Do Non-Compete Agreements Help or Hurt Workers? Evidence from the NLSY97

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Abstract

While non-compete agreements are prevalent, the incentives driving their use and their causal effects on workers remain poorly understood. We develop a model with inefficient turnover to show that non-compete agreements shift the nature of allocative inefficiency—reducing inefficient quits but increasing inefficient retention—while mitigating the canonical hold-up problem. The model predicts that non-compete agreements are more likely to be used in industries with high returns on industry-specific investments, and that signers have longer job tenures, higher wages, and receive more firm-provided investment than similar workers without such agreements. Using panel data from the NLSY97 and a difference-in-differences research design, we estimate the causal impact of signing a non-compete agreement. Within one year, we find that non-compete agreements raise job tenures by 6% and wages by 9%, consistent with a compensating wage differential. In the longer run, however, this initial gain is eroded, as non-compete agreements reduce annual wage growth by 1%. While the theory links non-competes to firm investment, we find no evidence of increased investment in formal training, suggesting any such investment prompted by the agreement is likely informal.

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1 Introduction

The assumption that labor markets are perfectly competitive has been increasingly questioned in recent decades (e.g. Card 2022). One factor that can limit competition is the prevalence of non-compete agreements, contractual provisions that restrict workers from joining competing firms after leaving their current employer. The impact of non-compete agreements on labor markets remains contentious. Proponents argue that non-compete agreements increase worker retention and encourage firms to invest in industry-specific training, potentially benefiting workers through higher wages in the long run. Critics argue that non-compete agreements create mobility frictions, reducing workers' bargaining power and preventing them from transitioning to firms where they would be more productive.[1]

Despite their widespread use — 15% of U.S. workers were bound by non-compete agreements in 2017 — there is limited causal evidence on the effects of signing a non-compete agreement on long-run individual labor market outcomes. Most empirical studies focus on the effects of non-compete regulation rather than the direct worker-level effects of signing a non-compete agreement (e.g. Johnson, Lavetti, and Lipsitz 2023; Lipsitz and Starr 2022; Jeffers 2023; Kini, Williams, and Yin 2021; Starr 2019; Balasubramanian et al. 2022). More limited research leveraging micro-data on the usage of non-compete agreements has focused on their effects on particular subpopulations such as physicians (Lavetti, Simon, and White 2020), or on the descriptive relationships between signing the agreement and various worker characteristics (Rothstein and Starr 2022; Shi 2023; Starr, Prescott, and Bishara 2021). While these studies provide valuable insights into how regulation of non-compete agreements affects labor markets and the types of workers who sign non-compete agreements, they do not address the fundamental question of whether signing a non-compete helps or harms workers, and for which types of workers. Understanding these worker-level effects is crucial for evaluating whether non-compete agreements create long-term benefits for labor, such as a more skilled workforce and higher earnings, or primarily serve to restrict labor mobility and suppress wages.

Theoretical research has provided important insights into how non-compete agreements affect investment incentives and labor market efficiency, but significant gaps remain. Prior models have explored how non-compete agreements encourage firms to invest in general training (e.g. Meccheri 2009; Posner, Triantis, and Triantis 2004; Shy and Stenbacka 2023) and influence the efficient matching between workers and firms (e.g. Shi 2023; Gottfries and Jarosch 2023). However, these theories do not fully explain why workers would voluntarily agree to sign non-compete agreements,

[1] Critics also argue that non-compete agreements deter business formation by making it difficult for startups to hire skilled workers (e.g., Aghion and Bolton 1987, Jeffers 2023). Additionally, some firms impose non-compete agreements on workers after they have already accepted job offers or without their full awareness, which may allow firms to retain workers at lower wages (Starr, Prescott, and Bishara 2021).

despite their restrictive nature. If non-compete agreements are detrimental to workers, as critics suggest, why do they remain so common? A complete framework must incorporate both firm and worker incentives, explicitly modeling the conditions under which signing a non-compete agreement is in the interest of both parties.

Our model connects with literature highlighting how contracts affect both investment incentives and labor market matching. The first strand of literature examines how contracts influence employer investment incentives, particularly when investments are general and non-contractible (e.g., Grossman and Hart 1986; Che and Hausch 1999; Acemoglu and Pischke 1999; Meccheri 2009; MacLeod and Malcomson 1993).[2] The second focuses on how contracts shape labor market matching efficiency and mobility (e.g., Shi 2023; Gottfries and Jarosch 2023; Pakes and Nitzan 1983). By combining these two perspectives in a single theoretical framework, we formalize the trade-offs arising from using a non-compete agreement in the employment relationship. We show that non-compete agreements reduce inefficient quits, increase inefficient retention (job lock), and encourage firms to provide non-contractible industry-specific training.[3] Our model predicts that non-compete agreements should be most prevalent in industries where firms make substantial investments in industry-specific human capital. At the individual level, the model generates testable predictions that (i) workers who sign non-compete agreements should have longer job tenures, higher wages, and greater employer-sponsored training, but (ii) mobility restrictions may prevent workers from accessing higher-paying external opportunities within the industry.

A key assumption in our model is that contract renegotiation is infeasible due to asymmetric information and high transaction costs, as in Hashimoto (1981) and Hart and Moore (1988). Prior work has shown that, in theory, firms could release workers from non-compete agreements in exchange for buyout payments, restoring efficient ex-post matching in a Coasean world (Coase 1960; Shi 2023; Posner, Triantis, and Triantis 2004). Our model departs from this idealized setting by assuming that workers hold private information about their outside options, which they cannot credibly communicate to firms. This feature prevents efficient renegotiation, leading to persistent allocative inefficiencies, consistent with the call by Hart and Moore (2007) to model ex-post inefficiencies arising from various market frictions.[4] Unlike Shi (2023), who focuses on

[2] When investments are non-contractible, variations in investment by one party cannot be measured or priced by the courts. The modelling choice to make investment non-contractible follows a long literature studying how contracts may be designed to encourage investment and resolve the hold-up problem (i.e. Grossman and Hart 1986; Che and Hausch 1999).

[3] Other contract theory models have examined the interplay between investment incentives and matching efficiency in various contexts (e.g. Hellmann and Thiele 2017; MacLeod and Malcomson 1993), but none have explicitly analyzed this trade-off in the specific setting of non-compete agreements.

[4] To further elaborate, in our model, the firm cannot verify the terms of the worker's outside offer since it is private information to the worker. As such, the worker cannot command a higher wage by claiming to have a superior outside offer because the firm will assume such claims are inflated. As a modelling extension, we relax the no-renegotiation assumption in Section 3. We show that when firms hold all the bargaining power, a contract with a non-compete

how non-compete agreements can generate excessive rent extraction via buyouts, we focus on a distinct inefficiency: the outright prevention of efficient matches when workers cannot be released from binding non-compete agreements. At the same time, our model shows that non-compete agreements help resolve the hold-up problem by encouraging firms to invest in industry-specific skills. These theoretical results generate the policy implication that blanket bans on non-compete agreements are unlikely to be socially efficient. Although such bans may increase short-term labor mobility and matching efficiency, they risk reducing firms' incentives to invest in worker training, leading to a less-skilled workforce over time.

We assess the causal impact of signing a non-compete agreement on various labor market outcomes using data from the National Longitudinal Survey of Youth (NLSY97) and a difference-in-differences research design, allowing us to test the model's predictions. The NLSY97 is a nationally representative longitudinal survey that tracks a cohort of individuals who were teenagers in 1997. By 2017, when the survey first includes a question on non-compete status, the sample is between the ages of 32 and 38 — an ideal period for studying labor market outcomes as respondents are in their prime working years. Of the 5,236 individuals who reported their non-compete status in the 2017 questionnaire, approximately 15% responded affirmatively to having a non-compete agreement in their contract and more than 90% are "Very Confident" in the accuracy of the response.[5] The NLSY97 includes a wide range of outcome variables, allowing us to assess the effects of non-compete agreements on key variables featured in the theoretical model — wages, job mobility, and training — but also on broader aspects of job quality, such as job tasks, job satisfaction, and working hours. The dataset also provides detailed worker characteristics, enabling us to examine heterogeneity across several dimensions, including race, income, gender, education, and cognitive ability.

An advantage of the NLSY97 is that it allows us to track individual workers over time and across jobs, enabling the use of panel data research methods to estimate the causal impact of signing a non-compete agreement on career trajectories. Unlike prior research using this dataset which has primarily examined non-compete usage in cross-section (Rothstein and Starr 2022), we follow workers across survey waves. Using the panel component of the NLSY97 is critical for several reasons. First, it allows us to use individual fixed effects to account for time-invariant unobserved heterogeneity across workers who do and do not sign non-compete agreements, improving causal identification. Second, it enables us to examine how non-compete agreements affect wage growth,

agreements implements the social planner's solution. However, even with renegotiation, investment and allocative inefficiencies arise when termination fees are constrained to be training repayment fees or expectation damages.

