\alpha > \alpha_L$

We relegate the proof of Proposition 6 to Appendix C.2. Concretely Proposition 6 shows that all workers of type $\alpha > \max\{\overline{\alpha}, \underline{\alpha}\}$ will quit in equilibrium while all workers of type $\alpha < \min\{\overline{\alpha}, \underline{\alpha}\}$ will be laid off. According to the relative value of the two thresholds two cases may arise. If $\overline{\alpha} < \underline{\alpha}$ there exists a range of worker types where neither strategy is an equilibrium. If $\overline{\alpha} > \underline{\alpha}$ there exists a range of worker types where both strategies are a possible equilibrium. While we do not have a general result on the ordering of $\underline{\alpha}$ and $\overline{\alpha}$, a numerical resolution of the model shows that both the multiple equilibria and no-equilibria case may arise under plausible parameter values.

Because firing costs make firms reluctant to layoff all employees, an increase in firing costs affects negatively $\underline{\alpha}$: when firing costs are high, even low-type workers will be pushed to quit before the firm decides to fire them. On the layoff side, however, firing costs have offsetting effects on $\overline{\alpha}$ the highest worker type that may be fired in equilibrium. At low levels of firing costs, severance payments are such that even low productivity workers prefer to quit before their firms get a chance to let them go. As firing costs increase (i) the incentive for higher type workers to wait for a layoff increases but (ii) at the same time the willingness of firms to fire these workers decreases. Under the first effect the $\overline{\alpha}$ layoff boundary goes up, but starts to decrease after the second effect kicks in at high levels of firing costs. Figure **??** in Appendix C.2 presents the results of a simple calibration where the counter-balancing effects of firing costs on the layoff behavior of firms and the quit strategies of workers give rise to a non-separation region as well as a multiple equilibria one for some intervals of worker types.

3.2.3 A Primer on Quit and Layoff Strategies

Albeit simple, this partial equilibrium framework has rich implications for both the timing and nature of worker/firms separations. In this subsection, we focus on the effects of (i) employment protection and (ii) productivity, as well as their interaction with the probability of a firm's bankruptcy.

Employment protection In this model, firing costs have a timing and selection effect. Inspection of the layoff productivity thresholds y_L shows that, given a worker's type, higher firing costs F will delay a firm's decision to lay off a worker and hence make layoffs altogether less likely to occur.

Firing costs also have an influence on the type α of workers who will be fired by the firm. The upper threshold for layoffs given in (3.3) shows that firing costs matter for worker selection through different channels. First the left term under the minimum of (3.3) decreases when firing costs increase: this is so because firms become more reluctant to fire low-productivity workers when faced with higher severance payments. Second, the right term under the minimum of (3.3) increases when firing costs increase: this happens because high firing costs mean high severance payments on the worker side, so highly productive workers become reluctant to quit, making this constraint less likely to be binding. Overall, increases in firing costs increase labor hoarding of productive workers and lower the average productivity of laid-off workers by protecting incumbent workers further down the idiosyncratic productivity range. What's more, the marginal effect of F on firms' selective layoff choices increases with the exogenous firm failure probability δ.

Although perhaps not surprising, this conclusion may have important practical consequences when one considers how crucial selective layoffs may be to help a declining firm reorganize and overcome negative shocks.

Productivity On the productivity side, match-specific productivity μ increases the option value of waiting for better times both for the worker and firm. An increase in μ will hence delay both quits and layoffs. Finally, while proposition 6 shows that worker idiosyncratic productivity α directly influences the nature of the separation decision (quit or layoff), inspection of the quit thresholds y_Q shows that the non-zero possibility of a firm's failure $\delta > 0$ plays an important role in high ability workers' self-selection into an early departure strategy. To see why, consider the simple case where U is constant and $Q(\alpha) = c + \phi\alpha/\rho$ is the present discounted value for worker α of waiting a finite amount of time to be matched to a secure outside sector where the expected trend productivity is 0. In this case:

$$y_Q = \frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{\phi}[(\rho+\delta)c + \delta\alpha - \delta U]$$

So that $\delta > 0$ implies that, conditional on quitting, high type workers will quit sooner than their lower type co-workers. This would be the case in a "secure" firm where the probability of exogenous match destruction would effectively be zero — i.e. $\delta = 0$.

This simple case outlines a potentially important link between bankruptcy risk δ and selective quits by highly productive workers. As the expression for y_L shows, firms value high type workers and are reluctant to let them go. If it were empirically verified, this selective quits mechanism could potentially exert a further drag on bankrupt firms' survival probability, thereby creating an endogenous feedback loop between bankruptcy risk δ and the flight of the most productive workers.

3.3 Institutional Background and Data

We briefly review the French bankruptcy system, the source of identification, and the data.

3.3.1 Institutional Background

Firm bankruptcy The French bankruptcy procedure is similar to other systems available in a wide range of countries (for example Chapter 7 and Chapter 11 in the United States). It is a compulsory–following a court order–entry under legal supervision because of a firm inability to service its debt. Two main procedures are available[3]: *liquidation*, during which the filing firm ceases its operation and all assets are sold, and *administration*, during which the filing firm is restructured. The main difference between them is that the latter targets firms which might be able to continue their activity in the long run, while the former mostly applies to firms that should cease their activity.

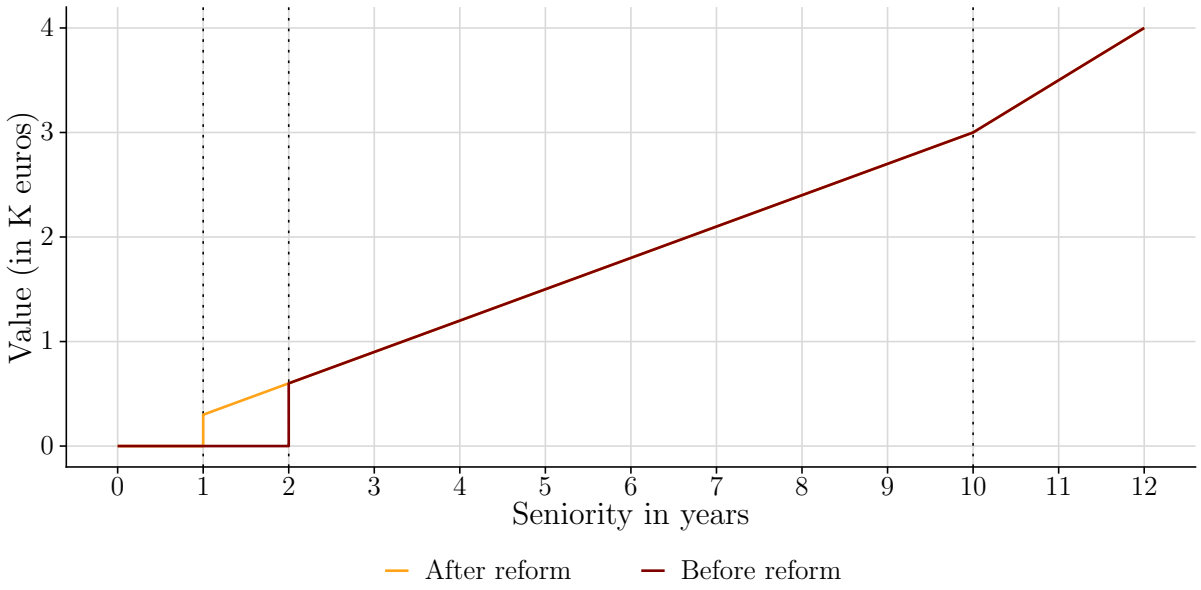
We now review the timeline of the administration procedure. Within the first couple of months following a firm's default, a legal court opens the administration procedure. It follows a short period of observation (up to 6 months[4]) during which an insolvency practitioner designated by the court assesses the firm's assets and liabilities. This practitioner can also engage in economic layoffs. Based on this evaluation, the court then decides to confirm the administration procedure, re-categorize the firm into liquidation or accept a disposal plan[5].

Firing costs Upon layoff, workers are eligible to a severance package paid by the firm. Both the eligibility rules and the cash transfer of the package are based on seniority and a reference wage. A legal standard stating the minimal seniority and the minimal amount conditional on the reference wage is defined at the national level. Sectors, industries or even firms, might set better parameters than the national one. While we do not have the full information on the precise severance package for each worker and firm, we use the national standard as a lower bound of the severance package schedule. Our estimation strategy should then be interpreted as an intent-to-treat design.

[3]The liquidation procedure is similar to Chapter 7 in the United States, while the administration procedure is similar to Chapter 11.
[4]This period can be renewed twice, but is in general lower than 6 months.
[5]Firms can also directly exit the bankruptcy procedure. Still, this option remains unlikely.

We exploit a change in the eligibility criteria which occurred in France on the 27th of June, 2008. Figure 3.1 plots the national legal severance payments schedule before and after the reform, for a reference wage of 1500 euros per month. Two discontinuities should be noted. First, a jump in the first years of seniority where workers shift from zero to a positive amount due to a change in the minimum seniority threshold. Following the reform, this threshold has been lowered from two years to one year .[6] Second, a change in the slope occurs at 10 years of seniority. After this point, workers are entitled to an increase in their severance payments. The slope remains constant at higher levels of seniority.

Figure 3.1: Severance payments schedule for 1500 euros of monthly wage



We recover a proxy for severance payments in our worker level data by inverting the relationship between the reference wage and total earnings in the last observed spell at a given tenure level whenever a worker's separation can be classified as a layoff (we explain in more detail how we classify layoffs and quits in section 3.3.3 below).

[6] All legal references are available at this link.

3.3.2 Firms

Firm level data Our first source of information on the firm side consists of publicly available bankruptcy data. We restrict our sample to firms filing for bankruptcy ("ouverture de redressement judiciaire") between 2008 and 2017. There are 148,248 records of such bankruptcy filings in our sample, amounting to an average yearly flow of a little less than 15,000 firms. Our publicly available data allows us to observe not only bankruptcy filings but other subsequent events. In this this particular sample of firms, the next event after bankruptcy filing itself took on average 7.44 months to materialize. 72% of firms filing for bankruptcy were liquidated, 27.6% underwent a reorganization plan and 5.5% were subject to a disposal plan.[7] Within this original sample of bankruptcy filings, we focus on firms which are privately owned and can be matched to fiscal records in the years leading to their bankruptcy filing with non-missing employment data. This selection trims our original sample down to 79,876 distinct firms filing for bankruptcy between 2008 and 2017. Compared to the literature on mass layoffs, which often focuses on large firms, in the year of their bankruptcy filing, the firms we observe employ on average 7.87 workers, while median employment is just 3.

Descriptive statistics How do the bankrupt firms we observe compare to non-bankrupt firms? Table 3.1 below reports observed differences in the sample of firms filing for bankruptcy in 2012 and the universe of privately managed firms which do not file for bankruptcy between 2008 and 2017. In the year of their bankruptcy filing, bankrupt firms are smaller, less productive, and less profitable than their non-bankrupt counterparts. Reminiscent of ongoing structural change, bankrupt firms operate also more frequently in the manufacturing sector. Finally, although not surprisingly, bankrupt firms exit much more frequently than their non-bankrupt counterparts.[8]

[7] These categories are not mutually exclusive: a firm can enter a reorganization plan but may still end up being liquidated.

[8] A firm's "exit" is defined here as the disappearance of its fiscal identifier from our administrative records in 2018.

Table 3.1: Bankrupt vs non bankrupt firms in 2012

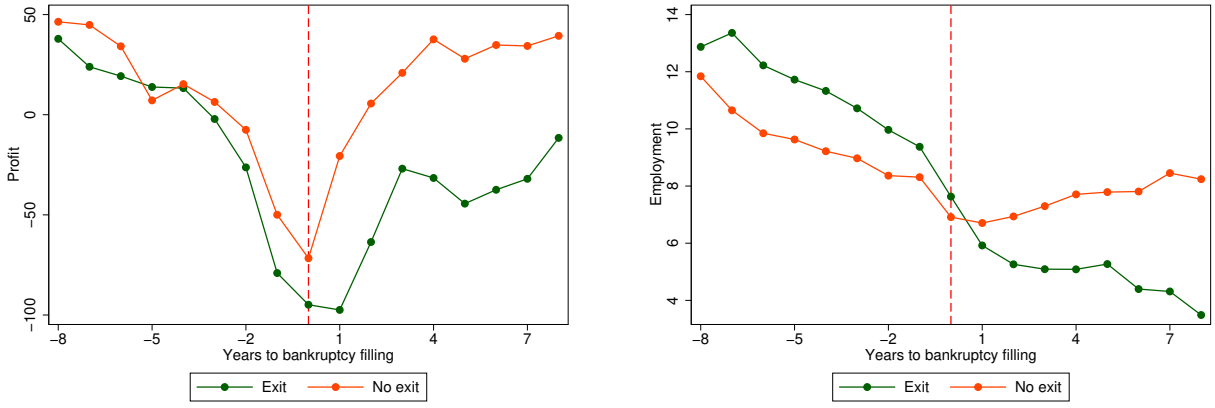
	Filing			No filing		
	mean	median	sd	mean	median	sd
Employment	9.02	3.5	30.2	11.7	2.5	307.5
Sales	1267.8	315.4	13139	2333.2	182.67	82926.1
Value added	272.3	93.7	1173.36	569.3	69.6	20211.2
Profit	-108.5	-16.3	947.6	136	9.6	9207.9
Manufacturing	0.123			0.075		
Exit	0.85			0.26		
Observations	8,610			1,436,718		

Notes: This table reports the 2012 mean, median and standard deviation of employment, sales, value added, profit and the mean of a manufacturing dummy for firms filing for bankruptcy in 2012 versus firms never filing for bankruptcy between 2008 and 2017. Sales, value added and profits are expressed in thousands of 2012 euros. Manufacturing is defined as the 10-33 range in the 2 digit NAF rev. 2 classification. Exit is defined as a firm's fiscal identifier missing from our administrative records in 2018.

Our fiscal data allows us to study bankrupt firms' in the years leading to and following their bankruptcy filing. Figure 3.2 plots firms' profits and employment in the years leading to and following a bankruptcy filing. What's more, Figure 3.2 distinguishes the outcomes of firms which survived their bankruptcy procedure (orange) and firms which did not (green curve). In both groups, firms' profits and employment decline continuously in the years leading to a bankruptcy filing. Profits drop into negative territory 3 years prior to the filing date. This negative stream of profits appears to prompt a strong and swift downsizing of distressed firms: mean firm employment drops suddenly by about 30% in the two years around a bankruptcy filing. This drop is consistent with the increase in voluntary and involuntary separations we observe at the firm level in our matched employer-employee data. In the years following the bankruptcy filing, survivors' mean employment stabilizes at a lower level while profits fully recover and come back to positive levels. Compared to their pre-bankruptcy size, survivors' long-term employment and sales are shrunk by a factor of 2. In the other group, despite a continued decline in employment, non-survivor firms are unable to restore a positive profit rate. This long period of negative profits ultimately culminates in these firms' exit from the market. These dynamic patterns stand in contrast with the findings of Fackler et al. (2018), who point to the sudden nature of bankrupt firms' fall in

sales and employment. In the French data, firms filing for bankruptcy appear to step on a path of slow decline several years before their actual exit.[9]

Figure 3.2: Firms' downward path to bankruptcy



(a) Profits

(b) Employment

Notes: These two graphs plot (a) mean firm profits (thousands of euros) and (b) mean firm employment in the years leading to and following each firm's bankruptcy filing. We distinguish between firms who survive after their bankruptcy procedure and firms exiting from the market in the years following their bankruptcy filing. Sample: all firms which file for bankruptcy between 2008 and 2017. The vertical red dashed line stands for the year in which each firm files for bankruptcy.

3.3.3 Workers

Worker level data We gather information on workers' labor market outcomes across time using the FH-DADS panel. This panel matches linked employer-employee data to administrative unemployment records, if any. Workers in the panel represent a random 1/12th sample of the universe of French workers during the 2002-2012 period.

We construct our main sample of interest by focusing on all workers who can be matched to a firm filing for bankruptcy between 2008 and 2017. We apply several selection steps in order to construct a sample of workers for which we are able to reconstruct a well-defined labor market history after they leave their bankrupt firm. First, we select workers who have worked in a bankrupt firm in a six-years window around this firm's bankruptcy. Secondly,

[9]This finding is consistent with previous studies of firms' exit in the French manufacturing sector by Bellone et al. (2006).

we only keep workers employed under a long-term contract ("CDI") when they are last observed in their bankrupt firm. In order to be able to reconstruct a robust labor market history, we drop workers whose next observed spell begins more than 30 days after the end of their bankruptcy spell. We then classify our departing workers as job-to-job movers versus layoffs thanks to two different sources of information. First, we check whether or not each departing worker's next registered spell is an unemployment spell (worker registering with public employment services, "FH" part of the panel). Second, we check whether each departing worker received insurance payments within the year. These insurance payments are recorded separately on a yearly basis as an "ASSEDIC" line in our work history file ("DADS"). If either one of these conditions is met we classify a departing worker as a layoff.[10] Conversely, we define a job-to-job transition as a worker leaving a bankrupt firm to work in another firm within 30 days, without registering to public employment services nor claiming unemployment benefits within the year. We do not include in our analysis workers who exit the labor market for good (in the sense that their bankruptcy spell is their last observed spell in our employment or unemployment data) or reappear after more than one month in our data. In order to discard workers whose contract is merely transferred to a new employer we also exclude workers who leave their origin firm after a disposal plan has been agreed on.

Descriptive statistics Our final sample of workers comprises 21,295 individuals whose 2002/2012 labor market history crossed paths with one of 12,981 firms filing for bankruptcy over the 2008/2017 period. In practice, we start observing workers in our set of bankrupt firms as soon as 2005. Table 3.2 below reports the mean, median and standard deviations of worker characteristics in our main sample when last observed in their bankrupt firm.

In our baseline sample, 51% of workers transition to another firm within 30 days, while the other 49% receive unemployment insurance payments within the year or register to public

[10] In practice, only 8% of workers observed in our sample receive unemployment benefits without registering with public employment services within one month.

Table 3.2: Workers when last observed in a bankrupt firm

	mean	median	sd	observations
Age	35.7	34	10.6	21,295
Male	0.66	1	0.47	21,295
Employer size	114.3	16	351.4	21,295
Manufacturing	0.14	0	0.35	21,295
Monthly wage	2433.2	1966.2	2222.2	21,252
Part time	0.20	0	0.40	21,295
Tenure (years)	2.91	1.64	3.95	19,969
Eligible to severance pay.	0.57	1	0.49	19.969
Potential severance pay.	2582.0	1503.2	4217.5	11,535

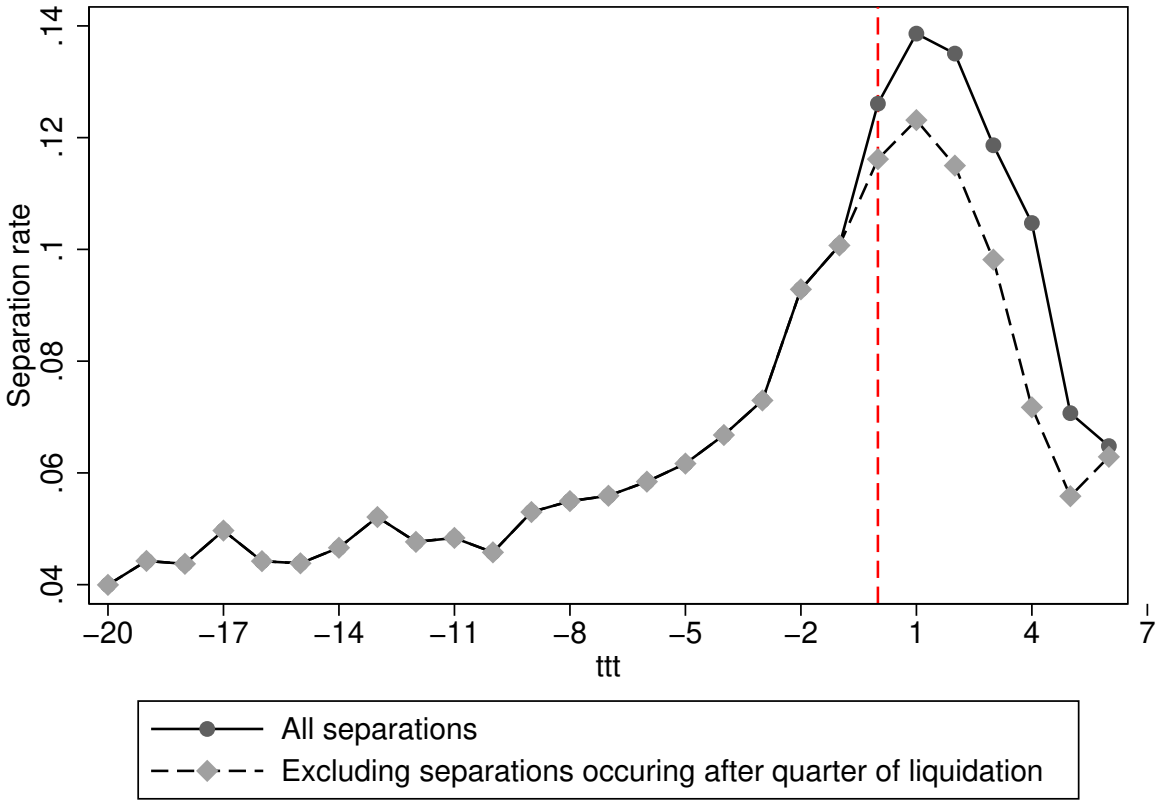
Notes: This table reports the mean, median and standard deviation of the monthly gross wage, age, tenure, dummy for male and size of bankrupt firm for workers who were last employed in one of our bankrupt firms on an indefinite duration contract. Gross monthly wages are computed as monthly equivalents of the gross hourly wage we observe in the data.

employment services (i.e. "layoffs"). Among workers transitioning to another firm within 30 days, only 69.7% are hired on a long-term contract. The average change in gross hourly wages associated with job-to-job transitions is -2.0%.

3.4 The ins and outs of worker flows in bankrupt firms

We start by documenting the pattern of separations taking place in distressed firms in the years leading up to and immediately following a bankruptcy filing. In order to do so at a quarterly rather than annual frequency, we reconstruct separation rates from our linked employer-employee data set. We start by selecting each worker's last observed spell in a bankrupt firm. As described in section 3.3.3 these spells extend over the 2002/2012 period and are restricted to workers employed by bankrupt firms under "indefinite duration" contracts. We define quarterly firm-level separation rates as the ratio of the measured number of separations within the quarter over a firm's yearly average employment level. Figure 3.3 below displays the evolution of the mean separation rate in a time window comprising quarters 5 years prior and 2 years after each firm's bankruptcy filing. Separations start to rise 2 years prior to, accelerate 1 year prior to, and peak one quarter after the bankruptcy filing date.

Figure 3.3: The pattern of separations in distressed firms



Notes: This graph plots bankrupt firms' mean separation rate prior to and after a bankruptcy filing event. The separation rate is defined as the number of separations occurring in a given quarter over a firm's average size in the relevant year. The first black curve includes all separations; the second gray curve excludes separations at firms which were liquidated.

A potential concern, however, could be that part of these separations are occurring because firms are shutting down entirely. The definition of a firm's "exit" is not trivial. The advantage of our data is that we know whether and when the bankruptcy procedure was terminated and converted into a liquidation. To check the extent to which the dynamic behavior of our measured separation rate comes from an extensive firm closure margin rather than the intensive margins of quits and layoffs, we exclude from our computations all separations taking place after each firm's liquidation date, if any. The result of this exercise is plotted as a gray dotted line alongside our main separation rate in Figure 3.3. By construction, our main measure of separations and the corrected "intensive-only" one do not differ prior

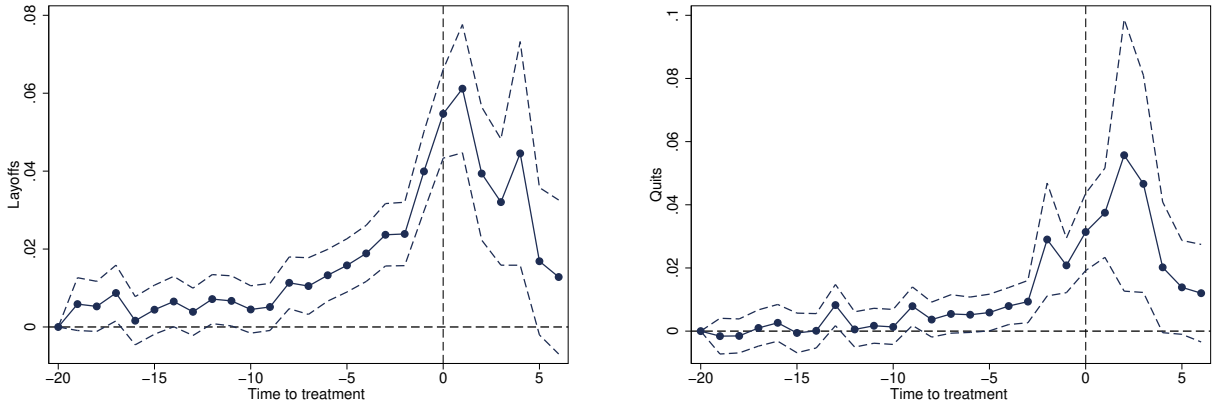
to the bankruptcy filing date. After the bankruptcy filing date, we find that the extensive firm closure margin explains at most one sixth of the overall separation rate. This finding seems to indicate that most workers are laid off from or quit their firm prior to its final administrative closure date.

Although the observation that firms' separation rate increases dramatically around bankruptcy filing events does not come as a surprise, an advantage of our precise matched employer-employee and unemployment insurance data is that we are able to observe workers' outcomes in the weeks, following their separation from bankrupt firms. We use this wealth of information to split our main measure of separations into two distinct categories: (i) job-to-job transitions, (ii) workers transitioning into unemployment. As explained in Section 3.3.3, we drop workers whose next observed spell (be it an employment or unemployment one) starts more than 30 days after the end of the last spell observed in the bankrupt firm. This selection criteria is strict (we drop 50% of observations) but ensures that the classification method we propose is reliable. Job-to-job transitions are defined as workers leaving a bankrupt firm and finding a job in another firm within 30 days and without registering with Public Employment Services. Unemployed workers are workers leaving a bankrupt firm and registering with Public Employment Services within 60 days. Finally, exits from the labor market are workers separating from a bankrupt firm before September 1st, 2012 and never reappearing in our data.

Given these definitions, Figure 3.4 below decomposes the baseline separation rate of Figure 3.3 into its two sub-components. More precisely, figures 3.4a and 3.4b present the result of a regression of firm-level separation rates on quarters-to-the-bankruptcy dummies. Separation rates 5 years prior to each firm's bankruptcy filing date are taken as the reference omitted category.

On the layoffs' side, inspection of Figure 3.4a reveals that bankrupt firms start to fire workers well in advance of the actual bankruptcy filing date. The timing of these preemptive layoffs, which start approximately 2 years prior to the filing date, is consistent with the

Figure 3.4: Firm-level separations by type of transition



(a) Quarterly layoff rate

(b) Quarterly quit rate

Notes: These graphs plot (a) the mean quarterly layoff rate and (b) the mean quarterly quit rate observed at firms filing for bankruptcy. Layoffs are defined as separations followed by registration with public employment services within one month and/or UI payments. Quits are defined as separations followed by an employment spell in another firm starting within one month, without UI payment or prior registration with public employment services. A reference quarter is taken 5 years prior to the bankruptcy filing date, and 95% confidence intervals are displayed alongside each curve.

pattern of falling profits and employment displayed in Figure 3.2. Consistent with firms laying off workers because of their falling profit rate, the share of displaced workers registering with public employment services under the "economic layoff" category peaks at 80% within the quarter following the bankruptcy filing date (see Figure C.1 in appendix).

Figure 3.4b displays the rate at which workers leave bankrupt firms in order to work for another employer. Contrary to layoffs, these job-to-job moves start to increase only one year prior to the actual filing date. The fact that job-to-job transitions appear to lag the increase in layoffs at the firm-level may indicate that workers (i) use their firm's layoff policy as a signal to form expectations on their firm's survival probability, (ii) use this information to intensify their job search effort and (iii) that it takes workers of distressed firms a relatively long amount of time to find an alternative healthy firm.

These observations relate to Pfann and Hamermesh (2008)'s two-sided learning model. As firms downsize, they collect information on their employees' loyalty, while workers learn

about their probability of being laid off. Contrary to their findings, Figure 3.4 suggests that workers learn from their employers' layoff policy and adapt their search behavior accordingly.

Note however that an important constraint placed upon any strategic reaction — on workers' side at least — is the inherently frictional nature of the labor market. As outlined in figure 3.4 by the difference in the timing of quits and layoffs in bankrupt firms, even if workers can increase their job search effort to avoid displacement, job finding itself will inevitably respond with a considerable lag.

3.5 The nature and timing of worker-firm separations: an empirical exploration.

We bring these predictions to the data and test which worker-level characteristics affect the timing and nature of separations in our set of bankrupt firms. To do this we first regress an early departure dummy equal to one for workers separating from a bankrupt firm before the bankruptcy filing. In order to distinguish the relative influence on the timing of worker/firm separations of firms' layoff strategies on the one hand and workers' quit strategies on the other hand, we break up the early departure dummy into an "early quit" dummy and an "early layoff" one. We regress these three separation outcomes on a set of worker-level observable characteristics including sex, a dummy for full-time work, a dummy for worker eligibility to severance payments in case of dismissal[11], and the logs of age, tenure and hourly wage. Columns (1), (3) and (5) of Table 3.3 show that: (i) high-tenure workers tend to leave at a later date than their low-tenure co-workers and that this effect comes from a lower probability to be laid off prior to bankruptcy, (ii) there is no apparent gender pattern in firms' and workers' separation strategies, (iii) controlling for tenure, older workers are more

[11] Worker eligibility criteria to severance payments in case of dismissal changed during our sample period. Between 2002 and 2008, workers had to have at least two years of tenure in the firm to be eligible to a severance payment. In 2008 this tenure threshold was lowered to 1 year. In our definition of eligibility we use eligibility criteria at the time of a worker's departure from its bankrupt firm.

likely to be fired early on, but less likely to quit, so that the overall effect on the timing of separations is not statistically different from zero, (iv) workers protected by firing costs are less likely to be fired early on and hence separate later, (v) high-wage workers are more likely to quit but less likely to be laid off prior to the bankruptcy filing so that the net effect of wages on the overall timing of separation is not statistically different from zero.

Table 3.3: The timing and nature of worker-firm separations

	(1) Early departure	(2) Early departure	(3) Layoff	(4) Layoff	(5) Quit	(6) Quit
Full time	-0.00925	-0.0160	0.00849	-0.0135	-0.0177	-0.00250
	(0.0116)	(0.0123)	(0.0133)	(0.0142)	(0.0122)	(0.0131)
Male	0.0111	-0.000102	0.0124	0.00881	-0.00129	-0.00892
	(0.00849)	(0.00907)	(0.0118)	(0.0128)	(0.00995)	(0.0112)
log(tenure)	-0.0152	-0.0222	-0.0143	-0.0228	-0.000860	0.000544
	(0.00478)	(0.00545)	(0.00603)	(0.00775)	(0.00591)	(0.00745)
log(age)	-0.0153	-0.0854	0.0656	0.00319	-0.0809	-0.0886
	(0.0137)	(0.0243)	(0.0167)	(0.0300)	(0.0158)	(0.0267)
Eligible to sev. pay.	-0.0435	-0.0509	-0.0473	-0.0628	0.00384	0.0120
	(0.0150)	(0.0171)	(0.0180)	(0.0209)	(0.0177)	(0.0206)
log(hourly wage)	0.00879		-0.105		0.114	
	(0.0136)		(0.0146)		(0.0139)	
$\hat{\epsilon}_{i,t}$		-0.0321		-0.184		0.151
		(0.0204)		(0.0223)		(0.0220)
$\hat{\alpha}_i$		0.0693		-0.0145		0.0839
		(0.0246)		(0.0275)		(0.0302)
$\hat{\beta}' X_{i,t}$		0.301		0.191		0.109
		(0.0930)		(0.121)		(0.103)
Obs	9109	7788	9109	7788	9109	7788
F	10.44	10.62	14.20	13.78	15.35	9.772
Mean	0.387	0.381	0.180	0.177	0.208	0.204
Adjusted R2	0.738	0.738	0.360	0.365	0.465	0.460

Notes: This table reports the results of six different OLS regressions. Models (1) and (2) take an early departure dummy (worker departing prior to the bankruptcy filling) as the dependent variable. Models (3) and (4) replace the early departure dummy by an early layoff one and models (5) and (6) by an early quit dummy. All models control for year, 2-digits occupations and origin firm fixed effects whose coefficients are not reported. Standard errors are clustered at the origin firm level and are reported in parentheses.

Whereas nothing warrants a causal interpretation of these estimates, they appear to be broadly consistent with the predictions of our model of worker-firm separations. While actual worker tenure is an equilibrium outcome depending on all the parameters of our

model, it is strongly dependent on match specific trend productivity μ which was predicted to increase match duration, both for layoffs and quits. The influence of the match specific trend in productivity should also be seen to operate through wages. However, the fact that high wage workers tend to quit more suggests that other wage components such as workers' idiosyncratic productivity may be at work in determining the nature of worker-firm separations. To understand which components of wages are driving the effects on quits and layoffs displayed in Table 3.3 we break down log hourly wages into a worker specific component reflecting workers' idiosyncratic productivity α and a residual term incorporating any potential match specific component of wages.

To do so we recover worker and firm fixed effects from a first step estimation of an AKM type log-wage equation (Abowd et al., 1999).[12] We run this first step on the full linked employer-employee panel underlying our analysis, including workers and firms who were never associated to a bankruptcy event. We follow standard practice in estimating a log-wage equation with worker and firm fixed effects:

$$\log(w_{i,t}) = \gamma + \beta X_{i,t} + \alpha_i + \psi_{j(i,t)} + \epsilon_{i,t} \tag{3.4}$$

where $w_{i,t}$ is worker i's wage at period t, $X_{i,t}$ contains all time-varying controls including workers' age and tenure, year fixed effects as well as workers' 2-digit occupation, α_i is a worker fixed effect and $\psi_{j(i,t)}$ is the firm fixed effect associated with worker i's employer j at time t.

We take each worker's estimated wage premium $\hat{\alpha}_i$ as an empirical proxy for workers' idiosyncratic productivity component α and use estimated residuals $\hat{\epsilon}_{i,t}$ as measure of potential match effects.[13]

[12] Because not all the workers of our main sample are in the AKM connected set, we are able to construct log-wage person effects for only 40.8% of our sample.

[13] Under a match effect model the error term of equation 3.4 hides a match specific component potentially correlated to other independent variables as well as an error term. We use this imperfect and indirect approach to measure match specific components of wages because estimating a true match specific model would further reduce the sample due to the stronger identification requirements.

The results of this decomposition exercise are presented in columns (2), (4) and (6) of Table 3.3. Confirming the effect found on tenure, the match component of wages now appears to be positively related to match duration (although not significantly so). Consistent with the main predictions of our model, workers characterized by a high idiosyncratic component of wages tend to leave earlier and self-select into the "quit" regime. These findings are consistent with Lengermann and Vilhuber (2002), who observe a right shift in the quality distribution of departing workers. Our results suggest that this right shift is driven by high-type quits rather than layoffs.

3.6 Should I stay or should I go: Outgoing workers' worsened labor market outcomes

An obvious limitation of our bare-bones models of worker-firm separations is the absence of any form of dependence between the timing of separations and outgoing workers' outcomes. The pattern of quits analyzed in the preceding section supports the idea that workers who *can* leave *do* leave before their firm's final closure. Given the sizable earnings losses incurred by displaced workers, it is possible that part of the self-selection of workers into an early-quit strategy can be attributed to deteriorating labor market outcomes as one gets closer to the bankruptcy filing date. In other words, the timing of quits itself could play an important role in shaping job-to-job movers' labor market outcomes through (i) a firm selection channel and/or (ii) a bargaining channel (departing workers settling for lower earnings at a given firm). The first selection channel would arise if workers departing from distressed firms aim at lower paying firms than they otherwise would. The second bargaining channel would matter if potential employers were able to exploit incoming workers' deteriorating prospects at their origin firm to lower their recruitment wage. This would happen in any model involving wages set through bilateral Nash bargaining as in Mortensen and Pissarides (1994).

To test this hypothesis we look at the influence of late departures on job-to-job movers' outcomes. As there is no ex-ante definition of what a "late departure" actually is, we use the change in bankrupt firms' layoff policy occurring two years prior to the actual filing date as our cut-off date. Table 3.4 below presents the results of different specifications (in rows) regressing job-to-job movers' outcomes (in columns) on a later departure dummy — where "late departure" is defined as job-to-job moves occurring less than two years prior to or anytime after the firm's bankruptcy filing date. Our control group comprises all workers that leave a bankrupt firm two years or more before the firm's bankruptcy filing date.

Dependent variables are (1) the variation of log-daily earnings between each job-to-job mover's destination and origin firms, (2) the variation of log-hourly wages, (3) the variation of estimated firm wage premia estimated from 3.4, (4) the variation of the log of hours per day, (5) the variation in log-hours per day firm specific premia, and dummies for (6) part time work and (7) change of occupation.