[5]NLSY97 respondents appear confident in reporting their non-compete status, which contrasts with findings from Cowgill, Freiberg, and Starr (2024). In a field experiment with job applicants for full-time positions at a large U.S. financial services company, they document that many workers fail to notice or recall non-compete clauses in their contracts, particularly when the clause is not made salient at the time of signing. Their results suggest that some workers unknowingly accept non-compete agreements.

rather than cross-sectional wage differences. Third, it allows us to track the effects of signing a non-compete agreement even if a worker later changes jobs, ensuring that we capture the longer-run impacts of the agreement on labor market outcomes.

Estimating the causal effects of signing a non-compete agreement is challenging because workers who sign these agreements differ systematically from those who do not. Signing a non-compete agreement is often coincident with job mobility, which itself is linked to wage increases (i.e. Topel and Ward 1992). Furthermore, in the cross-section, we observe that non-compete signers have characteristics that are associated with higher wages, which complements findings from prior research (i.e. Rothstein and Starr 2022; Starr, Prescott, and Bishara 2021).

To overcome these challenges, we leverage the fact that different individuals sign non-compete agreements at different points in time and compare their individual labor market outcomes to a control group of workers who never sign a non-compete agreement during the sample period but start jobs in the same year. This approach ensures that we are comparing the trajectories of new job holders (in a given year) with and without a non-compete agreement rather than workers with fundamentally different labor market experiences. We construct our dataset using NLSY97 data from 2013 to 2021, defining a cohort as a group of individuals who start a new job in a given year. In a given cohort, treated workers are those who begin a job with a non-compete agreement in that year, while control workers are those who start a job in the same year but never sign a non-compete agreement over the entire sample period.[6] This setup ensures that for each "experiment," we are comparing newly hired workers with and without non-compete agreements, reducing concerns about selection bias.

Following prior work on treatment effects with staggered adoption, we estimate the parameters of a stacked difference-in-differences model, aggregating across cohorts to estimate the average treatment effect of signing a non-compete agreement (Cengiz et al. 2019; Johnson, Lavetti, and Lipsitz 2023; Gormley and Matsa 2011). By stacking these cohorts together, we construct a series of clean difference-in-differences comparisons, avoiding the issues that arise in standard two-way fixed effects models with staggered treatment timing (Goodman-Bacon 2021; Callaway and Sant'Anna 2021; Sun and Abraham 2021). We are confident in the validity of our causal estimates because we do not observe pre-trends for wages, job mobility, or other key outcomes in

[6] Since the NLSY97 only begins tracking non-compete status in 2017, we assume that if an individual reports signing a non-compete agreement in 2017, they had it from the beginning of their job tenure. This assumption allows us to estimate the longer-term effects of signing a non-compete agreement, even though the dataset does not capture non-compete agreements from the job's start date. As a sensitivity check, we re-estimate our results using only the 2017, 2019, and 2021 cohorts—workers who started new jobs in those survey waves. For these workers, we directly observe their non-compete agreement status at the time of hiring, eliminating the need for any assumptions about when the agreement was signed. The results from this restricted sample closely align with our main findings, reinforcing the validity of our long-term estimates. If an individual signs multiple non-compete agreements over the sample period, the individual is only included in the treated cohort corresponding to the earliest recorded use of the agreement.

the event-study design, indicating that workers who go on to sign non-compete agreements are not experiencing systematically different trends before signing. We also perform a series of robustness checks to rule out alternative explanations, such as non-compete signers joining higher productivity firms.

Our primary empirical finding is that signing a non-compete agreement leads to a statistically significant, immediate and persistent increase in wages. Our stacked event-study estimates indicate that signing a non-compete agreement raises wages by 9.4% within one year, a magnitude comparable to the returns to an additional year of education (e.g. Card 1999). This wage premium persists for at least six years, though we observe that it declines by approximately 1% per year, consistent with non-compete agreements lowering wage growth over time.[7] Notably, the estimated causal wage effect from the quasi-experimental research design (9.4%) is similar in magnitude to the cross-sectional wage premium with controls (8%), suggesting that our cross-sectional wage results are not likely subject to substantial omitted variable bias. We also observe that non-compete agreements lower job mobility, as predicted by our theoretical model. On average, non-compete agreements increase job tenure by 0.3 years (approximately 6% of the average tenure in the 2017 cross-section). Despite theoretical predictions that non-compete agreements encourage firm-provided training, we find no significant effects on measures of employer-provided training. Similarly, we find no significant effects on job satisfaction, working hours, or the nature of job tasks.

We examine heterogeneity across several dimensions, including education, income, gender, race, cognitive skills, and whether contract terms were negotiated, and by job stayers versus leavers. The positive wage effects of non-compete agreements are relatively stable across worker subgroups, ranging from a low of 7.3% for Black and Hispanic workers to a high of 12.4% for above-median wage workers (as defined by 2011 wages). In contrast, tenure effects vary more substantially, ranging from an effect statistically indistinguishable from zero for workers with below-median cognitive skills to slightly above 0.5 years for college-educated workers and those with above-median cognitive skills. In our full sample, we do not find that non-compete agreements affect other job-related outcomes such as hours, job satisfaction, or task content.

The immediate positive wage effects for non-compete signers, along with lower wage growth, likely represent a compensating wage differential, with firms offering higher upfront wages to offset restrictions on future job mobility. However, the lack of significant employer-provided training effects contradicts the model's prediction that firms should invest more in worker skills. Despite this observation, non-compete signers continue to earn higher wages even six years after signing, suggesting that factors beyond formal training contribute to these wage gains. We leave to future

[7] The fact that career earnings remain higher for non-compete signers but that the wage gap narrows over time aligns with the descriptive statistics reported in Shi (2023).

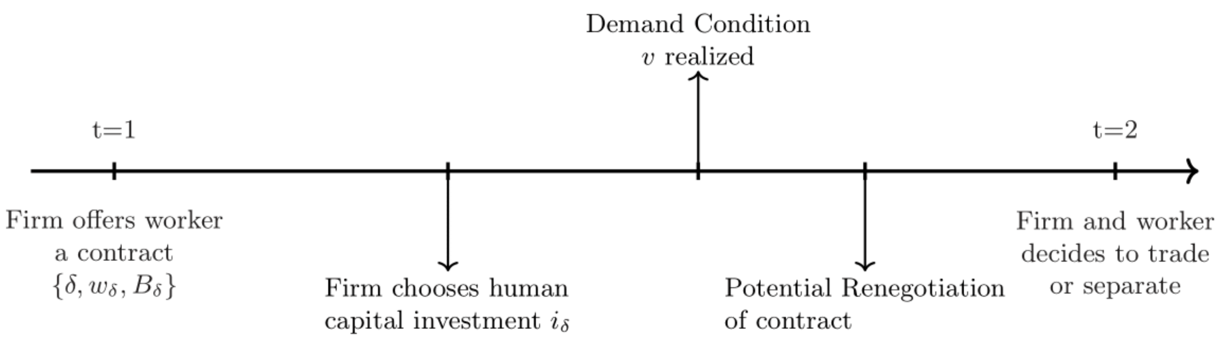
research potential mechanisms for these higher career earnings, such as stronger relationships with managers, mentorship, or social connections at work (e.g. Cullen and Perez-Truglia 2023).

The paper proceeds as follows. Section 2 lays out the theoretical framework. Section 4 discusses data sources and Section 5 examines the effect of signing a non-compete agreement on various labor market outcomes. Section 6 concludes.

2 Theoretical Framework

2.1 The Model

Figure 1: Timeline of the Model



We study a two-period model featuring a risk-neutral firm F and a risk-neutral worker W. The worker discounts future compensation by $\beta \leq 1$, while the firm values current and future profits equally. At the beginning of period 1, the firm and worker agree to a contract consisting of a non-compete clause $\delta \in \{0,1\}$, a fixed wage w_δ, and an up-front transfer B_δ from the firm to the worker. Production in the initial period is normalized to zero and we allow the worker to earn initial period wages below marginal product, or $B_\delta < 0$. The non-compete clause restricts the worker, upon separation in period 2, from joining firms in the same industry as F. We initially assume that the contract is rigid: the wage and the non-compete clause cannot be renegotiated in period 2. This assumption prevents the firm from tailoring the employment contract to realized conditions and thus results in inefficient turnover.