Table 3.4: Late departure and earning losses

	Daily earnings	Wage rate		Hours worked			Occupation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Δ log(daily earnings)	Δ log(hourly wage)	$\Delta\psi_{w}$	Δ log(hours per day)	$\Delta\psi_{hours/day}$	Part time	Change of occupation
OLS	-0.0805	0.00879	0.00859	-0.00910	0.00433	0.0336	-0.00992
	(0.0201)	(0.00851)	(0.00483)	(0.0187)	(0.00728)	(0.00833)	(0.0102)
OLS + Controls	-0.0640	0.00456	0.00571	-0.0735	0.00399	0.0319	0.00160
	(0.0199)	(0.00812)	(0.00450)	(0.0186)	(0.00733)	(0.00871)	(0.0116)
Matching	-0.0447	0.00970	0.00348	-0.0564	0.00396	0.0313	-0.00599
	(0.0196)	(0.00812)	(0.00451)	(0.0184)	(0.00671)	(0.00850)	(0.00997)
Obs	8829	8819	7752	8818	7608	8855	8676
Mean	0.0260	-0.0338	0.0209	0.0612	0.0235	0.196	0.306

Notes: This table reports the results of different specifications (in rows) regressing a late-departure dummy on different worker level outcomes in columns (see main text for details on the construction of the treatment dummy). While the first row reports the results of a series of simple OLS regressions, the second row adds detailed individual controls. Finally the third row uses nearest neighbor matching to control for selection on worker's observable characteristics. Standard errors in parenthesis are clustered at the origin firm level.

The first row of Table 3.4 reports raw OLS estimates using the late departure dummy as the independent variable. These raw estimates show that late movers incur substantial earnings losses. These earnings losses, however, are entirely driven by pressured workers moving to low-hours jobs (columns 4 and 5) rather than low-paying jobs (column 2) or firms (column 3). Running an AKM regression similar in every respect to 3.4 but taking the log of daily hours as dependent variable, we test whether the observed variation in log-hours per

day can be attributed to workers transitioning to firms offering lower hours on average. The result of this exercise reported in column (5) shows that this is apparently not the case, so that workers under the threat of a bankruptcy filing appear to settle for lower hours without changing their target destination firm. Looking at the proportion of workers accepting part-time contracts in column (6) confirms the negative result on hours worked. Finally, column (7) shows that workers do not appear to switch occupation more frequently when confronted with an increased risk of economic layoffs.

The fact that a deterioration in workers' perceived outside options leads to lower earnings through a drop in hours worked but no reduction in bargained wages is in itself of general interest. Indeed, this result is consistent with the study of Jäger et al. (2020) who finds that wages are insensitive to variations in workers' value of non-employment; as well as with Marinescu and Skandalis (2021)'s finding that exhaustion of UI benefits coincides with a drop in earnings which is mainly driven by a drop in hours worked (69%).

These OLS estimates obviously suffer from the self-selection of workers into a departure date. We try to partly account for this selection by (i) controlling for quantiles of worker-level observed characteristics used in Table 3.3, and (ii) using nearest neighbor matching on the same set of covariates. These two estimates reported in the second and third rows of Table 3.4 confirm that workers who would incur potential earnings losses when transitioning to another employer self-select into the late-departure category. Yet the matching estimator preserves half of the originally estimated drop in daily earnings, pointing toward a negative effect of late-departure on match quality.

3.7 Do firing costs really matter?

We conclude this analysis of separations in distressed firms by asking whether or not the positive influence of firing costs on eligible workers' match duration and their negative influence on non-eligible workers' layoff probability is likely to capture a causal impact of firing

costs on firms' downsizing process. As suggestive as they may be, the results displayed in Table 3.3 do not entirely settle the matter.

To this end, we exploit a change in eligibility criteria for minimum severance payments, which occurred in France on the 27th of June, 2008. The reform lowered the eligibility threshold from 2 years to 1 year of tenure. We use this change to isolate the effect of firing costs on firms' layoff policy using two distinct but complementary identifying strategies.

First, we use a difference-in-differences using the change in eligibility criteria between 2007 and 2008 as our treatment of interest and two cross-sections of workers employed under an indefinite duration contract on the 27th of June in 2007 or 27th of June 2008 as our reference population. More specifically we take workers with between 0 and 1 year of tenure and employed as of the 27th of June 2007 or 2008 as our control group, and workers with between 1 and 2 years of tenure employed as of the 27th of June 2007 or 2008 as our treated group.[14] This first strategy has the advantage of exploiting the full $[1, 2]$ years of tenure range for which an eligibility change occurred in 2008 as our treatment variation.

Table 3.5 below reports the results of this difference-in-differences specification where $D = \mathbb{1}(\text{tenure} \in [1, 2])$ is a treatment dummy and $T = \mathbb{1}(\text{year} = 2008)$ a treatment year one. We use an unemployment indicator as our dependent variable — where "unemployment" is defined in the same manner as in section 3.3.3 (i.e. an employment spell ending within one month and immediately followed by a registration with public employment services and/or unemployment insurance payments within the year.[15]

The raw difference-in-differences estimate reported in column (1) of Table 3.5 points to a 31% decrease in unemployment hazard associated with the change in treatment status of relatively more tenured employees in 2008. Adding worker-level controls in column (2) as well as firm fixed effects in column (3) does change the order of magnitude of the estimate. To test

[14] Tenure is only defined for individuals with non-missing firm entry date. What's more, this entry date comes in a "year plus share of year" format We recover the starting day of each worker's association with his current firm as $(\text{entry} - \lfloor \text{entry} \rfloor) * 365$.

[15] It may arise that separated workers receive unemployment insurance but do not appear as registered with public employment services. This case may result in measurement error in our dependent variable but is quantitatively rare.

Table 3.5: Layoff risk and firings costs: DID estimate

	(1)	(2)	(3)	(4)
T	0.00442	0.00432	0.00604	0.00429
	(0.000400)	(0.000420)	(0.000567)	(0.000419)
D	-0.00311	-0.00289	-0.00115	-0.00286
	(0.000341)	(0.000343)	(0.000455)	(0.000343)
T × D	-0.00296	-0.00278	-0.00240	-0.00275
	(0.000525)	(0.000527)	(0.000775)	(0.000526)
T × D × B				-0.00986
				(0.00957)
Constant	0.00935	0.00925	0.00630	0.00917
	(0.000256)	(0.000265)	(0.000277)	(0.000264)
Obs	524229	524226	428117	524226
F	138.6	120.1	66.59	54.45
Mean	0.00947	0.00947	0.00816	0.00947
Adjusted R2	0.000874	0.00200	0.0434	0.00210
Controls		✓	✓	✓
Firm FE			✓	

Notes: This table reports the results of a DID design where $T = (year = 2008)$ is the time variable and $D = (Tenure > 1year)$ is the treatment assignment variable. The dependent variable is a dummy for unemployment status within one-month. The sample is constructed taking workers employed under an indefinite duration contract on the 27th of june 2007 and 2008 and who had between 0 and 2 years of tenure. While column (1) presents the raw OLS estimate, columns (2) adds individual level controls (quantiles of age and wage, sex and 2-digit occupations) and (3) further adds firm fixed effects. Finally column (4) fully adds a full set of interactions with B a bankruptcy variable equal to one if the worker is employed by a firm filing for bankruptcy prior to 2008

whether bankrupt firms are more sensitive to firing costs than healthy ones, we fully interact our DID setup with a dummy variable equal to one for firms filing for bankruptcy in 2008. Consistent with our model of worker/firm separations, the coefficient on the triple interaction reported in column (4) points to a stronger impact, although imprecisely estimated, of firing costs on distressed firms' layoff policies.

A first drawback of the difference-in-differences approach, however, is that the parallel trends assumption will fail as soon as the unemployment hazard rate-tenure profile exhibits some degree of cyclicality. Another drawback of this approach is that as our bankruptcy records data start in 2008 and not in 2007 we are unable to assess whether bankrupt firms react to firing costs in a specific manner when compared to other firms.

With these caveats in mind, we next turn to a regression-discontinuity design exploiting the 1 year of tenure threshold for workers who were employed on the day in which the change in eligibility criteria took effect. Compared to the difference-in-differences strategy, the regression-discontinuity estimate is immune to violations of the parallel trends assumption but estimates the causal effect of firing costs only in a neighborhood of the 1 year of tenure threshold. Figure C.2 plots the density of the running variable (tenure in years) around the threshold. While large discontinuities exist away from the threshold because of increased seasonal hires in January, this should not impact our estimate which we recover from a locally linear polynomial approximation following the bandwidth selection method proposed by Calonico et al. (2014).

Table 3.6: Layoff risk and firing costs: RD estimate

	(1) All	(2) Healthy firm	(3) Bankrupt firm	(4) Placebo
A - Without controls				
RD at 1 year of tenure	-0.00494	-0.00485	-0.00696	0.000792
	(0.00203)	(0.00201)	(0.0229)	(0.00146)
Obs	261249	258325	2924	264029
B - With individual controls				
RD at 1 year of tenure	-0.00468	-0.00460	-0.00686	0.00133
	(0.00200)	(0.00197)	(0.0229)	(0.00143)
Obs	260723	257804	2919	263506

Notes: This table reports regression discontinuity estimates at the one-year of tenure threshold taking a one-month layoff dummy as the dependent variable. We select the sample of individuals employed in indefinite duration contracts on the 27th of june 2008 using a 2 years window around the threshold (0 to 2 years of tenure). We use a locally linear polynomial approximation and the two-sided optimal bandwith selection proposed by Calonico et al. (2014). While panel A presents raw RD estimates, panel B adds individual level controls (wage and age quantiles, sex and occupation). Column (1) reports the overall estimate, columns (2) and (3) break this estimate between firms without any bankruptcy filing in 2008 and firms which filed for bankruptcy in 2008, column (4) presents an overall placebo estimate using a sample of workers 1 year prior to the change in eligibility rights. Standard errors in parenthesis.

In the first panel of Table 3.6 column (1) reports our baseline RD estimate on the full sample of workers who were observed as working in an indefinite-duration contract on the date of the eligibility change. This point estimate confirms the negative effect of firing costs on unemployment risk and is larger in magnitude than the DID one. The different magnitudes

of the effect estimated through the RD and DID designs are not surprising insofar as the RD and DID estimands (i) do not use the same treatment variation (workers with 2 years of tenure exhibit a greater jump in firing costs) and (ii) the underlying treatment effects may be heterogeneous along the tenure dimension.

Columns (2) and (3) of Table 3.6 repeat the RD exercise but split the original sample of workers between workers working in a firm without any bankruptcy event and workers employed at a firm within one year of a bankruptcy filing event. While the point estimate in the bankruptcy sub-sample remains large and negative, indicating that firing cost may indeed affect the downsizing process of bankrupt firms, the small sample size does not allow us to detect a potential heterogeneous effect. Finally, column (4) presents a placebo test by running the same RD regression on the full sample of workers who were employed one year prior to the reform's date. Indeed, one might worry that the one-year tenure threshold may coincide with other institutional or behavioral discontinuities affecting firms' layoff policies. Reassuringly, this placebo RD estimate is not significant at any meaningful confidence level and is in absolute value an order of magnitude below our baseline RD estimate. Panel B presents the exact same specifications but adds individual-level controls. As shown in panel B of Table 3.6, these results are robust to adding a set of individual-level controls (wage, sex, occupation, age).

The fact that firing costs' appear to influence firms' layoff choices confirms that the non-causal estimate of Table 3.3 (which amounted to a 10% decrease in layoff risk for workers protected by severance payment eligibility) may be a first order issue when considering the downsizing process of distressed firms. Indeed, the amount of firing costs paid by firms to displaced workers is mandated by law and is strongly related to (i) tenure and (ii) past wages. As already noted, this dependence introduces a potentially sub-optimal correlation between firms' firing incentives and worker types. In our data, the correlation coefficient between estimated worker types and severance payments is mildly positive at 0.06, suggesting that

firing costs may entice firms to fire valuable workers, further jeopardizing their survival probability.

3.8 Conclusion

Using linked employer-employee data matched to unemployment records as well as bankruptcy filings from France, we document that distressed firms' layoffs change markedly two years prior to the actual bankruptcy filing and are followed one year later by a surge in job-to-job moves from departing employees. We show that micro-level patterns are consistent with a simple model of worker/firm separations. Both the data and the model are consistent with productive workers quitting their distressed firm early on and unproductive workers being fired by the firm in an attempt to restore profitability. On top of these heterogeneous patterns, we find that firing costs impact distressed firms' downsizing strategy by preventing the layoff of unproductive workers. What's more, the causal interpretation of this conclusion is supported by the analysis of a change in severance payment eligibility rights which occurred in France in 2008.

Appendix A

Appendix to Chapter 1

A.1 Additional figures

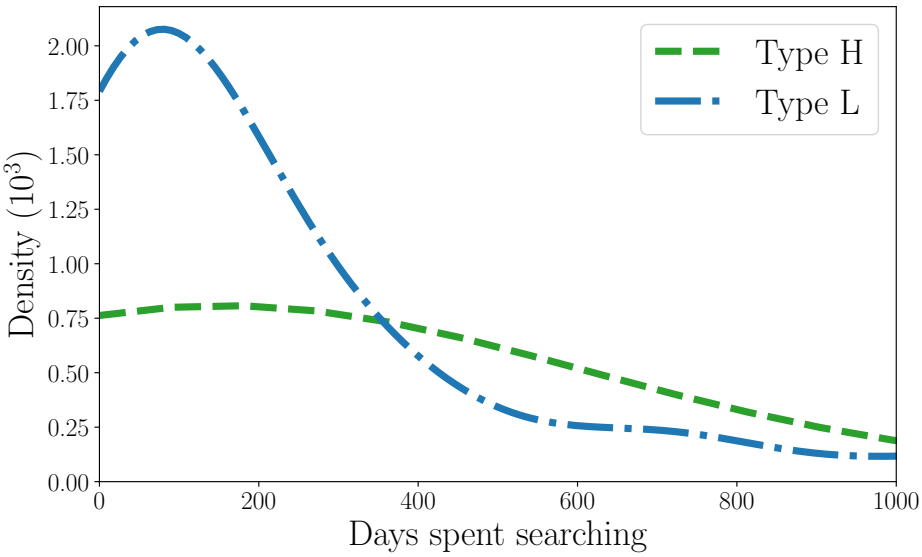


Figure A.1: Density of unemployment duration by type

Note: The two groups of unemployed workers are created by splitting the sample of unemployed workers in the SCE-JS based on their residual wage in their last job. This wage is residualized on education, age, age squared and gender. H-types and L-types are respectively the unemployed workers with a residualized wage above and below the median. The outcome variable is the density of answers to the question: "How many days have you spent looking for a job?".

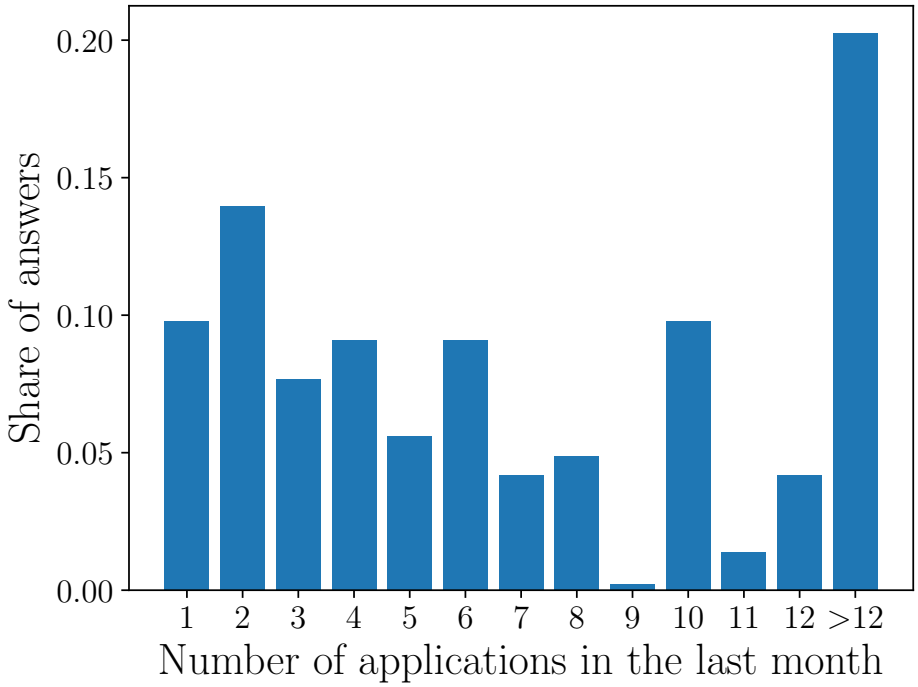


Figure A.2: Number of applications sent by unemployed workers over the past month

Note: This question is asked in the SCE-JS data.

A.2 Proofs

A.2.1 Proof of Proposition 1

The incentive compatibility constraint IC1 defines the lowest incentive compatible wage $\underline{w}^H$ implicitly as the wage which satisfies

$$\psi(q^H(\underline{w}^H, z_t))W^L(\underline{w}^H, z_t) + \Big(1 - \psi(q^H(\underline{w}^H, z_t))\Big)S^L_{a^L-1}(z_t) = S^L_{a^L}(z_t)$$

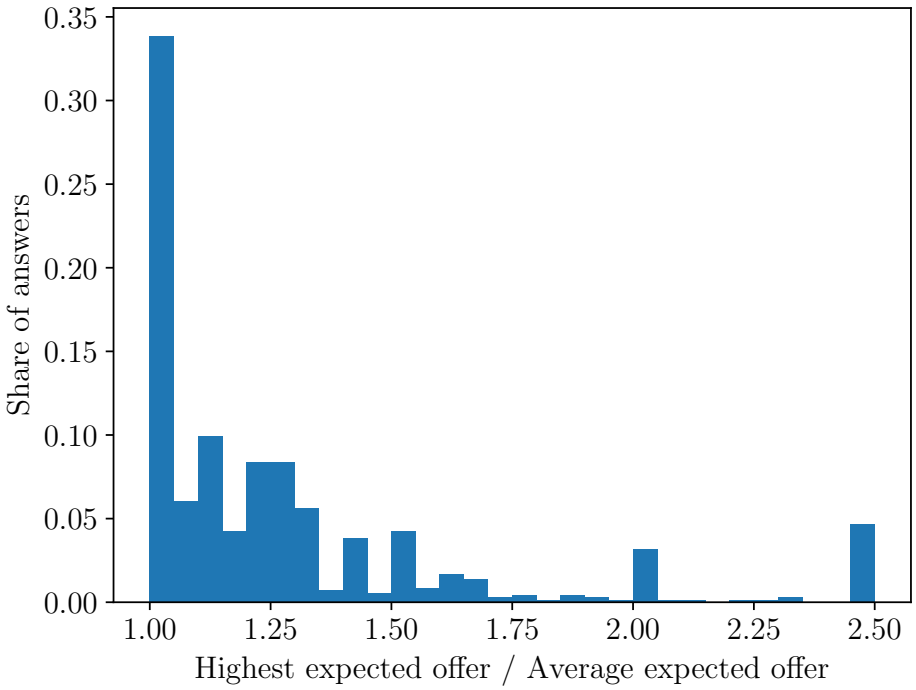


Figure A.3: Dispersion of expected offers

Note: This measure is constructed from two questions asked in the SCE-JS data, which correspond to the numerator and denominator of this index.

Differentiating this equation with respect to $\underline{w}^H$, b^L and τ yields (I drop the arguments z_t for clarity)

$$\frac{d\underline{w}^H}{db^L} = \frac{1}{\frac{\partial\left[\psi(q^H(\underline{w}^H,z_t))W^L(\underline{w}^H,z_t)+\left(1-\psi(q^H(\underline{w}^H,z_t))\right)S^L_{a^L-1}(z_t)\right]}{\partial \underline{w}^H}}\left[\left(\frac{\partial S^L_{a^L}}{\partial b^L}+\frac{\partial S^L_{a^L}}{\partial \tau}\frac{d\tau}{db^L}\right)\right.$$
$$-\left(\frac{\partial\left[\psi(q^H(\underline{w}^H))W^L(\underline{w}^H)+\left(1-\psi(q^H(\underline{w}^H))\right)S^L_{a^L-1}\right]}{\partial b^L}\right.$$
$$\left.\left.+\frac{\partial\left[\psi(q^H(\underline{w}^H))W^L(\underline{w}^H)+\left(1-\psi(q^H(\underline{w}^H))\right)S^L_{a^L-1}\right]}{\partial \tau}\frac{d\tau}{db^L}\right)\right]$$

The denominator,

$$\frac{\partial\left[\psi(q^H(\underline{w}^H,z_t))W^L(\underline{w}^H,z_t)+\left(1-\psi(q^H(\underline{w}^H,z_t))\right)S^L_{a^L-1}(z_t)\right]}{\partial \underline{w}^H}$$

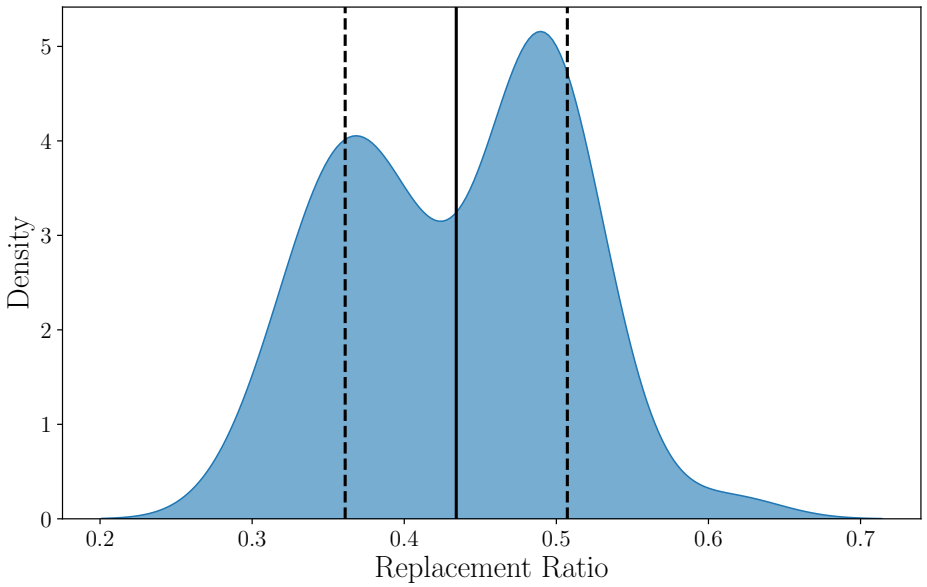


Figure A.4: Density of replacement ratios across states

Note: The replacement ratio for each state is measured as the average ratio of weekly benefits over wages. This measure is provided by the Department of Labor's report on the UI system and is measured in the first quarter of 2024. The solid black line represents the mean, and the two dashed black lines show the values that are one standard deviation away from the mean.

is negative, by definition of the lowest incentive compatible contract. A contract that offers a slightly higher wage than $\underline{w}^H$ provides a lower level of utility to workers of type L than their outside option $S^L_{a^L}(z_t)$, and thus a lower level of utility than contract $\underline{w}^H$. This is what makes the contracts with higher wages than $\underline{w}^H$ incentive compatible.

The numerator is the difference between the welfare gains from a higher level of insurance for the application portfolios $(w^L_1, ..., w^L_{a^L-1}, w^L_{a^L})$ and $(w^L_1, ..., w^L_{a^L-1}, \underline{w}^H)$. The first portfolio is the one chosen by workers of type L in equilibrium, when they apply to a^L jobs simultaneously. The second portfolio is the same one, except that the last application is sent to the lowest incentive compatible market. By definition, these two portfolios provide the same utility to workers of type L. However, the second portfolio bears more unemployment risk than the first one, which it offsets by providing a higher excepted wage. Hence, the

welfare gains from a marginal increase in unemployment insurance are higher for the riskier portfolio, $(w_1^L, ..., w_{a^L-1}^L, \underline{w}^H)$. Therefore, the numerator is negative, and

$$\frac{d\underline{w}^H}{db^L} > 0$$

This result means that, as the unemployment benefit for workers of type L, b^L, increases, the incentive compatibility constraint IC1 tightens, i.e. the set of incentive compatible wages shrinkens.

It follows that the set on incentive compatible queues shrinkens as well, given that the lowest incentive compatible queue length is defined by

$$\underline{q}^H = q^H(\underline{w}^H, z_t) \tag{A.1}$$

where $q^H(w, z_t)$ is increasing in w. Indeed, this function represents the isoprofit curve along which firms post contracts that satisfy the free-entry condition. As such, any increase in the posted wage needs to be compensated for by an longer queue for firms expected profits to remain equal to zero. Therefore,

$$\frac{d\underline{q}^H}{db^L} = \frac{\partial \underline{q}^H}{\partial b^L}\frac{d\underline{w}^H}{db^L} > 0$$

A.2.2 Model with aggregate risk

Productivity

I introduce aggregate shocks by assuming that the common component of labor productivity, z_t, is indexed by t and follows an AR(1) process

$$z_t = \rho_z z_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma_z)$$

where ρ_z is the persistence parameter of this process and σ_z is its volatility.

In period t, a job filled with a low-productivity worker produces z_t, while a job filled with a high-productivity worker produces $z_t(1+\xi)$, $\xi > 0$.

Contracts

A contract ϕ_t, which promises utility x in period t, is state-contingent and specifies the wages $\{w_{t+j}\}_{j=0}^{\infty}$ that the worker would obtain in any period $t+j$ and any aggregate state of the world ω_{t+j} Ω if the match survives idiosyncratic separation shocks. These contracts can be expressed recursively as $\phi = \{w, x'(\omega')\}$, that is a contract that specifies the current wage and the state-contingent promised utility for next period. I assume that these recursive contracts are written at the production phase of each period.

Firms

In terms of notations, I use tilde capital letters for the value functions that are expressed in terms of promised utility rather than wages. The expected payoff for a firm posting a vacancy, in period t, that promises utility x is

$$\widetilde{V}_t(x) = \mu(q_t(x)) \left[\gamma_t(x)\widetilde{J}_t^L(x) + (1-\gamma_t(x))\widetilde{J}_t^H(x)\right] - \kappa$$

where the value of a job filled with a worker of type $i \in \{H, L\}$, conditional on the aggregate state indexed by t and the utility x promised to the worker, is

$$\begin{aligned} \widetilde{J}_t^i(x) = \max_{\phi=\{w,\boldsymbol{x'(\omega')}\}} \quad & z_t\Big(1+\xi\mathbb{1}[i=H]\Big) - w_t + \beta(1-\delta)\mathbb{E}_t\left[\widetilde{J}_{t+1}^i\left(x'(\omega_{t+1})\right)\right] \\ \text{s.t.} \quad & \widetilde{W}_t^i(\phi) \geq x \end{aligned}$$

Each active firm rewrites its contract at the production stage of every period. It chooses its worker's current wage, w_t, and a state-contingent promised utility for the next period, $\boldsymbol{x'(\omega')}$, conditional on utility x promised in the previous period, to maximize its expected profits. $\boldsymbol{x'(z')}$ is a vector of promised utility for each possible value of ω_{t+1}.

Workers

The lifetime utility of a worker of type $i \in \{H, L\}$ employed with a contract ϕ is

$$\widetilde{W}_t^i(\phi) = v\Big((1-\tau)w_t\Big) + \beta \mathbb{E}_t \Big[\delta U_{t+1}^i + (1-\delta)x'(\omega_{t+1})\Big]$$

The lifetime utility of an unemployed worker of type $i \in \{H, L\}$ is

$$U_t^i = v(b^i + b_0^i) + \beta \mathbb{E}_t \left[\max_a \Big\{S_t^i(a) - c(a)\Big\}\right]$$

where the value of a portfolio of a applications, $S_t^i(a)$, is defined in a similar way than in the steady state case, that is

$$S_t^i(a) = \max_{\boldsymbol{x} \in \mathcal{X}_t^a} \quad \Bigg[\sum_{k=1}^{a} \underbrace{\Bigg(\prod_{j=k+1}^{a} \Big[1 - \psi(q_t(x_j))\Big]\Bigg)\psi(q_t(x_k))}_{\Pr\left[i\text{-th lowest app = first success}\right]} x_k \; + \; \underbrace{\prod_{j=1}^{a} \Big[1 - \psi(q_t(x_j))\Big]}_{\Pr\left[\text{no job offer}\right]} U_t^i\Bigg]$$

The recursive formulation of workers' application problem is

$$S_t^i(k) = \max_{x \in \mathcal{X}_t} \quad \psi(q_t(x))x + \Big[1 - \psi(q_t(x))\Big] S_t^i(k-1)$$

for every $k \in \{1, ..., a_t^i\}$, and where $S_t^i(0) = U_t^i$.

A.2.3 Optimal contracts under two-sided commitment

I assume that workers and firms can commit not separate until the match is exogenously destroyed. A job with contract ϕ, that promises utility x to its worker in period t, satisfies the constraint

$$\widetilde{W}_t^i(\phi) = x$$

Firms choose the lowest wage satisfying the promise-keeping constraint in order to maximize their current profits, which explains why this constraint is binding. Then, one can express the primsed utility x as

$$x = v\Big((1-\tau)w_t\Big) + \beta\mathbb{E}_t\Big[\delta U^i_{t+1} + (1-\delta)x'(\omega_{t+1})\Big]$$

which gives an expression for the wage

$$w_t = \frac{1}{1-\tau}v^{-1}\left(x - \beta\mathbb{E}_t\Big[\delta U^i_{t+1} + (1-\delta)x'(\omega_{t+1})\Big]\right)$$

I use this equation to substitute for w_t in the Bellman equation that defines the present discounted value of profits generated by a job that employs a worker of type i, such that it becomes a maximization over a single variable

$$\begin{aligned}\widetilde{J}^i_t(x) = \max_{\boldsymbol{x'(\omega')}} \quad & z_t\Big(1+\xi\mathbb{1}[i=H]\Big) - \frac{1}{1-\tau}v^{-1}\left(x - \beta\mathbb{E}_t\Big[\delta U^i_{t+1} + (1-\delta)x'(\omega_{t+1})\Big]\right) \\ & + \beta(1-\delta)\mathbb{E}_t\left[\widetilde{J}^i_{t+1}\left(x'(\omega_{t+1})\right)\right]\end{aligned}$$

There are as many first order conditions to this maximization problem as possible states of the world. The FOC with respect to $x'(\omega')$, i.e. the utility promised for one particular state ω', is

$$\begin{aligned}\frac{1}{1-\tau}(v^{-1})'\left(x - \beta\mathbb{E}_t\Big[\delta U^i_{t+1} + (1-\delta)x'(z_{t+1})\Big]\right)\beta(1-\delta)\mathbb{P}\mathrm{r}[\omega'|\omega] & \\ + \beta(1-\delta)\mathbb{P}\mathrm{r}[\omega'|\omega]\frac{\partial\widetilde{J}^i_{t+1}\left(x'(\omega')\right)}{\partial x'(\omega')} = 0 &\end{aligned}$$

i.e.

$$\frac{1}{1-\tau}(v^{-1})'\left(x - \beta\mathbb{E}_t\Big[\delta U^i_{t+1} + (1-\delta)x'(z_{t+1})\Big]\right) + \frac{\partial\widetilde{J}^i_{t+1}\left(x'(\omega')\right)}{\partial x'(\omega')} = 0$$

Using the envelope theorem, we get

$$\frac{\partial \widetilde{J}_t^i(x)}{\partial x} = -\frac{1}{1-\tau}(v^{-1})'\left(x - \beta \mathbb{E}_t\left[\delta U_{t+1}^i + (1-\delta)x'(\omega_{t+1})\right]\right)$$

Combining this condition at $t+1$ and for $x = x'(\omega')$ with the FOC yields

$$v'\left((1-\tau)w_t\right) = v'\left((1-\tau)w_{t+1}(\omega_{t+1})\right)$$

for any $\omega_{t+1} \in \Omega$, and where $w_{t+1}(\omega_{t+1})$ is the wage in period $t+1$ if the state is ω_{t+1}.

Hence, the promised wage is a constant wage if $v(.)$ is strictly concave. Under full-commitment on both sides (employer and employee), firms optimally post contracts that offer a constant wage. Intuitively, firms are risk-neutral while workers are risk-averse, which gives the former an incentive to post a contract that offers a relatively low average wage but a perfect insurance against aggregate shocks that occur during the period of activity of the match.

A.2.4 Block Recursive Equilibrium

Hence, we can rewrite the value functions in terms of the wage w associated with each contract instead of promised utility x. I will use capital letters without tildes to denote these value functions, that is $\widetilde{V}_t(w) := \widetilde{V}_t(x)$, $J_t^i(w) := \widetilde{J}_t^i(x)$, $W_t^i(w) := \widetilde{W}_t^i(x)$, and

$$S_t^i(k) = \max_{w \in \mathcal{W}_t} \quad \psi(q_t(w))W_t^i(w) + \Big[1 - \psi(q_t(w))\Big]S_t^i(k-1)$$

for every $k \in \{1, ..., a_t^i\}$, and where $S_t^i(0) = U_t^i$.

The corresponding FOC, for $k \in \{1, ..., a_t^i\}$, is

$$\psi'(q_t(w))q_t'(w)\Big[W_t^i(w) - S_t^i(k-1)] + \psi(q_t(w))\frac{\partial W_t^i(w)}{\partial w} = 0 \tag{A.2}$$

If the equilibrium is separating, i.e. if $\gamma(w) \in \{0, 1\}$, an entrant firm that targets low-productivity workers chooses a wage to post w by solving

$$\max_{w} \quad \mu(q_t(w))J_t^L(w) - \kappa$$

The corresponding FOC is

$$\mu'(q_t(w))q_t'(w)J\left(w, z\right) + \mu(q_t(w))\frac{\partial J_t^L(w)}{\partial w} = 0 \tag{A.3}$$

Following the market utility approach (Wright et al., 2021), I assume that firms expect queues to satisfy (A.2) for any wage they could post on markets that attract low-productivity workers, such that we can combine the two conditions to obtain

$$\frac{\mu'(q_t(w))\psi(q_t(w))\frac{\partial W_t^L(w)}{\partial w}J_t^L(w)}{\psi'(q_t(w))\Big[W_t^L(w) - S_t^L(k-1)]} = \mu(q_t(w))\frac{\partial J_t^L(w)}{\partial w} \tag{A.4}$$

Note that, given a value of unemployment U_t^L and a stochastic process for z_t, one can solve for $J_t^L(w)$ and $W_t^L(w)$ for any wage w. Indeed, $J_t^L(w)$ is a function of the aggregate state only through the productivity z_t, and $W_t^L(w)$ is a function of the aggregate state only through the value of unemployment.

Then, the free entry condition pins down the equilibrium queue $q_t(w)$ for any w,

$$\mu(q_t(w))J_t^L(w) = \kappa \tag{A.5}$$

Hence, conditional on a value of unemployment U_t^L and a stochastic process for z_t, one can solve for posted wages and associated queues by combining (A.5) and (A.4) starting from $k = 1$ up to any number of applications A. This process also determines the value functions $W_t^L(w)$, $J_t^L(w)$ and $S_t^L(k)$, $k \in \{1, ..., A\}$.

The optimal number of applications sent by low-productivity workers a_t^L is determined by

$$a_t^L = \arg\max_a \ \{S_t^L(a) - c(a)\}$$

This shows that one can solve for equilibrium wages and value functions for low-productivity markets without any other reference to the aggregate state than the aggregate productivity z_t and the value of unemployment U_t^L.

In order to solve for the same outcomes for high-productivity markets, one needs first solve for the unconstrained outcomes using exactly the same equations than for low-productivity workers, but with a productivity which is now $z_t(1+\xi)$ and a value of unemployment U_t^H. This yields a set of wages $(\widehat{w}_{1,t}^H, ..., \widehat{w}_{A,t}^H)$, queues $(\widehat{q}_{1,t}^H, ..., \widehat{q}_{A,t}^H)$, and portfolio values $(\widehat{S}_{1,t}^H, ..., \widehat{S}_{A,t}^H)$ that would be the equilibrium outcome for high-productivity workers if firms were perfectly informed about their applicants.

To construct the constrained equilibrium with asymmetric information, I use the equilibrium values of $S_t^L(a^L)$ and $S_t^L(a^L-1)$ to check whether the lowest wage posted in H-type markets under perfect information, $\widehat{w}_{1,t}^H$, and its associated queue $\widehat{q}_{1,t}^H$, satisfy the incentive compatibility constraints (IC1) and (IC2). If they do, these constraints are not binding and the equilibrium is the same as the one under perfect information.

However, if $(\widehat{w}_{1,t}^H, \widehat{q}_{1,t}^H)$ violates incentive compatibility constraints, the first equilibrium wage posted on H-type markets is the lowest one that satisfies both incentive compatibility constraints and free entry on this market. The wage-queue combination needs to be on the isoprofit curve defined by the free entry condition

$$\mu(q_t(w))J_t^H(w) = \kappa \tag{A.6}$$

The first incentive compatibility constraint, (IC1), can be represented as the wage-queue combinations that satisfy the following equation

$$\psi(q_t(w))W_t^L(w) + [1 - \psi(q_t(w))]S_t^L(a^L - 1) = S_t^L(a^L) \tag{A.7}$$

The second incentive compatibility constraint is represented similarly as the wage-queue pairs that satisfy

$$\psi(q_t(w))W_t^L(w) + [1 - \psi(q_t(w))]S_t^L(a^L) - [c(a^L + 1) - c(a^L)] = S_t^L(a^L) \tag{A.8}$$

Each of these two curves intersect with the isoprofit curve defined by (A.6) at on the interval of wages $(\widehat{w}_{1,t}^H, \infty)$ exactly once. As firms choose the lowest incentive compatible wage, they choose the highest of the two wages corresponding to these intersections as the equilibrium wage posted to attract the first application of high-productivity workers, $w_{1,t}^H$, and its associated queue (defined by the intersection point) $q_{1,t}^H$.