After the contract is signed, the firm chooses an investment level $i_\delta \geq 0$ to maximize its expected profits. Investment is industry-specific, costs the firm $\frac{1}{2}i_\delta^2$, and is non-contractible in the sense of Grossman and Hart (1986). An additional unit of investment raises the worker's productivity within the firm by r while raising the worker's productivity at industry competitors by ρ. A non-compete agreement prevents the worker from moving to industry competitors; as a result, additional investment by the firm does not raise the worker's outside option when $\delta = 1$.

We assume that the firm and worker know the values of r and ρ ex-ante and understand the probability distribution of future outside offers v, but do not observe the realization of v when making the contract or choosing investment. In particular, $v \sim \text{Exponential}(\lambda)$ is drawn at the beginning of period 2 and is privately observed by the worker. We interpret v as the demand for the worker from competing firms, which is private information to the worker, as in Hashimoto (1981). If unrestricted by a non-compete, the worker's outside option is $v + \rho i_0$; if bound by a non-compete, her option remains v. The worker then decides whether to stay at the firm and receive wage w_δ, or to leave and accept the outside offer. Simultaneously, the firm decides whether to retain or fire the worker. If the firm fires the worker, the firm can hire an untrained worker whose marginal product is zero; as a result, the firm will retain the incumbent worker so long as final period wages are less than or equal to marginal product, or $w_\delta \leq r i_\delta$. We remain agnostic about labor market conditions at the time of contracting. The worker has a reservation utility of μ^0 in the initial period that is commonly known to all parties, and will only accept the contract so long as expected utility exceeds this value.[8] Since the firm acts first, it will choose a contract so that the worker's participation constraint binds.

We allow both r and ρ to vary freely. When $\rho = 0$, investment is purely firm-specific; when $\rho = r$, it is fully transferable across firms in the industry. In practice, different sectors exhibit different returns to training, and the external value of a worker's training may vary substantially. We therefore allow the internal and external returns to investment to be arbitrary. Importantly, when $\rho > 0$, the firm's investment benefits not only the firm itself but also the worker by improving his outside option, so the investment is *industry-specific* in nature. This type of investment is common in relational settings and has been analyzed in, for example, Parent (2000). We focus on cases where $r > \rho$, meaning the internal return on investment exceeds the external return. However, the model can also handle situations in which a firm's investment increases the worker's productivity more for third parties than for the incumbent firm, as in Pakes and Nitzan (1983).

Although the firm has the option to fire the worker in period 2, this option is never exercised in equilibrium. To see why, observe that if wages are above marginal product in the final period, the firm must earn profits in the first period for the relationship to be profitable. However, anticipating that a firing will occur, the firm will make no investments. The worker is well aware of the firm's incentives and thus would be unwilling to earn below marginal product in the first period for investment that never occurs, so the relationship will not materialize in the first place. We denote this feature as the firm's "viability constraint", which rules out wage-tenure profiles where wages can exceed marginal product, as in the implicit insurance contracts explored in Harris and Holmstrom

[8] Although the model features a single firm, it can represent a perfectly competitive labor market. In that context, μ^0 should be interpreted as the endogenous utility level determined by perfect competition, which forces firms to offer contracts that yield zero expected profit.

(1982).

In standard hold-up models, firms underinvest because they anticipate having to share the additional surplus with workers through a higher wage (i.e. Becker 1962; Acemoglu and Pischke 1999). Here, instead, the firm underinvests without a non-compete agreement due to two reasons. First, the firm does not internalize the benefits to the worker when she leaves for a competitor. Second, the firm's investment raises the worker's outside option and thus the probability of a quit. As a result, the firm captures only a fraction of the marginal social returns to investment and invests sub-optimally.

Non-compete agreements mitigate this distortion by decoupling investment from the worker's outside option. When $\delta = 1$, the worker's outside option is fixed at v, so increased investment does not raise the probability the worker quits. Furthermore, for any given wage, a worker is less likely to quit with a non-compete than without a non-compete. Both of these forces raise the firm's incentives to invest in industry-specific skills. However, non-compete agreements also induce inefficient stays or "job lock." When $v + \rho i_1 > r i_1$ and $w_1 > v$, separation to the industry competitor is socially efficient but the worker is contractually barred from doing so. In these instances, the firm's private returns from investment exceed social returns. As a result, if investment is highly specific (large $r - \rho$), a non-compete agreement may lead to over-investment relative to the socially optimal level.

After analyzing the incentives to use non-competition agreements under asymmetric information, we then consider how renegotiation affects investment and matching properties. We show that when firms have full bargaining power and are free to set any termination payments, the first-best allocation can be achieved with a non-compete agreement. However, under standard legal remedies such as expectation damages or training repayment programs, non-compete agreements do not implement the first-best and often result in over-investment and under-separation.

2.2 Benchmark Outcomes

2.2.1 The Social Planner's Allocation

To establish an efficiency benchmark, we first characterize the allocation chosen by a social planner who controls both the investment and separation decisions to maximize total social surplus. The planner's problem unfolds in two stages. First, the planner chooses an investment level $i \geq 0$ at a social cost of $\frac{1}{2}i^2$. Second, after the outside option $v \sim \text{Exponential}(\lambda)$ is realized, the planner dictates whether the worker stays with the firm or separates. The planner makes this ex-post decision by comparing the total surplus generated in each state. If the worker stays, the surplus is ri. If the worker separates, the surplus is $v + \rho i$.

It is therefore socially efficient for the worker to stay if and only if the surplus from staying exceeds the surplus from separating. We assume $r > \rho$, meaning investment is more productive inside the firm.[9] The efficient separation rule is to continue the match whenever

$$ri \geq v + \rho i \quad \iff \quad v \leq (r - \rho)i. \tag{1}$$

Letting $\Delta := r - \rho$ denote the productivity gap, the planner retains the match if $v \leq \Delta i$.

Anticipating this efficient separation rule, the planner chooses the investment level i ex-ante to maximize the expected total surplus:

$$\mathscr{S}(i) = \int_0^{\Delta i} (ri)\lambda e^{-\lambda v} dv + \int_{\Delta i}^{\infty} (v + \rho i)\lambda e^{-\lambda v} dv - \frac{1}{2}i^2.$$

Using the properties of the exponential distribution, this simplifies to:

$$\mathscr{S}(i) = -\frac{1}{2}i^2 + ri + \frac{e^{-\lambda \Delta i}}{\lambda}.$$

The socially optimal level of investment, $i^\star$, is therefore implicitly defined by the first-order condition $\mathscr{S}'(i^\star) = 0$:

$$r - i^\star - \Delta e^{-\lambda \Delta i^\star} = 0. \tag{2}$$

Appendix A.1 shows the existence and uniqueness of the investment level as well as the comparative statics of optimal investments and quit probabilities with respect to the parameters of the model.

2.2.2 Allocative Inefficiency with Fixed Investments and Wages

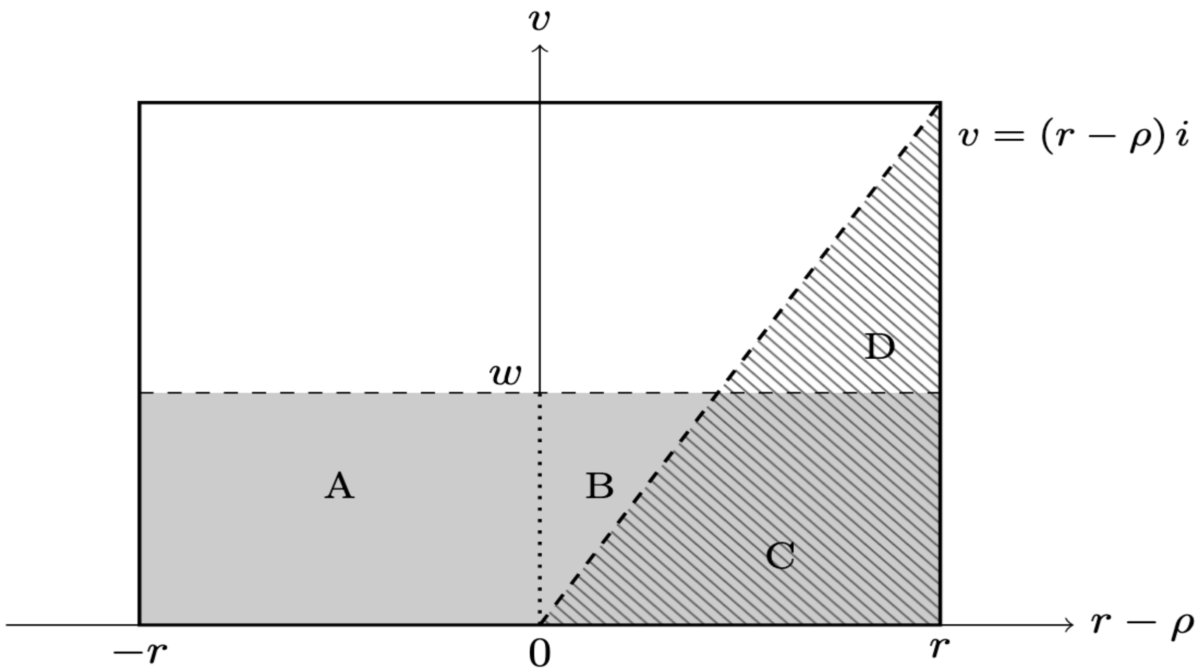
To isolate the allocative inefficiencies arising from contractual rigidity, we analyze a simplified case where investments and wages are fixed parameters. In this setting, the only actions consist of the parties making separation decisions in period 2. We compare the ex-post separation decisions under contracts with and without a non-compete agreement. The comparison between private and efficient decision rules is illustrated in Figures 2 and 3.