This new market for H-type workers' first application determines a new value $S_t^H(1)$ for a portfolio of one application. One needs to recompute the unconstrained wages for high-productivity markets for $k \in \{2, ..., A\}$, i.e. $(\widehat{w}_{2,t}^H, ..., \widehat{w}_{A,t}^H)$, as well as their associated queues $(\widehat{q}_{2,t}^H, ..., \widehat{q}_{A,t}^H)$. Then, it is possible to check whether $(\widehat{w}_{2,t}^H, \widehat{q}_{2,t}^H)$ is incentive compatible. If it is, H-type markets are characterized by wages $(w_{1,t}^H, \widehat{w}_{2,t}^H, ..., \widehat{w}_{A,t}^H)$ and queues $(q_{1,t}^H, \widehat{q}_{2,t}^H, ..., \widehat{q}_{A,t}^H)$. If it is not incentive compatible, the same process starts again to find the equilibrium wage and queues for the second H-type application, using the intersection of the free entry condition with incentive compatibility constraints (IC1) and (IC2).

This is how the separating equilibrium is constructed. Importantly, these equilibrum outcomes are found withtout any other reference to the aggregate state than through the aggregate productivity z_t and values of unemployment U_t^L and U_t^H. In particular, the distribution of workers across employment states and wages is not needed. This crucial element

proves the block recursivity of this equilibrium. I solve for U_t^L and U_t^H through value function iteration in an outer loop.

A.2.5 Tightening of IC1 as the number of applications increases

The first incentive compatibility constraint is

$$\psi(q)W^L(w, z_t) + [1 - \psi(q)]S^L_{a^L-1}(z_t) \leq S^L_{a^L}(z_t)$$

Need to show that the set of $(w, q) \in \mathbb{R}^2$ satisfying this constraint for $a^L + 1$ applications is a subset of the $(w, q) \in \mathbb{R}^2$ that satisfy the constraint for a^L applications.

Regardless of the number of applications, contracts posted in markets targeting high-type workers need to satisfy the zero-profit condition, such that q can be expressed as a function of w, i.e. $q^H(w, z_t)$. Hence, the constraint for a^L applications, can be rewrittent as

$$\psi(q^H(w, z_t))W^L(w, z_t) + [1 - \psi(q^H(w, z_t))]S^L_{a^L-1}(z_t) \leq S^L_{a^L}(z_t)$$

Function $q^H(w, z_t)$ is continuous and strictly increasing in w. Intuitively, a firm posting a contract with a high wage needs to be compensated with a long queue, i.e. a high job-filling rate, to reach the same level of expected profits.

Then, it is enough to prove that the lowest wage satisfying IC1 when workers of type L send a^L applications, denoted $\underline{w}(a^L)$, and implicitly defined by

$$\psi(q^H(\underline{w}(a^L), z_t))W^L(\underline{w}(a^L), z_t) + [1 - \psi(q^H(\underline{w}(a^L), z_t))]S^L_{a^L-1}(z_t) = S^L_{a^L}(z_t) \tag{A.9}$$

is lower than the lowest wage satisfying IC1 when workers of type L send a^L+1 applications, denoted $\underline{w}(a^L+1)$, and implicitly defined by

$$\psi\Big(q^H(\underline{w}(a^L+1),z_t)\Big)W^L\Big(\underline{w}(a^L+1),z_t\Big)+\Big[1-\psi\Big(q^H(\underline{w}(a^L+1),z_t)\Big)\Big]\,S^L_{a^L}(z_t)=S^L_{a^L+1}(z_t) \tag{A.10}$$

An indifference curve in the (w,q) space for the k-th lowest application, $k\geq 1$, sent by a worker of type L is

$$\psi(q)W^L(w,z_t)+[1-\psi(q)]S^L_{k-1}(z_t)=S^L_k(z_t)$$

The slope of this curve can be determined by differentiating this equation with respect to q and w, i.e.

$$\psi'(q)W^L(w,z_t)dq+\psi(q)\frac{\partial W^L(w,z_t)}{\partial w}dw-\psi'(q)S^L_{k-1}(z_t)dq=0$$

or

$$\frac{dq}{dw}=\frac{\psi(q)\frac{\partial W^L(w,z_t)}{\partial w}}{\psi'(q)\Big(S^L_{k-1}(z_t)-W^L(w,z_t)\Big)}$$

When $W^L(w,z_t)>S^L_{k-1}(z_t)$, which is always the case when w is a potential target for an additional application and $S^L_{k-1}(z_t)$ is its fallback option (can prove that from the fact that the cost of an extra application is strictly positive), $dq/dw>0$ along the indifference curve, and this slope is increasing in $S^L_{k-1}(z_t)$.

Consequently, two consecutive indifference curves, C(k) and C(k+1), corresponding to applications k and $k+1$, defined by the pairs of $(w,q)\in\mathbb{R}^2$ such that

$$\psi(q)W^L(w,z_t)+[1-\psi(q)]S^L_{k-1}(z_t)=S^L_k(z_t) \tag{C(k)}$$

and

$$\psi(q)W^L(w, z_t) + [1 - \psi(q)]S_k^L(z_t) = S_{k+1}^L(z_t) \qquad \text{(C(k+1))}$$

intersect only once in the (w, q) space, because $S_{k-1}^L(z_t) \neq S_k^L(z_t)$. Let $(w_{k,k+1}, q_{k,k+1})$ denote the wage and queue length that correspond to this intersection. Let q_0^k and q_0^{k+1} denote the images of a given wage w_0 on indifference curves C(k) and C(k+1), that is the queue lengths which satisfy the last two equations for wage w_0. Since $S_{k-1}^L(z_t) < S_k^L(z_t)$ for every $k \geq 1$, $q_0^k > q_0^{k+1}$ if $w_0 < w_{k,k+1}$, and $q_0^k < q_0^{k+1}$ if $w_0 > w_{k,k+1}$.

As mentioned above, both indifference curves have a positive slope in the (w, q) space, i.e. are such that dq/dw along the curves. Moreover, this slope is steeper for C(k+1) than for C(k). We also know that C(k+1) goes through the point (w_{k+1}^L, q_{k+1}^L), which denotes the optimal combination of wage and queue length that workers target with their $k+1$-th application. Similarly, the indifference curve C(k) goes through the point (w_k^L, q_k^L). These pairs are equilibrium outcomes, located on firms' isoprofit curve for L-type workers. Queue lengths are increasing with wages along this isoprofit curve, which implies that $q_{k+1}^L > q_k^L$ because $w_{k+1}^L > w_k^L$. Hence, C(k) is increasing at a lower rate than C(k+1) and goes through a point, (w_k^L, q_k^L), that is to the south-west of (w_{k+1}^L, q_{k+1}^L), which belongs to C(k+1). These properties imply that the unique wage $w_{k,k+1}$ at which C(k) and C(k+1) intersect necessarily belongs to the interval (w_k^L, w_{k+1}^L).

Let $f_k : \mathbb{R} \to \mathbb{R}$ denote the function that associates to every wage w a queue length q such that $(w, q) \in C(k)$, i.e. such that the point (w, q) belongs to the indifference curve $C(k)$. It follows from the above analysis that, for any wage w in the interval (w_{k+1}^L, ∞), $f_{k+1}(w) > f_k(w)$.

The two wages we are interested in, $\underline{w}(a^L)$ and $\underline{w}(a^L + 1)$, belong respectively to indifference curves C(a^L) and C($a^L + 1$). From the *lemons condition*, we know that both wages are higher than any wage that would be offered on a L-type market, in particular $w_{a^L+1}^L$.

Thus, both wages are strictly greater than the wage at which $C(a^L)$ and $C(a^L+1)$ intersect. It follows that $\underline{w}(a^L)$ and $\underline{w}(a^L+1)$ belong to the interval of wages $(w^L_{a^L+1}, \infty)$ such that $f_{a^L+1}(w) > f_{a^L}(w)$ for any w in that interval.

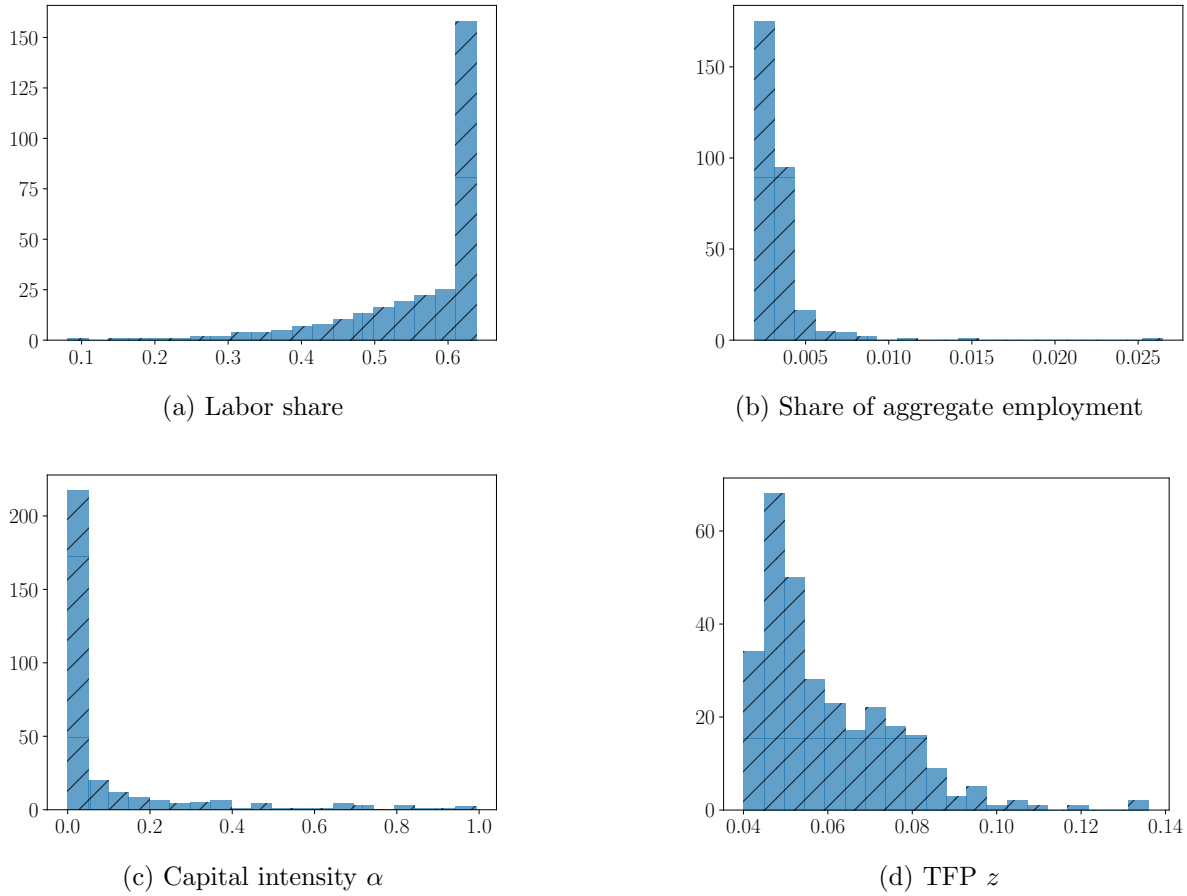
Let $g^H : \mathbb{R} \to \mathbb{R}$ denote the function that associates to every wage w a queue length q such that $(w,q) \in IP - H$, i.e. such that the point (w,q) belongs to the isoprofit curve for H-type markets. g^L is increasing in w.

Wages $\underline{w}(a^L)$ and $\underline{w}(a^L+1)$ are respectively the intersections of functions $f_{a^L}(w)$ and $f_{a^L+1}(w)$ with $g^H(w)$ on the interval $(w^L_{a^L+1}, \infty)$. As f_{a^L+1} lies strictly above f_{a^L} on this interval, a strictly increasing function like $g^H(w)$ necessarily intersects with f_{a^L} at a lower wage than with $f_{a^L+1}(w)$. Therefore, $\underline{w}(a^L) < \underline{w}(a^L+1)$.

Appendix B

Appendix to Chapter 2

B.1 Additional figures



(a) Labor share

(b) Share of aggregate employment

(c) Capital intensity α

(d) TFP z

Figure B.1: Firm distribution

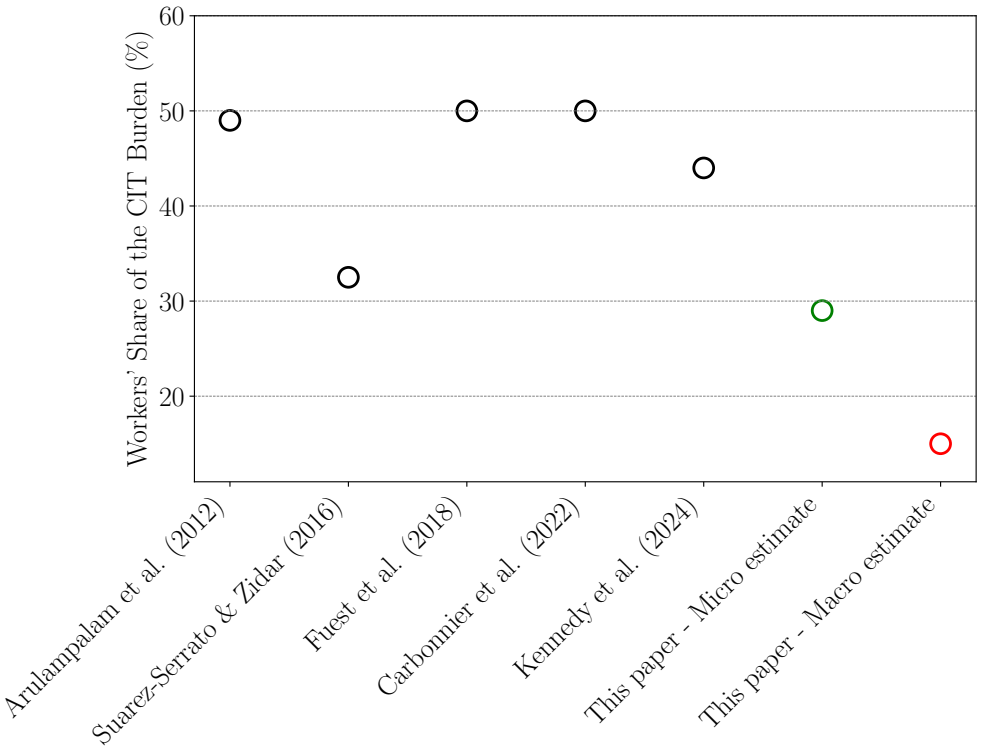


Figure B.2: Comparison to the recent literature

B.2 Data

I use French administrative data provided by the Public Finance Administration (DGFiP) and the National Institute of Statistics and Economic Studies (Insee). The three main datasets are employee and firm data called DADS, FARE and BIC-RN.

The DADS (*Déclarations Annuelles des Données Sociales*) dataset gathers social security reports provided to the French administration by every firm operating in France. It provides information at the contract level on gross and net wage earnings, hours worked, type of contract, age, gender. Each contract is assigned an employee identifier as well as a firm identifier. The latter remains constant across years, which gives a panel dimension at the firm level. This firm identifier is the same across datasets, which gives the possibility to match the DADS dataset with FARE data. I use DADS data for all worker-related variables, typically employment, wages, and skills.

FARE gathers firm-level balance sheet data based on their tax and social security reports. It covers all firms in France except financial and agricultural industries. It is an unbalanced panel on the 2009-2019 sample period. I use FARE data for the majority of firm-related variables that have no direct link with employment and wages, for example value added and sales.

Finally, I use BIC-RN (*Bénéfices industriels et commerciaux - Régime normal*) data for tax related variables. BIC-RN provides all information present on firms' tax returns. It notably provides firms' tax bases, or taxable corporate income, which is very useful to determine firms' marginal and average tax rates, as well as predicted changes in these two outcomes.

B.2.1 Sample selection

As is common in the literature, I drop firms that have less than five employees. I also drop the few firms that end up with a negative labor share because they have a negative value

added or a negative wage bill in the data. As described above, using firms that are present in these datasets implies to restrict the sample to the corporate sector. All firms in the final dataset are taxed under the "normal regime", which means that their are subject to the corporate income tax. This is an equivalent of C-corporations in the US. Moreover, the final dataset excludes financial and agricultural industries.

B.2.2 Marginal tax rates

I build a tax function that I apply to firms' reported income, and which includes multiple rules and reforms on top of the standard rate ("taux normal"): the reduced rate for small firms ("taux réduit"), the "contribution sociale sur les bénéfices", the "contributions exceptionnelles", the sequential 2017 reform. See Bach et al. (2019) for more details. These features yield a tax schedule and a thus a marginal tax rate for any reported income.

This tax function allows me to create the instrument used in the empirical design, which relies on a predicted marginal tax rate corresponding to the mechanical effect of a tax reform. This predicted tax rate is computed by plugging the previous years' reported income in the current tax function.

B.2.3 Employment and wage variables

Employment and wage data are taken from the DADS dataset. This data report before-tax income, hours worked, contract type, and many other information for each contract a firm has with an employee. An observation in this data is a contract in a given year. Workers can have multiple contracts in the same year, typically if they have multiple jobs. I drop observations that report negative hours worked, negative days worked, or negative wages.

I compute firms' wage bill as the sum of gross income reported in each of their contracts. Firms' employment is the sum of days worked in each of their contracts, divided by 360, which is the maximum number of days worked for a contract. Firms' average wage in a given year is then simply their wage bill divided by their employment.

B.2.4 Summary statistics

Table B.1: Summary statistics

Variable	Mean	Std. Dev.	Median
Value added	2,649.4	47,334.5	597.6
CIT bill	106.3	3,681.9	3.6
Total assets	14,975.4	631,976.2	1,280.3
EBE	713.1	21,687.0	78.2
Wage bill	1,371.0	21,653.8	358.2
Sales	10,035.4	184,147.3	1,587.8
Employment	38.9	670.2	11.0
Investment (intangible)	118.8	18,655.7	0.0
Investment (tangible)	414.6	20,130.0	14.1
Reported income	589.9	25.9	73.8

Note: All values, except for Employment, are expressed in thousands of 2015 euros.