First, we establish the socially efficient separation benchmark. An allocation is efficient if the worker is placed where they are most productive. Separation is therefore efficient if and only if the surplus from the worker moving to a competing firm exceeds the surplus from remaining at the incumbent firm. This condition is given by $v + \rho i > ri$, or equivalently, $v > (r - \rho)i$. When $r > \rho$, trade is efficient whenever $v \leq (r - \rho)i$. Conversely, when $\rho > r$, continuing the match is never efficient. Efficient stay is depicted by the hatched regions C and D in Figure 2 and A and B in Figure 3.

[9]When $\rho \geq r$, it is straightforward to show that the planner always separates ex-post and sets $i^\star = \rho$.

With a non-compete agreement ($\delta = 1$), the worker's outside option is simply v and will stay as long as $w \geq v$. This decision rule is represented by the shaded regions A, B and C in Figure 2. This arrangement creates two types of allocative inefficiency. First, it leads to inefficient stays ("job lock"), depicted by region A and B in Figure 2, where separation is efficient but does not occur. In region A, separation is efficient since $\rho > r$, but since $w > v$, the worker will stay in the job. Similarly, in region B, $v > (r-\rho)i$ but $w > v$ and it leads to inefficient stay. Second, inefficient separations can still occur when a worker quits despite retention being socially optimal. This corresponds to the region below the dashed line and above the shaded area in region D of Figure 2 , where $(r-\rho)i > v > w$.

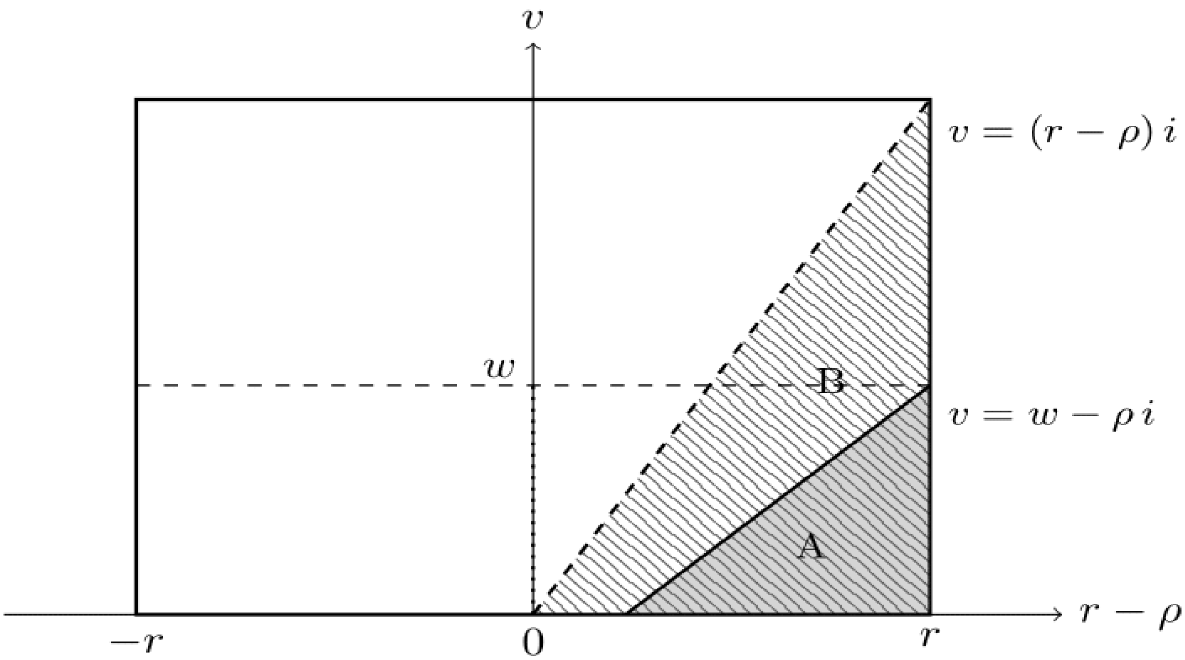
Figure 2: Separation Decisions with a Non-Compete Agreement



In the absence of a non-compete agreement ($\delta = 0$), the worker's outside option is $v+\rho i$, and their private decision rule is to separate if $v+\rho i > w$. This can lead to inefficient quits, depicted by region B in Figure 3, which occur when the worker leaves even though retention is socially optimal ($ri > v+\rho i > w$). However, this arrangement ensures all socially efficient separations are realized. Since the firm's participation constraint ensures $w \leq ri$, the condition for an efficient separation ($v+\rho i > ri$) necessarily implies the condition for a private separation ($v+\rho i > w$). Thus, no inefficient stays occur.

This analysis of the fixed investment and wage case reveals a fundamental trade-off. Contracts without non-compete agreements ensure all efficient separations occur but are susceptible to in-

Figure 3: Separation Decisions without a Non-Compete Agreement



efficient quits. Conversely, contracts with non-compete agreements reduce inefficient quits but introduce the possibility of inefficient stays (job-lock).

2.2.3 Outcomes with No Contract ("Spot Market")

To establish a benchmark for the value of contractual commitments, we analyze an equilibrium where no long-term contract is signed. The firm first chooses its investment level. Then, in the second period, after the worker's outside option v is privately realized, the firm makes a take-it-or-leave-it spot wage offer. This sequence creates a classic hold-up problem due to the non-contractibility of investment (Grossman and Hart 1986), which is exacerbated by the ex-post asymmetric information that can lead to bargaining failure (Myerson and Satterthwaite 1983).

Optimal Spot Wage (Ex-Post Decision) In the second period, after the firm has sunk its investment i_s and the worker has observed v, the firm offers a spot wage w_s. The worker's outside option is $v+\rho i_s$. The worker accepts the offer if and only if $w_s \geq v+\rho i_s$, which is equivalent to $v \leq w_s - \rho i_s$. The firm, knowing only the exponential distribution of v, chooses w_s to maximize its expected second-period profit:

$$\max_{w_s} \quad \Pi_2(w_s|i_s) = \underbrace{\Pr(v \le w_s - \rho i_s)}_{\text{Prob. accepts}} \times \underbrace{(ri_s - w_s)}_{\text{Profit if accepts}}$$

Given that $v \sim \text{Exponential}(\lambda)$, the problem is:

$$\max_{w_s} \quad \left(1 - e^{-\lambda(w_s - \rho i_s)}\right)(ri_s - w_s)$$

The first-order condition implicitly defines the optimal spot wage, $w_s^*(i_s)$, which solves:

$$\lambda e^{-\lambda(w_s^* - \rho i_s)}(ri_s - w_s^*) - \left(1 - e^{-\lambda(w_s^* - \rho i_s)}\right) = 0 \tag{3}$$

When choosing the wage, the firm balances the trade-off between a higher retention probability and a lower profit margin.

Optimal Investment (Ex-Ante Decision) In the first period, the firm anticipates its own future wage-setting behavior and chooses the investment level i_s to maximize its total lifetime profit, $\Pi_s(i_s) = \Pi_2(w_s^*(i_s)|i_s) - \frac{1}{2}i_s^2$. The firm's first-order condition for investment is:

$$\frac{d}{di_s}\Pi_2\left(w_s^*(i_s)|i_s\right) - i_s = 0.$$

By the Envelope Theorem, the derivative of the optimized ex-post profit with respect to investment is equal to the partial derivative of the profit function, evaluated at the optimal wage. Calculating this derivative and simplifying using the wage FOC from Equation (3) yields the firm's Private Marginal Benefit (PMB) of investment:

$$\text{PMB}_s(i_s) = (r - \rho)\left(1 - e^{-\lambda(w_s^*(i_s) - \rho i_s)}\right).$$

The firm chooses its investment level i_s to satisfy $\text{PMB}_s(i_s) = i_s$.

Proposition 1 (Under-investment in the Spot Market)**.** *In the spot market equilibrium, the firm's investment level, i_s, is strictly less than the socially optimal level, i^*.*

Proof. We compare the firm's Private Marginal Benefit (PMB) of investment with the Social Marginal Benefit (SMB) derived from the planner's problem. The equilibrium investment levels are determined by the points where the marginal benefit equals the marginal cost, which is i. The conditions are $\text{PMB}_s(i_s) = i_s$ for the spot market and $\text{SMB}(i^*) = i^*$ for the social planner. To prove that $i_s < i^*$, we need only show that $\text{PMB}_s(i) < \text{SMB}(i)$ for all $i > 0$.

The Social Marginal Benefit is $\text{SMB}(i) = r - (r-\rho)e^{-\lambda(r-\rho)i}$. The firm's Private Marginal Benefit is $\text{PMB}_s(i) = (r-\rho)\big(1 - e^{-\lambda(w_s^*(i)-\rho i)}\big)$. First, the firm's viability requires $w_s^*(i) \leq ri$, which implies the separation threshold satisfies $w_s^*(i) - \rho i \leq (r-\rho)i$. Since the exponential function is monotonic, this means $1 - e^{-\lambda(w_s^*(i)-\rho i)} \leq 1 - e^{-\lambda(r-\rho)i}$. This allows us to place an upper bound on the PMB:

$$\text{PMB}_s(i) \leq (r-\rho)\big(1 - e^{-\lambda(r-\rho)i}\big).$$

Now, we can rewrite the SMB by adding and subtracting ρ:

$$\text{SMB}(i) = (r-\rho)\big(1 - e^{-\lambda(r-\rho)i}\big) + \rho.$$

Combining these facts yields the final inequality chain that proves the result:

$$\text{PMB}_s(i) \leq (r-\rho)\big(1 - e^{-\lambda(r-\rho)i}\big) < (r-\rho)\big(1 - e^{-\lambda(r-\rho)i}\big) + \rho = \text{SMB}(i).$$

Since the private marginal benefit is strictly less than the social marginal benefit for all $i > 0$, the firm's chosen investment level must be strictly less than the socially optimal level, $i_s < i^*$. ■

Equilibrium Surplus The total joint surplus generated in the spot market equilibrium, Σ_s^*, is the sum of the firm's total profit and the worker's discounted expected utility. This can be expressed as the total surplus generated by the match, given the equilibrium investment i_s^* and the privately-optimal separation rule induced by the wage w_s^*:

$$\Sigma_s^* = \int_0^{w_s^* - \rho i_s^*} (r i_s^*)\lambda e^{-\lambda v} dv + \int_{w_s^* - \rho i_s^*}^{\infty} (v + \rho i_s^*)\lambda e^{-\lambda v} dv - \frac{1}{2}(i_s^*)^2.$$

This surplus is suboptimal for two reasons. First, the investment level i_s^* is inefficiently low due to the traditional hold-up problem. Second, the firm maximizes its own profit by setting the wage strictly below the worker's marginal product $(w_s^\star < r i_s^\star)$, which leads to inefficiently high turnover as some workers quit even when it is socially optimal for them to stay.

2.3 Subgame Perfect Equilibrium with a Non-Compete Agreement

2.3.1 Equilibrium Characterization

The equilibrium is solved via backward induction. Before analyzing the firm's choices, we first define the worker's expected utility. In the Production Stage, the worker stays if $v \leq w_1$ and quits if $v > w_1$. The worker's ex-ante expected future utility, $E[U_W(w_1)]$, calculated before the outside option v is realized, is therefore:

$$\begin{aligned} E[U_W(w_1)] &= \int_0^{w_1} w_1 \lambda e^{-\lambda v} dv + \int_{w_1}^{\infty} v \lambda e^{-\lambda v} dv \\ &= w_1(1-e^{-\lambda w_1}) + e^{-\lambda w_1}(w_1 + 1/\lambda) \\ &= w_1 + \frac{1}{\lambda} e^{-\lambda w_1}. \end{aligned}$$

The worker's participation constraint, checked in Stage 1, is $B_1 + \beta E[U_W(w_1)] \geq \mu^0$.

In Stage 2, for a given wage w_1, the firm chooses investment i_1 to maximize its expected profit, anticipating the worker's separation decision:

$$\max_{i_1 \geq 0} \quad \underbrace{(ri_1 - w_1)}_{\text{Profit if stay}} \underbrace{\Pr(v \leq w_1)}_{(1-e^{-\lambda w_1})} - \frac{1}{2} i_1^2$$

The first-order condition yields the firm's optimal investment response function:

$$i_1(w_1) = r(1-e^{-\lambda w_1}). \tag{4}$$

In Stage 1, the firm chooses (w_1, B_1) to maximize its profit. Since the bonus B_1 can be used to transfer utility ex-ante, this is equivalent to choosing w_1 to maximize the private joint surplus of the match, Σ_1, subject to the constraint that the firm will not fire the worker ($w_1 \leq ri_1$). The joint surplus is the sum of the firm's profit (before the bonus) and the worker's discounted expected utility:

$$\Sigma_1(w_1) = \left[(ri_1(w_1) - w_1)(1-e^{-\lambda w_1}) - \frac{1}{2} i_1(w_1)^2 \right] + \beta E[U_W(w_1)].$$

Substituting in the expression for $E[U_W(w_1)]$, maximizing Σ_1 with respect to w_1, and applying the Envelope Theorem yields the following key relationship.

Proposition 2 (Optimal Contract Structure)**.** *The optimal wage w_1 and the corresponding investment level $i_1(w_1)$ are related by the equation:*

$$w_1 = ri_1(w_1) + \frac{(\beta-1)(e^{\lambda w_1}-1)}{\lambda}. \tag{5}$$

For any worker patience $\beta \leq 1$, this ensures the equilibrium wage satisfies the firm's viability constraint, $w_1 \leq r i_1(w_1)$, so the firm does not fire the worker.

In Appendix Section A.2, we provide the necessary and sufficient conditions for a non-zero wage. All further analysis assumes $\lambda r^2 > 2$, which provides a sufficient condition. This wage structure creates a back-loaded compensation profile, where workers receive lower compensation early in the job in exchange for higher wages in the future. The steepness of this intertemporal trade-off is governed by the worker's patience β. A more patient worker is more willing to trade present for future earnings, accepting lower initial compensation (B_1) in exchange for a higher future wage (w_1).

2.3.2 Comparison with the Social Optimum

The structure of the private contract deviates from the social optimum because the firm's objective function ignores the external productivity parameter ρ. We formally compare the investment levels for the case where the worker is perfectly patient ($\beta = 1$).

Proposition 3 (Private vs. Social Investment)**.** *When $\beta = 1$, private investment with a non-compete, i_1, is compared to the social optimum, i^*, as follows:*

- *A sufficient condition for under-investment ($i_1 < i^*$) is $1 - \lambda r i^* > 0$.*
- *A sufficient condition for over-investment ($i_1 > i^*$) is $1 - \lambda \Delta i^* < 0$, where $\Delta = r - \rho$.*

Proof. The optimal investments are the roots of the first-order conditions for the planner, $F_P(i) \equiv i - r + \Delta e^{-\lambda \Delta i} = 0$, and the firm, $F_F(i) \equiv i - r + r e^{-\lambda r i} = 0$. Since $\partial F_F / \partial i > 0$ by the second-order condition, the sign of the investment distortion is determined by the sign of $F_F(i^*)$. From the planner's FOC, $r - i^* = \Delta e^{-\lambda \Delta i^*}$. Substituting this into the firm's FOC evaluated at i^* yields

$$F_F(i^*) = -(r - i^*) + r e^{-\lambda r i^*} = r e^{-\lambda r i^*} - \Delta e^{-\lambda \Delta i^*}.$$

The sign of this expression is given by the sign of $f(r) - f(\Delta)$ where the auxiliary function is $f(K) = K e^{-\lambda K i^*}$. The derivative, $f'(K) = e^{-\lambda K i^*}(1 - \lambda K i^*)$, determines if $f(K)$ is increasing or decreasing over the interval $[\Delta, r]$.

If $1 - \lambda r i^* > 0$, then $f'(K) > 0$ for all $K \in [\Delta, r]$. As $r > \Delta$, this implies $f(r) > f(\Delta)$, so $F_F(i^*) > 0$ and thus $i_1 < i^*$ (under-investment).

If $1 - \lambda \Delta i^* < 0$, then $f'(K) < 0$ for all $K \in [\Delta, r]$. This implies $f(r) < f(\Delta)$, so $F_F(i^*) < 0$ and thus $i_1 > i^*$ (over-investment).

Note that these two sufficient conditions are mutually exclusive. The former requires $\lambda r i^* < 1$ while the latter requires $\lambda \Delta i^* > 1$ For both to hold simultaneously would imply $\Delta > r$, which contradicts the model's assumption that $\rho > 0$.