B.3 Omitted proofs

Derivation of (2.10)

$$\begin{aligned}\frac{\epsilon_{\boldsymbol{w_t},1-\tau}}{\gamma} &= \sum_j l_j \epsilon^j_{w,1-\tau} \\ &= N\mathbb{E}\left[l_j \epsilon^j_{w,1-\tau}\right] \\ &= \mathbb{E}\left[\epsilon^j_{w,1-\tau}\right] + N\mathbb{C}\mathbb{O}\mathbb{V}\left(l_j, \epsilon^j_{w,1-\tau}\right)\end{aligned}$$

Sufficient conditions for Lemma 2

Multiply both sides of equation 2.15 by l_j, and sum over firms j to obtain

$$\epsilon_{\boldsymbol{w}_t,1-\tau} = -\frac{[1-\sigma(1-\xi)]\sum_j l_j \Lambda_r(s^j_{l,0})}{1-\sum_j l_j \Lambda_w(s^j_{l,0})}\epsilon_{u_t,1-\tau}$$

The numerator is positive, which means that we need to prove that

$$1 - \sum_j l_j \Lambda_w(s^j_{l,0}) > 0$$

i.e.

$$\gamma + \sigma + \frac{1-\sigma(1-\xi)}{1-\xi}\frac{1+\gamma}{\gamma}\frac{s^j_{l,t}}{\xi} > 1$$

Straightforward sufficient conditions this inequality to hold are that $\gamma \geq 1$ and $\sigma > 0$, given that the third term of the left-hand side is weakly positive. This is the case in all the cases considered in this paper. □

B.4 Model - Details

B.4.1 Capital owner

The representative capital owner chooses, in each period t, her consumption of each good c_{jt} and next period capital K_{t+1} to maximize

$$V_k = \max_{\{c_{jt}, K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \ln(C^K_t) \quad , \quad C^K_t = \int_0^N c^K_{jt} dj \tag{B.1}$$

$$\text{s.t. } C^K_t + [K_{t+1} - (1-\delta)K_t] + \phi\left(K_t, K_{t+1}\right) = r_t K_t$$

The first order conditions of the problem are

$$\frac{\beta^t}{C^K_t} = \xi_t$$

$$\xi_t \left[1 + \phi_2\left(K_t, K_{t+1}\right)\right] = \left[r_{t+1} + (1-\delta) - \phi_1\left(K_{t+1}, K_{t+2}\right)\right] \xi_{t+1}$$

Combining these two equations yields the Euler equation:

$$\frac{C_{t+1}^K}{\beta C_t^K} = \frac{r_{t+1} + (1-\delta) - \phi_1\left(K_{t+1}, K_{t+2}\right)}{1 + \phi_2\left(K_t, K_{t+1}\right)} \tag{B.2}$$

I assume that $\phi(K, K') = \psi \frac{(K' - (1-\delta)K)^2}{2K}$. Then, in steady state:

$$1 = \beta \frac{r^* + (1-\delta) + \frac{\psi}{2}}{1 + \psi\left(1 - (1-\delta)\right)} \implies r^* = \frac{1 + \psi\delta}{\beta} - (1-\delta) - \frac{\psi}{2}$$

B.4.2 Firm problem

Firms choose a vector of inputs (k, l) and a wage w to maximize

$$\begin{aligned} \max_{k,l,w} \quad & z f(k,l,\alpha) - lw - uk \\ \text{s.t.} \quad & f(k,l,\alpha) = \left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha) l^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}} \\ & l(w) = \frac{w^\gamma}{\boldsymbol{w}} \end{aligned}$$

or

$$\max_{k,w} \quad z\left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(w^\gamma \boldsymbol{w}^{-1})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}} - w^{1+\gamma}\boldsymbol{w}^{-1} - uk$$

The FOC's are

$$\begin{aligned} (k) \quad & z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha) l^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1} \alpha k^{-\frac{1}{\sigma}} = u \\ (w) \quad & z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(w^\gamma \boldsymbol{w}^{-1})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1} (1-\alpha)\boldsymbol{w}^{-\frac{\sigma-1}{\sigma}} \gamma w^{\gamma\frac{\sigma-1}{\sigma}-1} = (1+\gamma) w^\gamma \boldsymbol{w}^{-1} \end{aligned}$$

Rearranging the second equation yields

$$(w) \quad z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(\boldsymbol{w}^{-1} w^\gamma)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1} (1-\alpha)\boldsymbol{w}^{\frac{1}{\sigma}} \frac{\gamma}{1+\gamma} w^{-\frac{\gamma+\sigma}{\sigma}} = 1$$

Dividing (k) by (w) gives

$$\frac{\alpha}{1-\alpha}\frac{k^{-\frac{1}{\sigma}}}{\boldsymbol{w}^{\frac{1}{\sigma}}w^{-\frac{\gamma+\sigma}{\sigma}}}=\frac{\gamma}{1+\gamma}u$$

i.e.

$$k^{\frac{\sigma-1}{\sigma}}=\left(\frac{\gamma}{1+\gamma}u\frac{1-\alpha}{\alpha}\right)^{1-\sigma}\boldsymbol{w}^{-\frac{\sigma-1}{\sigma}}w^{\frac{(\gamma+\sigma)(\sigma-1)}{\sigma}}$$

B.4.3 Wage bill

We can take our FOC (w)

$$z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}}+(1-\alpha)(\boldsymbol{w}^{-1}w^{\gamma})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1}(1-\alpha)\boldsymbol{w}^{\frac{1}{\sigma}}\frac{\gamma}{1+\gamma}w^{-\frac{\gamma+\sigma}{\sigma}}=1$$

and use our previous result to substitute for k

$$
\begin{aligned}
& z\xi\left(\alpha\left(\frac{\gamma}{1+\gamma}u\frac{1-\alpha}{\alpha}\right)^{1-\sigma}\boldsymbol{w}^{-\frac{\sigma-1}{\sigma}}w^{\frac{(\gamma+\sigma)(\sigma-1)}{\sigma}}+(1-\alpha)(\boldsymbol{w}^{-1}w^{\gamma})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1} \\
& (1-\alpha)\boldsymbol{w}^{\frac{1}{\sigma}}\frac{\gamma}{1+\gamma}w^{-\frac{\gamma+\sigma}{\sigma}}=1 \\
\Longrightarrow\quad & z\xi\left(\alpha^{\sigma}\left(\frac{\gamma}{1+\gamma}\frac{u}{w}(1-\alpha)\right)^{1-\sigma}+(1-\alpha)\right)^{\frac{\sigma\xi}{\sigma-1}-1}(1-\alpha)\boldsymbol{w}^{1-\xi}\frac{\gamma}{1+\gamma}w^{-[1+\gamma(1-\xi)]}=1 \\
\Longrightarrow\quad & z\xi\left(\alpha^{\sigma}u^{1-\sigma}+(1-\alpha)^{\sigma}\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)^{\frac{\sigma\xi}{\sigma-1}-1}\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma(1-\xi)} \\
& (1-\alpha)^{\sigma(1-\xi)}\boldsymbol{w}^{1-\xi}\frac{\gamma}{1+\gamma}w^{-[1+\gamma(1-\xi)]}=1 \\
\Longrightarrow\quad & z\xi\left(\alpha^{\sigma}u^{1-\sigma}+(1-\alpha)^{\sigma}\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)^{-\frac{1-\sigma(1-\xi)}{1-\sigma}} \\
& (1-\alpha)^{\sigma(1-\xi)}\left(\frac{\gamma}{1+\gamma}\right)^{\sigma(1-\xi)}\boldsymbol{w}^{(1-\xi)}w^{-(\gamma+\sigma)(1-\xi)}=1 \\
\Longrightarrow\quad & (z\xi)^{\frac{1}{1-\xi}}\left(\alpha^{\sigma}u^{1-\sigma}+(1-\alpha)^{\sigma}\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)^{-\frac{1-\sigma(1-\xi)}{(1-\sigma)(1-\xi)}} \\
& (1-\alpha)^{\sigma}w^{(1-\sigma)}\left(\frac{\gamma}{1+\gamma}\right)^{\sigma}=\boldsymbol{w}^{-1}w^{1+\gamma}=wl
\end{aligned}
$$

B.4.4 Output

Back to the FOCs:

$$
\begin{aligned}
(k)\quad & z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}}+(1-\alpha)l^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1}\alpha k^{-\frac{1}{\sigma}}=u \\
(w)\quad & z\xi\left(\alpha k^{\frac{\sigma-1}{\sigma}}+(1-\alpha)(\boldsymbol{w}^{-1}w^{\gamma})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}-1}(1-\alpha)\boldsymbol{w}^{\frac{1}{\sigma}}\frac{\gamma}{1+\gamma}w^{-\frac{\gamma+\sigma}{\sigma}}=1
\end{aligned}
$$

Dividing (k) by (l) gives

$$k^{\frac{\sigma-1}{\sigma}} = \left(\frac{\gamma}{1+\gamma}u\frac{1-\alpha}{\alpha}\right)^{1-\sigma} \boldsymbol{w}^{-\frac{\sigma-1}{\sigma}} w^{\frac{(\gamma+\sigma)(\sigma-1)}{\sigma}}$$

Let's rewrite the FOCs as

$$\begin{aligned}
(k) \quad & z^{\frac{\sigma-1}{\sigma\xi}}\xi y^{\frac{1-\sigma(1-\xi)}{\sigma\xi}}\alpha k^{-\frac{1}{\sigma}} = u \\
(w) \quad & z^{\frac{\sigma-1}{\sigma\xi}}\xi y^{\frac{1-\sigma(1-\xi)}{\sigma\xi}}(1-\alpha)\boldsymbol{w}^{\frac{1}{\sigma}}\frac{\gamma}{1+\gamma}w^{-\frac{\gamma+\sigma}{\sigma}} = 1
\end{aligned}$$

or

$$\begin{aligned}
(k) \quad & z^{\frac{\sigma-1}{\sigma\xi}}\left(\frac{\xi\alpha}{u}\right)^{\sigma-1} y^{\frac{(1-\sigma(1-\xi))(\sigma-1)}{\sigma\xi}} = k^{\frac{\sigma-1}{\sigma}} \\
(w) \quad & z^{\frac{(\sigma-1)^2}{\sigma\xi}}\left(\frac{\xi(1-\alpha)}{w}\frac{\gamma}{1+\gamma}\right)^{\sigma-1} y^{\frac{(1-\sigma(1-\xi))(\sigma-1)}{\sigma\xi}} = (\boldsymbol{w}^{-1}w^{\gamma})^{\frac{\sigma-1}{\sigma}}
\end{aligned}$$

where I used $f = y/z$.

We can use this to substitute for k and l in the production function:

$$\begin{aligned}
& y = z\left(\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)l^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma\xi}{\sigma-1}} \\
\implies \quad & y = z^{\frac{1}{(1-\xi)}}\xi^{\frac{\xi}{1-\xi}}\left(\alpha^{\sigma}u^{1-\sigma} + (1-\alpha)^{\sigma}\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)^{\frac{\xi}{(\sigma-1)(1-\xi)}}
\end{aligned}$$

or simply rearranging (w),

$$y = \left(\frac{1+\gamma}{\gamma\xi(1-\alpha)}\right)^{\frac{\sigma\xi}{1-\sigma(1-\xi)}} z^{-\frac{\sigma-1}{1-\sigma(1-\xi)}}\boldsymbol{w}^{-\frac{\xi}{1-\sigma(1-\xi)}} w^{\frac{(\gamma+\sigma)\xi}{1-\sigma(1-\xi)}}$$

and when $\xi = 1$,

$$y = \left(\frac{1+\gamma}{\gamma(1-\alpha)}\right)^{\sigma} z^{1-\sigma} \boldsymbol{w}^{-1} w^{\gamma+\sigma}$$

B.4.5 Labor share

We can easily compute a firm's labor share, s_l, with our last results:

$$\begin{aligned}
s_l &= \frac{wl}{y} \\
&= \frac{(z\xi)^{\frac{1}{1-\xi}} \left(\alpha^{\sigma} u^{1-\sigma} + (1-\alpha)^{\sigma} \left(\frac{1+\gamma}{\gamma} w\right)^{1-\sigma}\right)^{-\frac{1-\sigma(1-\xi)}{(1-\sigma)(1-\xi)}} (1-\alpha)^{\sigma} w^{(1-\sigma)} \left(\frac{\gamma}{1+\gamma}\right)^{\sigma}}{z^{\frac{1}{(1-\xi)}} \xi^{\frac{\xi}{1-\xi}} \left(\alpha^{\sigma} u^{1-\sigma} + (1-\alpha)^{\sigma} \left(\frac{1+\gamma}{\gamma} w\right)^{1-\sigma}\right)^{\frac{\xi}{(\sigma-1)(1-\xi)}}} \\
&= \xi \frac{(1-\alpha)^{\sigma} w^{1-\sigma} \left(\frac{\gamma}{1+\gamma}\right)^{\sigma}}{\alpha^{\sigma} u^{1-\sigma} + (1-\alpha)^{\sigma} \left(\frac{1+\gamma}{\gamma} w\right)^{1-\sigma}} \\
&= \xi \frac{\gamma}{1+\gamma} \frac{(1-\alpha)^{\sigma} \left(\frac{1+\gamma}{\gamma} w\right)^{1-\sigma}}{\alpha^{\sigma} u^{1-\sigma} + (1-\alpha)^{\sigma} \left(\frac{1+\gamma}{\gamma} w\right)^{1-\sigma}}
\end{aligned}$$

B.4.6 Capital share

From the FOC:

$$k = \left(\frac{\gamma}{1+\gamma} \frac{u}{w} \frac{1-\alpha}{\alpha}\right)^{-\sigma} \boldsymbol{w}^{-1} w^{\gamma}$$

Thus, the firm-level capital share is

$$\begin{aligned}
s_k &= \frac{rk}{y} \\
&= \left(\frac{\gamma}{1+\gamma}\frac{u}{w}\frac{1-\alpha}{\alpha}\right)^{-\sigma} r\frac{l}{y} \\
&= \left(\frac{\gamma}{1+\gamma}\frac{u}{w}\frac{1-\alpha}{\alpha}\right)^{-\sigma} \frac{r}{w}s_l \\
&= \left(\frac{\gamma}{1+\gamma}\frac{u}{w}\frac{1-\alpha}{\alpha}\right)^{-\sigma} \frac{r}{w}\xi\frac{\gamma}{1+\gamma}\frac{(1-\alpha)^\sigma\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}}{\alpha^\sigma u^{1-\sigma}+(1-\alpha)^\sigma\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}} \\
&= \frac{1-\tau}{1-\lambda\tau}\xi\frac{\alpha^\sigma u^{1-\sigma}}{\alpha^\sigma u^{1-\sigma}+(1-\alpha)^\sigma\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}} \\
&= \frac{1-\tau}{1-\lambda\tau}\left(\xi-\frac{1+\gamma}{\gamma}s_l\right)
\end{aligned}$$

B.4.7 Labor income elasticity

$$wl = (z\xi)^{\frac{1}{1-\xi}}\left(\alpha^\sigma u^{1-\sigma}+(1-\alpha)^\sigma\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)^{-\frac{1-\sigma(1-\xi)}{(1-\sigma)(1-\xi)}}(1-\alpha)^\sigma w^{(1-\sigma)}\left(\frac{\gamma}{1+\gamma}\right)^\sigma$$

$$\begin{aligned}
d\ln(wl) &= -\frac{1-\sigma(1-\xi)}{(1-\sigma)(1-\xi)}d\ln\left(\alpha^\sigma u^{1-\sigma}+(1-\alpha)^\sigma\left(\frac{1+\gamma}{\gamma}w\right)^{1-\sigma}\right)+(1-\sigma)d\ln(w) \\
&= -\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)d\ln u \\
&\quad +\left[(1-\sigma)-\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right]d\ln w
\end{aligned}$$

Using

$$\begin{aligned}
wl = \boldsymbol{w}^{-1}w^{1+\gamma} &\implies d\ln(wl) = -d\ln(\boldsymbol{w})+(1+\gamma)d\ln(w) \\
&\implies d\ln(w) = \frac{1}{1+\gamma}[d\ln(wl)+d\ln(\boldsymbol{w})]
\end{aligned}$$

we can express the log change in wage bill as

$$d\ln(wl) = -\frac{\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{1-\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}}d\ln u - \frac{\left[\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}\right]}{1-\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}}d\ln \boldsymbol{w}$$

The elasticity of labor income with respect to the net-of-tax rate is

$$\begin{aligned}\epsilon_{wl,1-\tau} &= \frac{d\ln(wl)}{d\ln(1-\tau)} \\ &= -\frac{[1-\sigma(1-\xi)]\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{1-\xi-\frac{(1-\xi)(1-\sigma)}{1+\gamma}+[1-\sigma(1-\xi)]\frac{s_l}{\gamma\xi}}\frac{d\ln u}{d\ln(1-\tau)} \\ &\quad + \frac{\left[\frac{(1-\xi)(1-\sigma)}{1+\gamma}-[1-\sigma(1-\xi)]\frac{s_l}{\gamma\xi}\right]}{1-\xi-\frac{(1-\xi)(1-\sigma)}{1+\gamma}+[1-\sigma(1-\xi)]\frac{s_l}{\gamma\xi}}\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}\end{aligned}$$

If $\xi = 1$,

$$\epsilon_{wl,1-\tau} = -\frac{\gamma-(1+\gamma)s_l}{s_l}\frac{d\ln u}{d\ln(1-\tau)} - \frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}$$

In partial equilibrium, i.e. $dr = d\boldsymbol{w} = 0$,

$$\epsilon^{PE}_{wl,1-\tau} = \frac{\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{1-\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}}\frac{1-\lambda}{1-\lambda\tau} > 0$$

If $\xi = 1$,

$$\epsilon^{PE}_{wl,1-\tau} = -(1+\gamma)\frac{\frac{\gamma}{1+\gamma}-s_l}{s_l}\frac{1-\lambda}{(1-\tau)^2}r$$

The indirect effect is summarized by the following elasticity:

$$\begin{aligned}\epsilon^{GE}_{wl,1-\tau} &= \epsilon_{wl,1-\tau} - \epsilon^{PE}_{wl,1-\tau} \\ &= -\frac{\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{1-\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}}\frac{1-\lambda\tau}{1-\tau}\frac{d\ln r}{d\ln(1-\tau)} + \frac{\left[\frac{1-\sigma}{1+\gamma}-\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}\right]}{1-\frac{1-\sigma}{1+\gamma}+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{s_l}{\gamma\xi}}\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}\end{aligned}$$

B.4.8 Wage elasticity

From our previous results,

$$\begin{aligned}d\ln(wl) = &-\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)d\ln u \\ &+\left[(1-\sigma)-\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right]d\ln w\end{aligned}$$

Using

$$wl = \frac{w^{1+\gamma}}{\boldsymbol{w}} \implies d\ln(wl) = (1+\gamma)d\ln(w) - d\ln \boldsymbol{w}$$

then,

$$\begin{aligned}d\ln w &= \frac{-\frac{1-\sigma(1-\xi)}{(1-\xi)}\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)d\ln u + d\ln \boldsymbol{w}}{\gamma+\sigma+\frac{1-\sigma(1-\xi)}{(1-\xi)}\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}} \\ &= \frac{-[1-\sigma(1-\xi)]\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)d\ln u + (1-\xi)d\ln \boldsymbol{w}}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\end{aligned}$$

and,

$$\epsilon_{w,1-\tau} = \underbrace{-\frac{[1-\sigma(1-\xi)]\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}}_{<0}\frac{d\ln u}{d\ln(1-\tau)} + \underbrace{\frac{(1-\xi)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}}_{>0}\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}$$