■

With a high distribution of outside offers (low λ), a non-compete agreement may still yield under-powered investment incentives, as quits (to non-industry competitors) are frequent. When quit risk is minimal and when investments are highly specific (high λ, Δ), a non-compete agreement may result in over-investment relative to socially optimal.

2.3.3 Comparative Statics of the Non-Compete Equilibrium

The parameters of the model influence the equilibrium wage, which in turn affects the worker's quit decision, the firm's investment level, and the total surplus generated by the match. The following proposition summarizes these relationships.

Proposition 4 (Comparative Statics of Equilibrium Outcomes)**.** *In the equilibrium with a non-compete agreement, the effects of the model parameters on the equilibrium wage (w_1), bonus (B_1), quit probability ($q_1 = e^{-\lambda w_1}$), investment (i_1), and maximized joint surplus (Σ_1^*) are as follows:*

(i) An increase in r raises the wage, lowers the bonus, lowers the quit probability, increases investment, and increases the joint surplus.

(ii) A change in the spillover parameter, ρ, has no effect on any equilibrium outcome.

(iii) An increase in worker patience, β, raises the wage, lowers the bonus, lowers the quit probability, increases investment, and increases the joint surplus.

(iv) The effect of the quit rate parameter, λ, depends on worker patience.

- *If $\beta = 1$, an increase in λ raises the wage, lowers the quit probability, and increases investment, but decreases the joint surplus.*
- *If $\beta < 1$, the effects of an increase in λ on all equilibrium variables are ambiguous.*

Proof. The proof proceeds by establishing the comparative static for the wage, w_1, and then deriving the effects on B_1, q_1, i_1, and Σ_1^* as logical consequences. The wage response, $\frac{dw_1}{dx}$, is found by applying the Implicit Function Theorem to the wage FOC, $G(w_1, \mathbf{p}) \equiv d\Sigma_1/dw_1 = 0$. The sign is given by $\text{Sign}(\frac{dw_1}{dx}) = \text{Sign}(G_x)$, where $G_x \equiv \partial^2\Sigma_1/\partial w_1 \partial x$.

(i) Effect of Productivity r.

- **Wage:** The cross-partial with respect to r is $G_r = 2\lambda i_1 e^{-\lambda w_1}$. Since $i_1 > 0$, $G_r > 0$, which implies $\frac{dw_1}{dr} > 0$.
- **Bonus:** $\frac{dB_1}{dr} = -\beta(1-e^{-\lambda w_1})\frac{dw_1}{dr} < 0$ since $\frac{dw_1}{dr} > 0$.
- **Quit Probability:** $\frac{dq_1}{dr} = -\lambda e^{-\lambda w_1}\frac{dw_1}{dr}$. Since $\frac{dw_1}{dr} > 0$, we have $\frac{dq_1}{dr} < 0$.
- **Investment:** By the product rule, $\frac{di_1}{dr} = \frac{d}{dr}[r(1-q_1)] = (1-q_1) - r\frac{dq_1}{dr}$. Since $q_1 < 1$ and $\frac{dq_1}{dr} < 0$, both terms are positive, thus $\frac{di_1}{dr} > 0$.
- **Surplus:** By the Envelope Theorem, $\frac{d\Sigma_1^*}{dr} = \frac{\partial \Sigma_1}{\partial r} = i_1(1-e^{-\lambda w_1}) > 0$.

(ii) Effect of Spillover ρ. The parameter ρ does not appear in the joint surplus function Σ_1 or its first-order conditions under a non-compete. Thus, all derivatives with respect to ρ are zero.

(iii) Effect of Worker Patience β.

- **Wage:** The cross-partial is $G_\beta = \frac{d}{dw_1}\left(\frac{\partial \Sigma_1}{\partial \beta}\right) = \frac{d}{dw_1}(E[U_W(w_1)]) = 1-e^{-\lambda w_1} > 0$. Thus, $\frac{dw_1}{d\beta} > 0$.
- **Bonus:** $\frac{dB_1}{d\beta} = \frac{\partial B_1}{\partial \beta} + \frac{dB_1}{dw_1}\cdot\frac{dw_1}{d\beta} = -(w_1 + \frac{1}{\lambda}e^{-\lambda w_1}) - (1-e^{-\lambda w_1})\beta\frac{dw_1}{d\beta} < 0$.
- **Quit Probability:** $\frac{dq_1}{d\beta} = -\lambda e^{-\lambda w_1}\frac{dw_1}{d\beta} < 0$.
- **Investment:** $\frac{di_1}{d\beta} = -r\frac{dq_1}{d\beta} > 0$.
- **Surplus:** By the Envelope Theorem, $\frac{d\Sigma_1^*}{d\beta} = \frac{\partial \Sigma_1}{\partial \beta} = E[U_W(w_1)] > 0$.

(iv) Effect of Quit Rate Parameter λ. The effects depend on the value of β.

- **Wage:** The sign depends on the cross-partial $G_\lambda \equiv \partial^2\Sigma_1/\partial w_1\partial\lambda$. Using the property of mixed partials, we find:

$$G_\lambda = \frac{d}{dw_1}\left(\frac{\partial \Sigma_1}{\partial \lambda}\right) = \frac{d}{dw_1}\left[(ri_1 - w_1)w_1e^{-\lambda w_1} - \frac{\beta}{\lambda^2}e^{-\lambda w_1}(1+\lambda w_1)\right]$$
$$= \frac{\beta-1}{\lambda}\left(1-e^{-\lambda w_1} + \lambda w_1 e^{-\lambda w_1}\right) + \beta w_1 e^{-\lambda w_1}.$$

  If $\beta = 1$, the first term is zero, leaving $G_\lambda = w_1 e^{-\lambda w_1} > 0$. Thus, $\frac{dw_1}{d\lambda} > 0$. If $\beta < 1$, the first term is negative while the second is positive, making the sign of G_λ ambiguous. Thus, the sign of $\frac{dw_1}{d\lambda}$ is ambiguous.

- **Quit Probability:** The total derivative is $\frac{dq_1}{d\lambda} = -w_1 e^{-\lambda w_1} - \lambda e^{-\lambda w_1} \frac{dw_1}{d\lambda}$. If $\beta = 1$, $\frac{dw_1}{d\lambda} > 0$, so both terms are negative, implying $\frac{dq_1}{d\lambda} < 0$. If $\beta < 1$, the sign is ambiguous because the sign of $\frac{dw_1}{d\lambda}$ is ambiguous.

- **Investment:** The derivative is $\frac{di_1}{d\lambda} = -r\frac{dq_1}{d\lambda}$. If $\beta = 1$, $\frac{dq_1}{d\lambda} < 0$, implying $\frac{di_1}{d\lambda} > 0$. If $\beta < 1$, the sign is ambiguous.

- **Surplus:** By the Envelope Theorem, $\frac{d\Sigma_1^*}{d\lambda} = (ri_1 - w_1)w_1 e^{-\lambda w_1} - \frac{\beta}{\lambda^2} e^{-\lambda w_1}(1 + \lambda w_1)$. If $\beta = 1$, the first term is zero (since $w_1 = ri_1$), leaving a strictly negative result. If $\beta < 1$, the first term is positive and the second is negative, so the sign is ambiguous.

■

2.4 Subgame Perfect Equilibrium Without a Non-Compete Agreement

2.4.1 Equilibrium Characterization

The equilibrium is characterized by the firm's optimal investment and wage choices. The firm chooses the wage w_0 to maximize the private joint surplus of the match, anticipating its own investment response in the subsequent stage. The joint surplus, Σ_0, is the sum of the firm's expected profit and the worker's discounted expected future utility:

$$\Sigma_0(w_0, i_0) = (ri_0 - w_0)(1 - e^{-\lambda T_0}) - \frac{1}{2}i_0^2 + \beta\left(w_0 + \frac{1}{\lambda}e^{-\lambda T_0}\right)$$

where $T_0 = w_0 - \rho i_0$ is the retention threshold for the outside shock v.