If $\xi = 1$,

$$d\ln w = \left(1-\frac{\gamma}{(1+\gamma)s_l}\right)d\ln u$$

and

$$\epsilon_{w,1-\tau} = \underbrace{-\left(\frac{\gamma/(1+\gamma)}{s_l}-1\right)}_{<0}\frac{d\ln u}{d\ln(1-\tau)}$$

In partial equilibrium, i.e. $dr = d\boldsymbol{w} = 0$,

$$\epsilon^{PE}_{w,1-\tau} = \frac{[1-\sigma(1-\xi)]\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\frac{1-\lambda}{1-\lambda\tau} > 0$$

If $\xi = 1$,

$$\epsilon^{PE}_{w,1-\tau} = \left(\frac{\gamma/(1+\gamma)}{s_l}-1\right)\frac{1-\lambda}{1-\lambda\tau} > 0$$

The indirect effect is summarized by the following elasticity:

$$\begin{aligned}\epsilon^{GE}_{w,1-\tau} &= \epsilon_{w,1-\tau} - \epsilon^{PE}_{w,1-\tau} \\ &= -\frac{[1-\sigma(1-\xi)]\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\frac{1-\lambda\tau}{1-\tau}\frac{d\ln r}{d\ln(1-\tau)} \\ &\quad + \frac{(1-\xi)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}\end{aligned}$$

If $\xi = 1$,

$$\epsilon^{GE}_{w,1-\tau} = -\left(\frac{\gamma/(1+\gamma)}{s_l} - 1\right)\frac{1-\lambda\tau}{1-\tau}\frac{d\ln r}{d\ln(1-\tau)}$$

B.4.9 Aggregate wage effect

$$\mathbb{E}\left[\epsilon^{PE}_{w,1-\tau}\right] = [1-\sigma(1-\xi)]\frac{1-\lambda}{1-\lambda\tau}\mathbb{E}\left[\frac{\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right]$$

$$\mathbb{C}\text{ov}\left(l_j, \epsilon^{PE}_{w,1-\tau}\right) = [1-\sigma(1-\xi)]\frac{1-\lambda}{1-\lambda\tau}\mathbb{C}\text{ov}\left(l_j, \frac{\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right)$$

$$\begin{aligned}\mathbb{E}\left[\epsilon^{GE}_{w,1-\tau}\right] &= -[1-\sigma(1-\xi)]\frac{1-\lambda\tau}{1-\tau}\mathbb{E}\left[\frac{\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right]\frac{d\ln r}{d\ln(1-\tau)} \\ &\quad + \mathbb{E}\left[\frac{(1-\xi)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right]\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}\end{aligned}$$

$$\begin{aligned}\mathbb{C}\text{ov}\left(l_j, \epsilon^{GE}_{w,1-\tau}\right) &= -[1-\sigma(1-\xi)]\frac{1-\lambda\tau}{1-\tau}\mathbb{C}\text{ov}\left(l_j, \frac{\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right)\frac{d\ln r}{d\ln(1-\tau)} \\ &\quad + \mathbb{C}\text{ov}\left(l_j, \frac{(1-\xi)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}\right)\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}\end{aligned}$$

or

$$
\begin{aligned}
\mathbb{E}\left[\epsilon^{PE}_{w,1-\tau}\right] &= [1-\sigma(1-\xi)]\frac{1-\lambda}{1-\lambda\tau}\mathbb{E}\left[\Lambda_r(s_l)\right] \\
\mathbb{C}\mathrm{ov}\left(l_j, \epsilon^{PE}_{w,1-\tau}\right) &= [1-\sigma(1-\xi)]\frac{1-\lambda}{1-\lambda\tau}\mathbb{C}\mathrm{ov}\left(l_j, \Lambda_r(s_l)\right) \\
\mathbb{E}\left[\epsilon^{GE}_{w,1-\tau}\right] &= -[1-\sigma(1-\xi)]\frac{1-\lambda\tau}{1-\tau}\mathbb{E}\left[\Lambda_r(s_l)\right]\frac{d\ln r}{d\ln(1-\tau)} \\
&\quad + \mathbb{E}\left[\Lambda_w(s_l)\right]\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)} \\
\mathbb{C}\mathrm{ov}\left(l_j, \epsilon^{GE}_{w,1-\tau}\right) &= -[1-\sigma(1-\xi)]\frac{1-\lambda\tau}{1-\tau}\mathbb{C}\mathrm{ov}\left(l_j, \Lambda_r(s_l)\right)\frac{d\ln r}{d\ln(1-\tau)} \\
&\quad + \mathbb{C}\mathrm{ov}\left(l_j, \Lambda_w(s_l)\right)\frac{d\ln \boldsymbol{w}}{d\ln(1-\tau)}
\end{aligned}
$$

where

$$
\begin{aligned}
\Lambda_r(s_l) &= \frac{\left(1-\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}\right)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}} \\
\Lambda_w(s_l) &= \frac{(1-\xi)}{(1-\xi)(\gamma+\sigma)+[1-\sigma(1-\xi)]\frac{1+\gamma}{\gamma}\frac{s_l}{\xi}}
\end{aligned}
$$

Moreover, if $\xi = 1$,

$$
\begin{aligned}
\mathbb{E}\left[\epsilon^{PE}_{w,1-\tau}\right] &= \frac{1-\lambda}{1-\lambda\tau}\left(\frac{\gamma}{1+\gamma}\mathbb{E}\left[\frac{1}{s_l}\right]-1\right) \\
\mathbb{C}\mathrm{ov}\left(l_j, \epsilon^{PE}_{w,1-\tau}\right) &= \frac{1-\lambda}{1-\lambda\tau}\frac{\gamma}{1+\gamma}\mathbb{C}\mathrm{ov}\left(l_j, \frac{1}{s_l}\right) \\
\mathbb{E}\left[\epsilon^{GE}_{w,1-\tau}\right] &= -\frac{1-\lambda\tau}{1-\tau}\left(\frac{\gamma}{1+\gamma}\mathbb{E}\left[\frac{1}{s_l}\right]-1\right)\frac{d\ln r}{d\ln(1-\tau)} \\
\mathbb{C}\mathrm{ov}\left(l_j, \epsilon^{GE}_{w,1-\tau}\right) &= -\frac{1-\lambda\tau}{1-\tau}\frac{\gamma}{1+\gamma}\mathbb{C}\mathrm{ov}\left(l_j, \frac{1}{s_l}\right)\frac{d\ln r}{d\ln(1-\tau)}
\end{aligned}
$$

B.5 Model inversion

Let N denote the number of firms in the economy. For a given labor supply elasticity and an initial normalization of $\boldsymbol{w}_0$, there is a one-to-one mapping between firms' observed

employment shares $l_{j,0}$ and their wages $w_{j,0}$, defined by the labor supply equation (2.2). Using this mapping, I recover firms' initial wages from the observed distribution of employment in 2010.

Then, we can recover firms' capital intensity α_j from these wages and firms' observed labor share $s^j_{l,0}$ in 2010, using equation (2.16), for given values of the parameters $\{\sigma, \xi, \gamma\}$.

Finally, we can recover firms' TFP z_j from the vector of wages, the vector of capital intensities, parameters $\{\sigma, \xi, \gamma, \boldsymbol{w}_0\}$, and firms' FOC derived in Appendix B.4.3.

Appendix C

Appendix to Chapter 3

C.1 Composition of separation flows

C.2 Model

C.2.1 Set-up

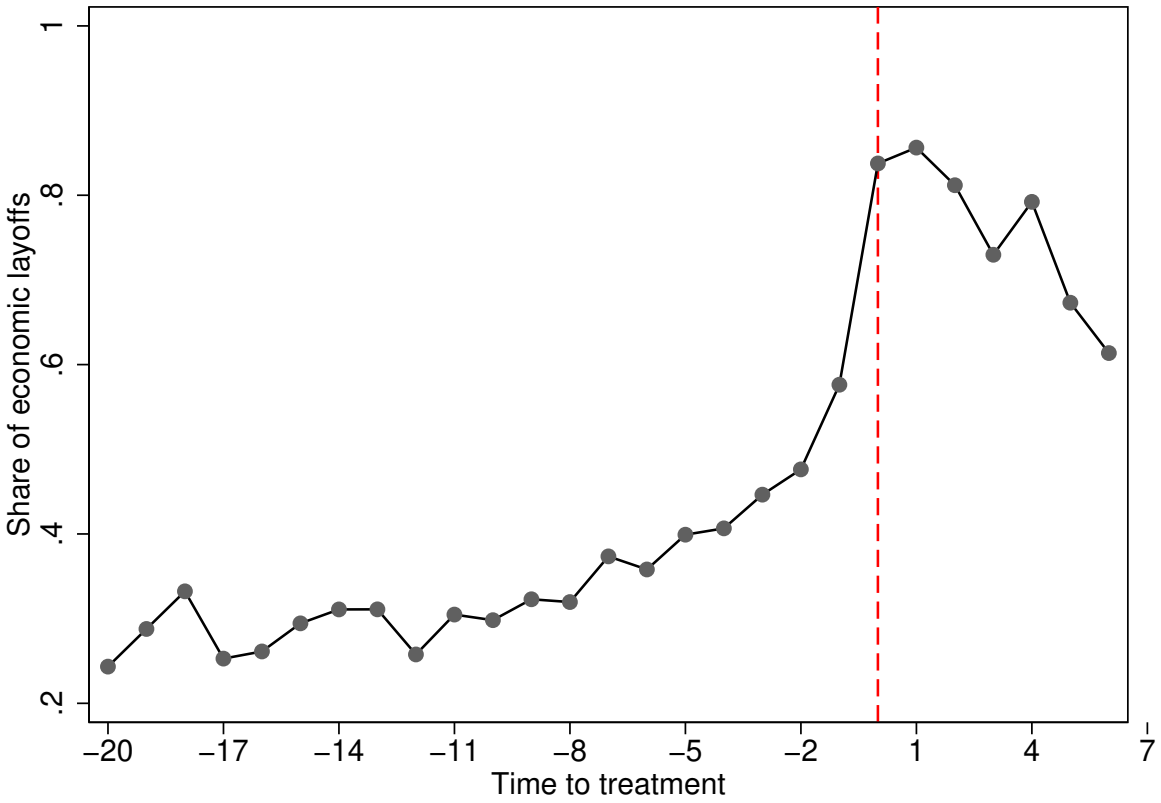
Environment Time is continuous and indexed by t. Workers and firms are risk neutral and discount future outcomes at the market rate ρ. To produce Y, a firm combines one worker and one unit of capital. We decompose Y between a match specific component y and the worker's idiosyncratic productivity type $\alpha \geq 0$. The law of motion of y is a geometric Brownian motion:

$$\mathrm{d}y = \mu y \mathrm{d}t + \sigma y \mathrm{d}z$$

with match specific drift μ and variance σ^2.

Value function when matched We now define the worker and the firm value function when producing. In our baseline model we assume a fixed share ϕ of the gross flow output Y is paid to the worker by its firm. Note also that this type of sharing rule could be derived

Figure C.1: The pattern of separations in distressed firms



Notes: This graph plots the share of public employment services registrations of workers coming from bankrupt firms which are categorized as economic layoffs in the broad sense (MOTINS variable of the FH file). We include in this category the economic layoff motive as well as other minor categories related to economic layoffs.

from an offer/counter-offer game as in Cahuc et al. (2006). A lay-off can either happen endogenously through the firm decision or exogenously under the threat of a bankruptcy procedure as a Poisson process with intensity δ. When laid off, the worker receives utility $U(\alpha)$ which we assume to be increasing in worker type α. The worker value and firm value functions are:

$$\rho E(y_t) = \phi(y_t + \alpha) + \delta[U(\alpha) - E(y_t)] + \frac{\mathbb{E}_t[\mathrm{d}E(y_t)]}{\mathrm{d}t}$$
$$\rho J(y_t) = (1-\phi)(y_t + \alpha) - \delta J'(y_t) + \frac{\mathbb{E}_t[\mathrm{d}J(y_t)]}{\mathrm{d}t}$$

Using Ito's Lemma, we expand $\mathrm{d}E(y)$ and $\mathrm{d}J(y)$:

$$\mathrm{d}E(y) = E'(y)\mathrm{d}y + \frac{1}{2}E''(y)(\mathrm{d}y)^2$$
$$\mathrm{d}J(y) = J'(y)\mathrm{d}y + \frac{1}{2}J''(y)(\mathrm{d}y)^2$$

Taking the expectation and dividing both sides by $\mathrm{d}t$, we find the usual Bellman equations associated to an underlying diffusion process:

$$(\rho+\delta)E(y) = \phi(y+\alpha) + \delta U(\alpha) + \mu y E'(y) + \frac{\sigma^2}{2}y^2E''(y) \tag{C.1}$$
$$(\rho+\delta)J(y) = (1-\phi)(y+\alpha) + \mu y J'(y) + \frac{\sigma^2}{2}y^2J''(y) \tag{C.2}$$

Value function when quitting The worker quits when $y < y_Q$ and the worker and firm value matching conditions are defined by:

$$E(y_Q) = Q(\alpha) \tag{C.3}$$
$$J(y_Q) = \frac{1}{\rho} \tag{C.4}$$

Value function when laid off The firm lay off the worker when $y < y_L$ and tranfers an amount F of firing costs to the worker. The worker and firm value matching conditions are then defined by:

$$E(y_L) = U(\alpha) + F \tag{C.5}$$
$$J(y_L) = \frac{1}{\rho} - F \tag{C.6}$$

C.2.2 Equilibrium regimes

We want to determine the worker's quit threshold y_Q under what we call the "quit regime" and the firm's layoff threshold y_L under the "layoff" regime.

Quit regime Using equation bellman equations (C.1)-(C.2), value matching conditions (C.3)-(C.4) and the smooth pasting condition $E'(y_Q) = 0$, we can solve anatically for y_Q:

$$y_Q = \frac{\gamma}{\gamma + 1} \frac{\rho + \delta - \mu}{\rho + \delta} \frac{1}{\phi} [(\rho + \delta)Q(\alpha) - \phi\alpha - \delta U(\alpha)]$$

where:

$$\gamma = -\frac{(1 - \frac{2\mu}{\sigma^2}) - \sqrt{(1 - \frac{2\mu}{\sigma^2})^2 + 4\frac{2(\rho+\delta)}{\sigma^2}}}{2}$$

is the absolute value of the negative root associated to the two Bellman equations' characteristic polynomial. See Dixit (1989) for a full treatment.

We now need to verify the following boundary condition on the firm side: the unique solution for J verifying $J(y_Q) = 1/\rho$ also verifies that for all $y > y_Q$, $J(y) \geq \frac{1}{\rho} - F$. Intuitively, it means that the firm has no interest in laying off a worker above the threshold for which the worker will quit. In this case, it means that the "quit" strategy is valid. For all $y \geq y_Q$ the value of the firm can be written as:

$$J(y) = B_J y^{-\gamma} + J_P(y)$$

where B_J is a constant and

$$J_P(y) = \frac{1 - \phi}{\rho + \delta - \mu} y + \frac{(1 - \phi)\alpha}{\rho + \delta}$$

is the permanent value associated to match productivity y. The value function J is pinned down to the continuity condition:

$$J(y_Q) = \frac{1}{\rho}$$

Combining these two expressions we can solve for B_J as:

$$B_J = y_Q^{\gamma}(\frac{1}{\rho} - J_P(y_Q))$$

which pins down our candidate J. We now have to check under which condition $J(y) > \frac{1}{\rho} - F$. This is trivially verified for $y \leq y_Q$ where $J(y) = \frac{1}{\rho}$. On $]0, +\infty[$, generic solution to the firm's Bellman equation will start to decrease, reach a minimum and increase to infinity as long as $\phi < 1$. A sufficient condition for J to be greater than the firm's layoff outside option hence is that:

$$J'(y_Q) \geq 0$$

This will be the case if and only if:

$$-\gamma B_J y_Q^{-\gamma-1} + \frac{1-\phi}{\rho+\delta-\mu} \geq 0$$

$$-\gamma y_Q^{\gamma}(\frac{1}{\rho} - J_P(y_Q))y_Q^{-\gamma-1} + \frac{1-\phi}{\rho+\delta-\mu} \geq 0$$

$$\frac{1-\phi}{\rho+\delta-\mu} y_Q \geq \gamma(\frac{1}{\rho} - J_P(y_Q))$$

$$\frac{1-\phi}{\rho+\delta-\mu} y_Q \geq \gamma(\frac{1}{\rho} - \frac{1-\phi}{\rho+\delta-\mu} y_Q - \frac{(1-\phi)\alpha}{\rho+\delta})$$

$$\frac{1-\phi}{\rho+\delta-\mu} y_Q \geq \frac{\gamma}{(1+\gamma)}(\frac{1}{\rho} - \frac{(1-\phi)\alpha}{\rho+\delta})$$

$$y_Q \geq \frac{\gamma}{(1+\gamma)} \frac{\rho+\delta-\mu}{1-\phi} (\frac{1}{\rho} - \frac{(1-\phi)\alpha}{\rho+\delta})$$

$$\frac{\gamma}{\gamma+1} \frac{\rho+\delta-\mu}{\rho+\delta} \frac{1}{\phi} [(\rho+\delta)Q(\alpha) - \phi\alpha - \delta U(\alpha)] \geq \frac{\gamma}{(1+\gamma)} \frac{\rho+\delta-\mu}{1-\phi} (\frac{1}{\rho} - \frac{(1-\phi)\alpha}{\rho+\delta})$$

$$\frac{1}{\phi} [(\rho+\delta)Q(\alpha) - \phi\alpha - \delta U(\alpha)] \geq \frac{1}{1-\phi} [(\rho+\delta)\frac{1}{\rho} - (1-\phi)\alpha]$$

Which simplifies to:

$$\frac{(\rho+\delta)Q(\alpha) - \delta U(\alpha)}{\phi} \geq \frac{(\rho+\delta)}{1-\phi} \frac{1}{\rho}$$

As long as $\lim_{\alpha \mapsto \infty} \frac{(\rho+\delta)Q(\alpha) - \delta U(\alpha)}{\phi} > \frac{(\rho+\delta)}{1-\phi} \frac{1}{\rho}$ there will be an α_Q such that the sufficient condition $J'(y_Q)$ will be verified for all $\alpha > \alpha_Q$.