First-Order Condition for Investment. In Stage 2, the firm chooses i_0 to maximize its own expected profit, $E[\Pi_0] = (ri_0 - w_0)(1 - e^{-\lambda T_0}) - \frac{1}{2}i_0^2$, taking the wage w_0 as given. The first-order condition implicitly defines the firm's investment response function, $i_0(w_0)$:

$$H(i_0, w_0) \equiv r\left(1 - e^{-\lambda T_0}\right) - (ri_0 - w_0)\lambda\rho e^{-\lambda T_0} - i_0 = 0 \tag{6}$$

First-Order Condition for Wages. The firm chooses w_0 to maximize the joint surplus $\Sigma_0(w_0, i_0(w_0))$, subject to the viability constraint $w_0 \le ri_0(w_0)$. The unconstrained optimum, which we denote w^*_{unc}, is the wage that solves the first-order condition $\frac{d\Sigma_0}{dw_0} = 0$. This total derivative is:

$$\frac{d\Sigma_0}{dw_0} = \frac{\partial\Sigma_0}{\partial w_0} + \frac{\partial\Sigma_0}{\partial i_0}\frac{di_0}{dw_0} = 0 \tag{7}$$

The partial derivatives are $\partial\Sigma_0/\partial w_0 = (\beta - 1)(1 - e^{-\lambda T_0}) + \lambda(ri_0 - w_0)e^{-\lambda T_0}$ and $\partial\Sigma_0/\partial i_0 = \beta\rho e^{-\lambda T_0}$. Substituting these into the above equation yields the wage FOC:

$$\lambda e^{-\lambda T_0}(ri_0 - w_0) + (\beta - 1)(1 - e^{-\lambda T_0}) + \beta\rho e^{-\lambda T_0}\frac{di_0}{dw_0} = 0 \tag{8}$$

However, this unconstrained solution is only chosen if it is feasible. If w^*_{unc} violates the viability constraint (i.e., if $w^*_{unc} > ri_0(w^*_{unc})$), then the equilibrium wage will be a corner solution. In this case, the firm is constrained and will choose the highest possible wage that still satisfies viability. This is the wage w^*_0 that lies on the boundary of the feasible set, solving the fixed-point equation $w^*_0 = ri_0(w^*_0)$. We show the existence of this fixed point and the conditions under which it is positive in Appendix A.3.[10]

As in the case with a non-compete, this optimal contract features a back-loaded compensation profile. The worker's patience, β, determines the steepness of this intertemporal trade-off. A more patient worker is more willing to trade lower initial compensation (B_0) for a higher future wage (w_0) that encourages greater firm investment. This dynamic is most apparent in the limit where the worker is perfectly patient ($\beta = 1$). In this case, the unconstrained solution would feature a wage above marginal product. As this is not profitable for the firm, the viability constraint binds, and the equilibrium is a corner solution where the worker receives exactly product in the final period.[11]

2.4.2 The Hold-Up Problem: Under-investment

Proposition 5 (Under-investment without a Non-Compete)**.** *In the equilibrium without a non-compete agreement, the firm's investment level, i^*_0, is strictly less than the socially optimal level, i^*.*

Proof. The proof proceeds by establishing an upper bound for the equilibrium investment and showing this bound is below the social optimum. Let the social planner's marginal benefit be $\text{SMB}(i) = r - \Delta e^{-\lambda\Delta i}$, where $\Delta = r - \rho$. The social optimum i^* solves $\text{SMB}(i^*) = i^*$, as previously shown in Equation 2.

1. The Benchmark Case ($w_0 = ri_0$). Consider the boundary case where the firm earns zero profits ex-post. Let the investment at this boundary be i_{bench}. Substituting $w_0 = ri_0$ into the investment FOC (1) yields $i_{\text{bench}} = r(1 - e^{-\lambda\Delta i_{\text{bench}}})$. The firm's private marginal benefit in this case is $\text{PMB}_{\text{bench}}(i) = r(1 - e^{-\lambda\Delta i})$. The difference between the social and private marginal benefit

[10] Throughout our analysis, we assume parameter values satisfy both $\lambda r(r-\rho) > 1$ and $\lambda r^2 > 2$. As shown in the Appendix, the first condition ensures a positive wage and investment in the equilibrium without a non-compete, while the second is a sufficient condition ensuring a positive wage in the equilibrium with a non-compete. These assumptions ensure that we are always comparing two non-trivial contractual outcomes.

[11] We prove formally that $\frac{di_0}{dw_0} > 0$ in Appendix A.4, which guarantees the unconstrained wage is above marginal product.

is $\text{SMB}(i) - \text{PMB}_{\text{bench}}(i) = \rho e^{-\lambda\Delta i} > 0$. Since the social marginal benefit is strictly greater than the firm's private marginal benefit for all i, the socially optimal investment level must be strictly greater than the firm's choice, i.e., $i^* > i_{\text{bench}}$.

2. The General Case ($w_0 < ri_0$). In any equilibrium where the firm earns positive profits ex-post, $w_0 < ri_0$. The firm's investment reaction function is strictly increasing in the wage ($\frac{di_0}{dw_0} > 0$). Therefore, any equilibrium investment $i_0^*(w_0^*)$ must be less than the investment level at the boundary benchmark: $i_0^*(w_0^*) < i_0(ri_0) = i_{\text{bench}}$. Combining these two results ($i_0^* \leq i_{\text{bench}}$ and $i_{\text{bench}} < i^*$), transitivity implies that the equilibrium investment is always strictly below the social optimum:

$$i_0^* < i^*$$

■

2.5 Comparison of Investment, Contract Choice, Wage-Tenure Profiles

2.5.1 Non-Compete Agreements Raise Investment

Proposition 6. *Let $i_0(w_0)$ be the firm's optimal investment response to a given wage w_0 in the absence of a non-compete agreement. Let i_1 be the equilibrium investment with a non-compete agreement. For any wage w_0 that satisfies the firm's viability constraint, $w_0 \leq r \cdot i_0(w_0)$, it holds that*

$$i_1 > i_0(w_0)$$

provided the investment spillover $\rho > 0$.

Proof. The proof establishes the result by demonstrating that for any viable investment choice under the no-non-compete (No-NC) rules, there is a strict incentive to increase investment under non-compete (NC) rules. First, for any given wage w_0, the firm's investment response $i_0(w_0)$ is determined by the first-order condition (FOC) of its profit maximization problem in the No-NC regime:

$$i_0(w_0) = r\left(1 - e^{-\lambda(w_0 - \rho i_0)}\right) - \left(ri_0 - w_0\right)\lambda\rho e^{-\lambda(w_0 - \rho i_0)} \tag{9}$$

Let $\text{NMB}_1(i,w) = r(1 - e^{-\lambda w}) - i$ be the Net Marginal Benefit of investment under the NC regime. The NC equilibrium investment i_1 is part of a pair (i_1, w_1) that solves $\text{NMB}_1(i_1, w_1) = 0$.

Now, consider any wage w_0 and its corresponding investment response $i_0 \equiv i_0(w_0)$ that satisfy the viability constraint $w_0 \leq ri_0$. We evaluate NMB_1 at this point (i_0, w_0) and substitute for i_0 using its FOC from (9):

$$
\begin{aligned}
\mathrm{NMB}_1(i_0,w_0) &= r(1-e^{-\lambda w_0}) - i_0 \\
&= r(1-e^{-\lambda w_0}) - \left[r\left(1-e^{-\lambda(w_0-\rho i_0)}\right) - \left(ri_0-w_0\right)\lambda\rho e^{-\lambda(w_0-\rho i_0)}\right] \\
&= r\left(e^{-\lambda(w_0-\rho i_0)} - e^{-\lambda w_0}\right) + (ri_0-w_0)\lambda\rho e^{-\lambda(w_0-\rho i_0)} \\
&= \underbrace{re^{-\lambda w_0}\left(e^{\lambda\rho i_0}-1\right)}_{\text{Term A}} + \underbrace{(ri_0-w_0)\,\lambda\rho e^{-\lambda(w_0-\rho i_0)}}_{\text{Term B}}
\end{aligned}
$$

The sign of this expression is determined as follows:

1. **Term A** is strictly positive, since $r,\lambda,i_0>0$ and we assume $\rho>0$.
2. **Term B** is non-negative. This follows directly from our premise that the wage w_0 satisfies the viability constraint $w_0 \le ri_0$, which ensures $(ri_0-w_0)\ge 0$.

Therefore, for any viable wage w_0 and its investment response i_0,

$$\mathrm{NMB}_1(i_0,w_0) > 0$$

Since $\mathrm{NMB}_1(i,w)$ is strictly decreasing in i, the NC equilibrium investment i_1 where $\mathrm{NMB}_1=0$ must be greater than i_0. Because this holds for any wage satisfying the viability constraint, it must also hold for the specific wage chosen in the No-NC equilibrium. If $\rho=0$, both terms are zero, yielding $i_1=i_0$. ■

Corollary 1. *For the benchmark case of a perfectly patient worker ($\beta=1$), the non-compete agreement alters the structure of the equilibrium contract in the following ways:*

(a) The equilibrium wage is strictly higher ($w_1>w_0$).

(b) The equilibrium quit probability is strictly lower ($q_1<q_0$).

(c) The comparison of the upfront bonuses (B_1 vs. B_0) is ambiguous, as it depends on a trade-off between the wage level and the option value of quitting.