The minimum of a solution to the firm's Bellman equation is attained for y_J such that $J'(y_J) = 0$:

$$y_J = [\frac{1-\phi}{\rho+\delta-\mu} \frac{1}{\gamma B_J}]^{\frac{-1}{1+\gamma}}$$

What's more we know that for α small enough (i.e. $\alpha < \alpha_Q$) then $y_J > y_Q$ and value of this minimum is $\underline{J}$:

$$\underline{J} = B_J [\frac{1-\phi}{\rho+\delta-\mu} \frac{1}{\gamma B_J}]^{\frac{\gamma}{1+\gamma}} + J_P \Big([\frac{1-\phi}{\rho+\delta-\mu} \frac{1}{\gamma B_J}]^{\frac{-1}{1+\gamma}} \Big)$$

As $y_Q \mapsto 0$ when $\alpha \mapsto 0$, so does B_J and so does $\underline{J}$. Hence, there exists $\underline{\alpha}$ such that for all $\alpha < \underline{\alpha}$ the quit equilibrium is not sustainable — i.e. such that $J(y) < \frac{1}{\rho} - F$ for some $y > y_Q$.

Layoff regime Using equation bellman equations (C.1)-(C.2), value matching functions (C.5)-(C.6) and the smooth pasting condition $J'(y_L) = 0$, we can solve anatically for y_L:

$$y_L = \frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{1-\phi}[(\rho+\delta)(\frac{1}{\rho}-F)-(1-\phi)\alpha]$$

where:

$$\gamma = -\frac{(1-\frac{2\mu}{\sigma^2}) - \sqrt{(1-\frac{2\mu}{\sigma^2})^2 + 4\frac{2(\rho+\delta)}{\sigma^2}}}{2}$$

is the absolute value of the negative root associated to the two Bellman equations' characteristic polynomial.

We now need to verify that, at this threshold, given the value matching condition we impose on the worker side, the boundary condition on E holds: the solution for E pinned down by $E(y_L) = U(\alpha) + F$ also verifies that for all $y > y_L$, $E(y) \geq Q(\alpha)$. Intuitively, it is not profitable for the worker to quit the firm before the firm laying off the worker, such that the "layoff" strategy is valid. For all $y \geq y_L$ the value of the worker can be written as:

$$E(y) = B_E y^{-\gamma} + \frac{\phi}{\rho+\delta-\mu}y + \frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta}$$

where B_E is a constant. E is subject to the value matching condition:

$$E(y_L) = U(\alpha) + F$$

Combining these two expressions we can solve for B_E as:

$$B_E = y_L^{\gamma}(U(\alpha) + F - E_P(y_L))$$

where

$$E_P(y_L) = \frac{\phi}{\rho+\delta-\mu}y_L + \frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta}$$

is the permanent value associated to match productivity y_L. The condition $E'(y_Q) \geq 0$ now writes:

$$-\gamma B_E y_L^{-\gamma-1} + \frac{\phi}{\rho+\delta-\mu} \geq 0$$

$$\frac{\phi}{\rho+\delta-\mu} \geq \gamma B_E y_L^{-\gamma-1}$$

$$\frac{\phi}{\rho+\delta-\mu} \geq \gamma y_L^{\gamma}(U(\alpha)+F-E_P(y_L))y_L^{-\gamma-1}$$

$$\frac{\phi}{\rho+\delta-\mu} y_L \geq \gamma(U(\alpha)+F-E_P(y_L))$$

$$\frac{\phi}{\rho+\delta-\mu} y_L \geq \gamma(U(\alpha)+F-\frac{\phi}{\rho+\delta-\mu} y_L - \frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta})$$

$$\frac{\phi}{\rho+\delta-\mu} y_L \geq \frac{\gamma}{1+\gamma}(U(\alpha)+F-\frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta})$$

$$y_L \geq \frac{\gamma}{1+\gamma}\frac{\rho+\delta-\mu}{\phi}(U(\alpha)+F-\frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta})$$

$$\frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{1-\phi}[(\rho+\delta)(\frac{1}{\rho}-F)-(1-\phi)\alpha] \geq \frac{\gamma}{1+\gamma}\frac{\rho+\delta-\mu}{\phi}(U(\alpha)+F-\frac{\phi\alpha+\delta U(\alpha)}{\rho+\delta})$$

$$\frac{\gamma}{\gamma+1}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{1-\phi}[(\rho+\delta)(\frac{1}{\rho}-F)-(1-\phi)\alpha] \geq \frac{\gamma}{1+\gamma}\frac{\rho+\delta-\mu}{\rho+\delta}\frac{1}{\phi}((\rho+\delta)(U(\alpha)+F)-\phi\alpha-\delta U(\alpha))$$

$$\frac{1}{1-\phi}[(\rho+\delta)(\frac{1}{\rho}-F)-(1-\phi)\alpha] \geq \frac{1}{\phi}((\rho+\delta)(U(\alpha)+F)-\phi\alpha-\delta U(\alpha))$$

Which simplifies to:

$$\frac{(\rho+\delta)(\frac{1}{\rho}-F)}{1-\phi} \geq \frac{\rho U(\alpha)+(\rho+\delta)F}{\phi}$$

Let $\rho U(0)$ the flow level of utility reached by lowest type workers when the become unemployed. Under the assumption that these baseline unemployment benefits are not too high:

$$\rho U(0) < \frac{\phi}{1-\phi}(\rho+\delta)(\frac{1}{\rho}-F)-(\rho+\delta)F$$

then there will exist an $\alpha_L > 0$ such that the sufficient condition for a layoff equilibrium to exist $E'(y_L) \geq 0$ will be met for all $\alpha < \alpha_L$.

The minimum of a solution to the worker's Bellman equation is attained for y_E such that $E'(y_E) = 0$:

$$y_E = [\frac{\phi}{\rho+\delta-\mu}\frac{1}{\gamma B_E}]^{\frac{-1}{1+\gamma}}$$

What's more we know that for α high enough (i.e. $\alpha > \alpha_L$) then $y_E > y_L$ and the value of this minimum is $\underline{E}$:

$$\underline{E} = B_E[\frac{\phi}{\rho+\delta-\mu}\frac{1}{\gamma B_E}]^{\frac{\gamma}{1+\gamma}} + E_P\Big([\frac{\phi}{\rho+\delta-\mu}\frac{1}{\gamma B_E}]^{\frac{-1}{1+\gamma}}\Big)$$

As y_L reaches 0 when $\alpha \mapsto (\rho+\delta)(\frac{1}{\rho}-F)/(1-\phi)$, so does B_E and so does $\underline{E}$. Hence, there exists $\overline{\alpha}$ such that for all $\alpha > \overline{\alpha}$ the layoff equilibrium is not sustainable — i.e. such that the worker would rather quit $E(y) < Q(\alpha)$ at some $y > y_L$ instead of waiting to get fired.

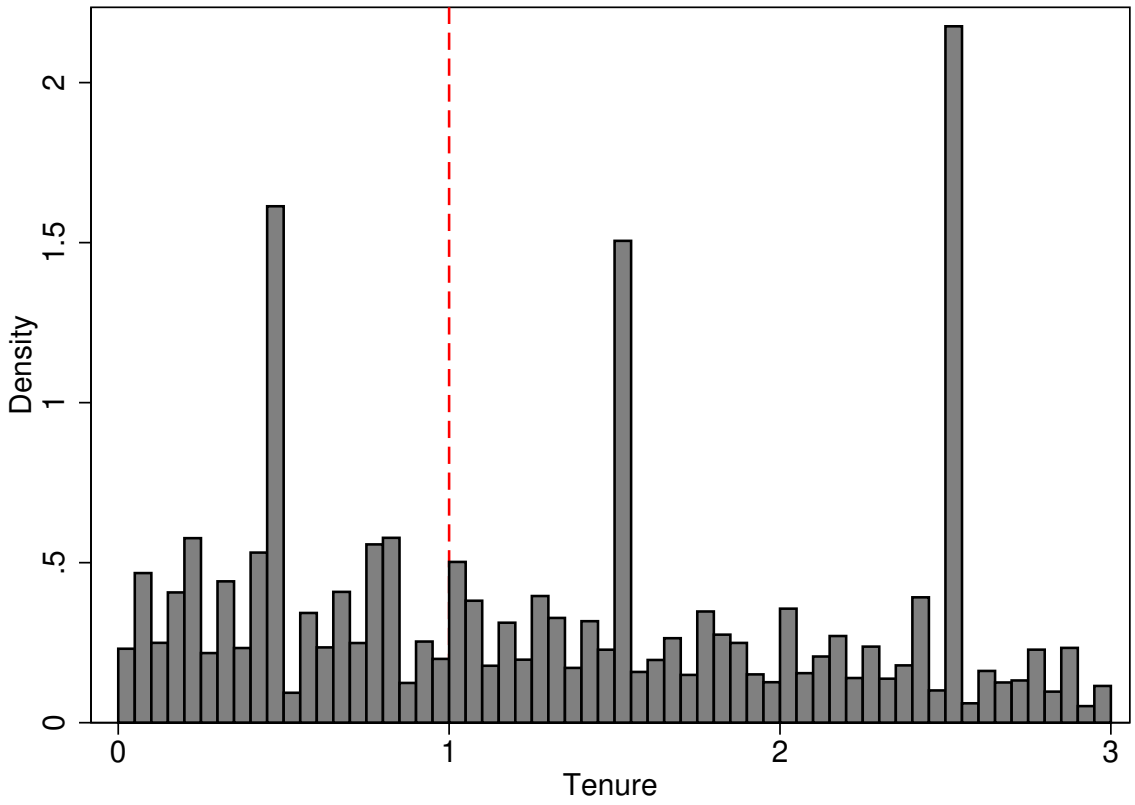
C.3 Difference in discontinuity

$$Y_{it} = \alpha_i + \alpha_t + D_{it}\left[tenure \in [1,2]\right] + \sum_{h=-5}^{4} \beta_h \cdot 1\left[t_0 + h = t\right] \cdot D_{it}\left[tenure \in [1,2]\right] + \varepsilon_{it}$$

restricting to the population with $tenure \in [0, 2]$.

C.4 Regression discontinuity

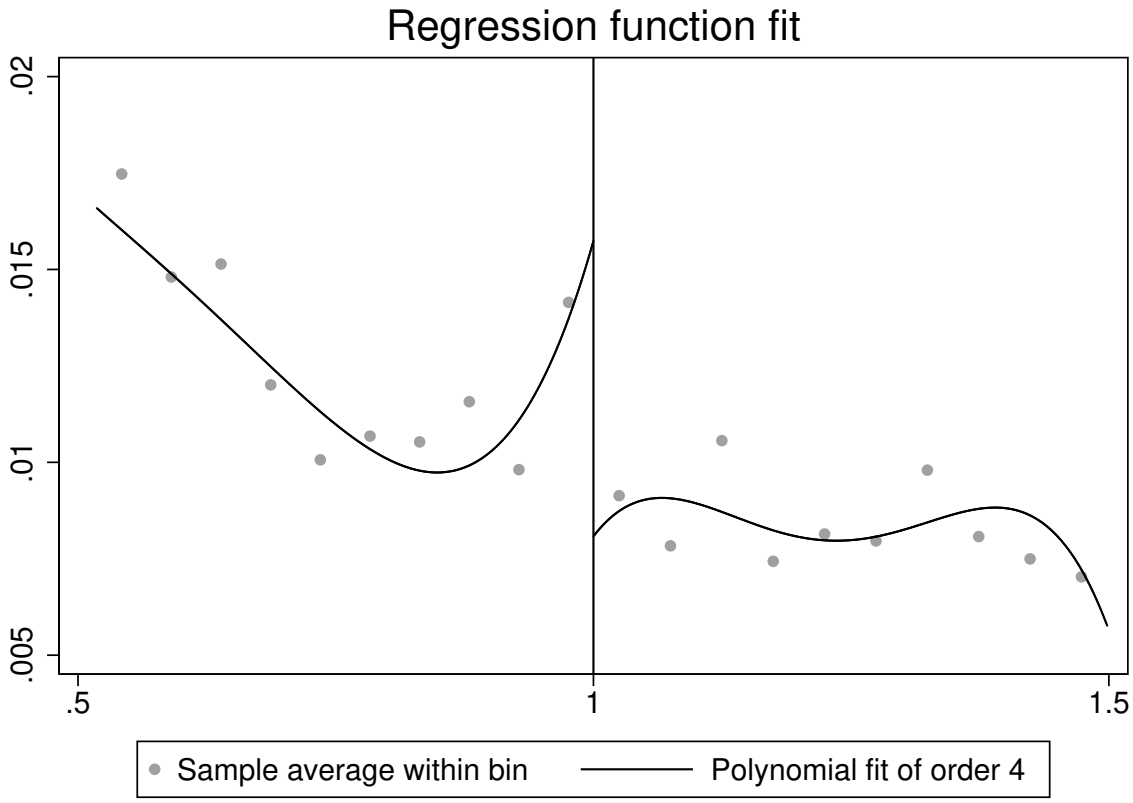
Figure C.2: Distribution of the running variable around the one year threshold



Notes: This graph plots the density of tenure, our running variable, for workers employed under an indefinite duration contract on June 27th 2008. The spikes at 0.5, 1,5 and 2,5 come from contracts beginning on the first of January.

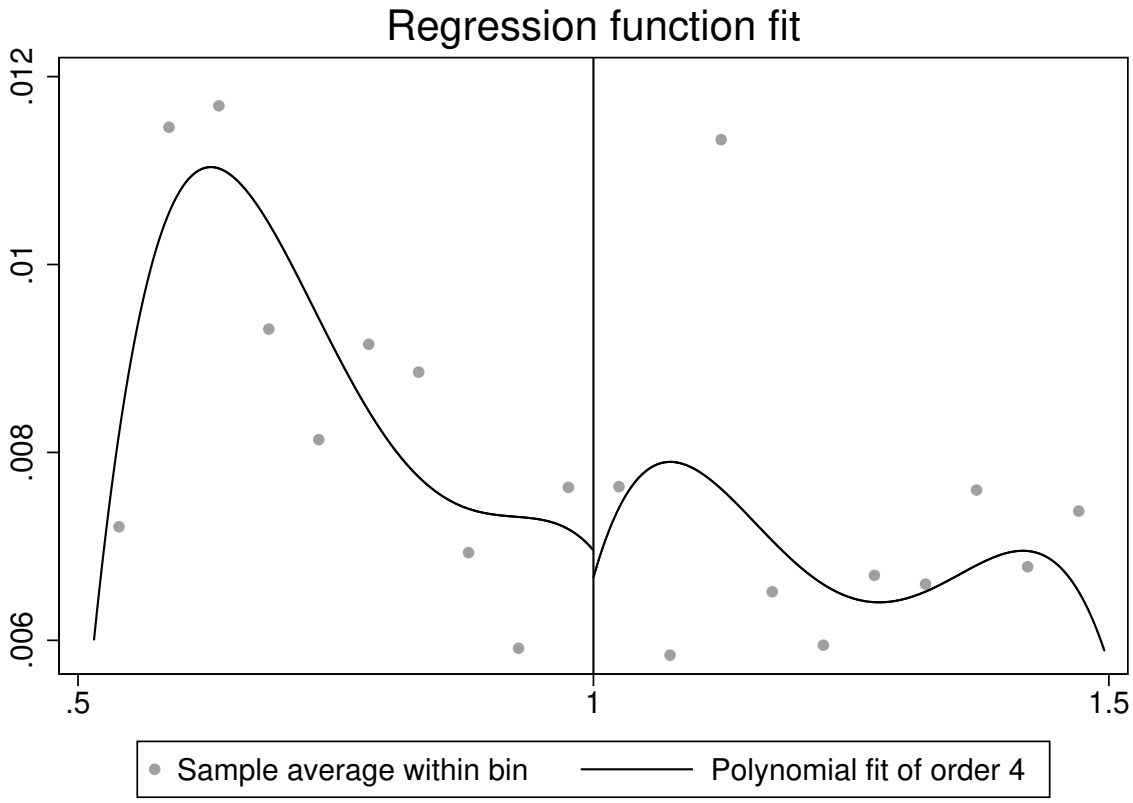
C.5 The timing of quits and layoffs: no firm FE

Figure C.3: Regression discontinuity: unemployment hazard rate vs tenure.



Notes: This graph plots one month unemployment rate against tenure for workers employed under an indefinite duration contract on June 27th 2008 as well as separate fourth order polynomial fits on the left and right of the one year tenure threshold.

Figure C.4: Placebo regression discontinuity: unemployment hazard rate vs tenure.



Notes: This graph plots one month unemployment rate against tenure for workers employed under an indefinite duration contract on June 27th 2007 as well as separate fourth order polynomial fits on the left and right of the one year tenure threshold.

Table C.1: The timing and nature of worker-firm separations: no firm FE

	(1) Early departure	(2) Early departure	(3) Layoff	(4) Layoff	(5) Quit	(6) Quit
Complet	-0.00838	-0.00484	0.0396	0.0158	-0.0480	-0.0206
	(0.0125)	(0.0129)	(0.00976)	(0.0114)	(0.0106)	(0.0112)
Male	0.0327	0.0354	0.00937	0.00761	0.0233	0.0278
	(0.0102)	(0.0115)	(0.00920)	(0.0106)	(0.00848)	(0.00954)
log(tenure)	-0.0568	-0.0693	-0.0391	-0.0543	-0.0178	-0.0150
	(0.00495)	(0.00624)	(0.00432)	(0.00563)	(0.00423)	(0.00534)
log(age)	-0.0977	-0.236	0.0119	-0.0930	-0.110	-0.143
	(0.0153)	(0.0285)	(0.0130)	(0.0257)	(0.0131)	(0.0258)
Eligible to sev. pay.=1	-0.0917	-0.0962	-0.0605	-0.0637	-0.0312	-0.0325
	(0.0148)	(0.0174)	(0.0133)	(0.0159)	(0.0127)	(0.0152)
log(hourly wage)	-0.00747		-0.123		0.116	
	(0.0129)		(0.0109)		(0.0102)	
$\hat{\epsilon}_{i,t}$		-0.0368		-0.244		0.207
		(0.0204)		(0.0196)		(0.0163)
$\hat{\alpha}_i$		0.0675		-0.0199		0.0874
		(0.0219)		(0.0180)		(0.0179)
$\hat{\beta}' X_{i,t}$		0.496		0.308		0.188
		(0.102)		(0.0989)		(0.0943)
Obs	15722	12134	15722	12134	15722	12134
F	115.1	78.76	86.32	62.62	71.68	53.98
Mean	0.477	0.466	0.235	0.222	0.242	0.244
Adjusted R2	0.208	0.216	0.0640	0.0733	0.150	0.163

Notes: This table reports the results of six different OLS regressions. Models (1) and (2) take an early departure dummy (worker departing prior to the bankruptcy filling) as the dependent variable. Models (3) and (4) replace the early departure dummy by an early layoff one and models (5) and (6) by an early quit dummy. All models control for year and 2-digits occupations fixed effects. Standard errors are clustered at the origin firm level and are reported in parentheses.

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