Proof. The proofs rely on the main proposition that equilibrium investment is higher with a non-compete, $i_1>i_0$. For the entirety of this proof, we use the benchmark condition that for $\beta=1$, the equilibrium wage is set at the viability frontier, so $w_1=ri_1$ and $w_0=ri_0$.

Proof of (a): Wages. The comparison is immediate from the wage rules and the main proposition:

$$w_1 = ri_1 > ri_0 = w_0.$$

Proof of (b): Quit Probabilities. The quit probability is lower if the worker's retention threshold is higher. We must show $w_1 > T_0$, where $T_0 = w_0 - \rho i_0$. Using the wage rule $w_0 = ri_0$:

$$T_0 = ri_0 - \rho i_0 = (r - \rho)i_0.$$

We can now construct a direct chain of inequalities:

$$w_1 = ri_1 > ri_0 > (r - \rho)i_0 = T_0.$$

The steps follow from the NC wage rule, the main proposition ($i_1 > i_0$), the fact that $\rho > 0$, and the expression for T_0. Since $w_1 > T_0$, it follows that the quit probability is lower, $q_1 = e^{-\lambda w_1} < e^{-\lambda T_0} = q_0$.

Proof of (c): Bonus Ambiguity. The upfront bonus B is set as $B = \mu^0 - E[U_W]$, where $E[U_W]$ is the worker's ex-ante expected utility. The comparison of B_1 and B_0 is therefore determined by the sign of the difference $E_0 - E_1$. The formal expressions for worker utility in each regime are:

$$\begin{aligned} E_1 &= w_1 + \frac{1}{\lambda}e^{-\lambda w_1} \\ E_0 &= w_0 - \rho i_0 e^{-\lambda T_0} + \frac{1}{\lambda}e^{-\lambda T_0} \end{aligned}$$

We can group the difference, $E_0 - E_1$, into three components representing different economic forces:

$$E_0 - E_1 = \underbrace{(w_0 - w_1)}_{\text{Wage Effect}} + \underbrace{\frac{1}{\lambda}\left(e^{-\lambda T_0} - e^{-\lambda w_1}\right)}_{\text{Option Value Effect}} - \underbrace{\rho i_0 e^{-\lambda T_0}}_{\text{Spillover Penalty}}$$

We now sign each component:

1. **Wage Effect:** From part (a), we know $w_1 > w_0$, so this term is **negative**. The No-NC contract provides a lower wage, which reduces worker utility.

2. **Option Value Effect:** From part (b), we know $w_1 > T_0$, which means $e^{-\lambda T_0} > e^{-\lambda w_1}$. This term is **positive**. The No-NC contract provides a more valuable option to quit for a better outside offer because the retention threshold is lower.

3. **Spillover Penalty:** This term is also **negative**. It represents the utility loss to the worker because the firm's investment i_0, through the spillover ρ, drives a wedge between the wage w_0 and the retention threshold T_0.

The total difference in the worker's expected utility is the sum of one positive effect and two negative effects. Since these forces work in opposing directions, the sign of $E_0 - E_1$ cannot be determined without specific parameter values. Therefore, the ordering of the upfront bonuses, B_1 versus B_0, is ambiguous. ■

2.5.2 Incentives to Use Non-Compete Agreements Rise with Industry-Specificity of Skills

Proposition 7. *When skills are entirely firm-specific ($\rho = 0$), the hold-up problem vanishes and the no-non-compete (No-NC) contract is identical to the non-compete (NC) contract, yielding the same joint surplus, $\Sigma_0^* = \Sigma_1^*$. For $\rho > 0$, the relative attractiveness of the No-NC contract is determined by the total derivative $\frac{d\Sigma_0^*}{d\rho}$, which measures how the No-NC surplus changes as skills become more industry-specific. An increase in Σ_0^* makes the No-NC contract more attractive.*

- *(i) For a general worker patience $\beta \in (0,1]$, the effect of ρ on the No-NC surplus is ambiguous.*
- *(ii) For a perfectly patient worker ($\beta = 1$) and an equilibrium wage at the firm's viability constraint ($w_0^* = ri_0^*$), the effect simplifies and its sign is determined by the term $f \equiv 1 - \lambda r^2 e^{-\lambda\Delta i_0^*}$, where $\Delta = r - \rho$.*
- *(iii) Under the conditions of (ii), an increase in skill generality, ρ, makes the No-NC contract less attractive and favors a non-compete, while the effects of quit risk, λ, and productivity, r, are ambiguous.*

Proof. The total derivative of the maximized No-NC surplus is given by the Envelope Theorem:

$$\frac{d\Sigma_0^*}{d\rho} = \frac{\partial\Sigma_0}{\partial\rho} + \frac{\partial\Sigma_0}{\partial i_0}\frac{di_0^*}{d\rho}$$

Proof of (i): The General Case. For arbitrary β, the direct effect is $\partial\Sigma_0/\partial\rho = i_0^* e^{-\lambda T_0^*}[\beta - \lambda(ri_0^* - w_0^*)]$, which is of ambiguous sign. The indirect effect is the product of $\partial\Sigma_0/\partial i_0 = \beta\rho e^{-\lambda T_0^*} > 0$ and the investment response $di_0^*/d\rho$, which is of ambiguous sign. The sum of two ambiguous effects is therefore ambiguous.

Proof of (ii) and (iii): The Benchmark Case ($\beta = 1, w_0^* = ri_0^*$). Under these assumptions, let $s \equiv e^{-\lambda\Delta i_0^*}$. The components of the total derivative simplify to $\partial\Sigma_0/\partial\rho = i_0^* s$ and $\partial\Sigma_0/\partial i_0 = \rho s$. The investment response is $di_0^*/d\rho = -r\lambda i_0^* s/(1-\lambda r\Delta s)$, where the denominator is positive by the second-order condition. Substituting these into the total derivative yields:

$$\frac{d\Sigma_0^*}{d\rho} = i_0^* s + (\rho s)\left(-\frac{r\lambda i_0^* s}{1-\lambda r\Delta s}\right) = \frac{i_0^* s\left(1-\lambda r^2 s\right)}{1-\lambda r\Delta s}$$

The sign is determined by the term $f \equiv 1 - \lambda r^2 s$. We now find the derivative of f with respect to ρ to prove part (iii). The function f depends on ρ directly through $\Delta = r - \rho$ and indirectly through

$i_0^*(\rho)$. Applying the chain rule:

$$\begin{aligned}
\frac{df}{d\rho} &= \frac{d}{d\rho}\left(1-\lambda r^2 e^{-\lambda(r-\rho)i_0^*(\rho)}\right) \\
&= -\lambda r^2 s \cdot \left[-\lambda \frac{d}{d\rho}\left((r-\rho)i_0^*(\rho)\right)\right] \\
&= \lambda^2 r^2 s \left[(-1)i_0^* + (r-\rho)\frac{di_0^*}{d\rho}\right] = \lambda^2 r^2 s \left[\Delta \frac{di_0^*}{d\rho} - i_0^*\right]
\end{aligned}$$

Substituting the expression for $di_0^*/d\rho = \frac{r\lambda i_0^* s}{r\lambda\Delta s - 1}$:

$$\begin{aligned}
\frac{df}{d\rho} &= \lambda^2 r^2 s \left[\Delta\left(\frac{r\lambda i_0^* s}{r\lambda\Delta s - 1}\right) - i_0^*\right] \\
&= \lambda^2 r^2 s \left[\frac{r\lambda\Delta i_0^* s - i_0^*(r\lambda\Delta s - 1)}{r\lambda\Delta s - 1}\right] = \frac{\lambda^2 r^2 s i_0^*}{r\lambda\Delta s - 1}
\end{aligned}$$

The numerator is strictly positive. The denominator is strictly negative by the second-order condition of the firm's profit maximization. Thus, $\frac{df}{d\rho} < 0$, which shows that the sign-determining function $f(\rho)$ is strictly decreasing. This monotonicity implies that the sign of $\frac{d\Sigma_0^*}{d\rho}$ can switch at most once, from positive to negative. While the ultimate contract choice depends on the total surplus level (the integral of the derivative from $\rho = 0$), the sign of the derivative indicates the direction of the marginal incentive. Since $\frac{df}{d\rho} < 0$, any increase in skill generality ρ unambiguously increases the marginal incentive to adopt a non-compete, confirming the conclusion in part (iii). The effects of λ and r remain ambiguous as they involve countervailing direct and indirect effects. ■

3 Allowing for Renegotiation of the Non-Compete Agreement

3.1 Firm Holds All Bargaining Power

We extend the model to allow for renegotiation after labor demand conditions v are realized. Now the firm can restructure the non-compete agreement and contractual wages after investment is sunk but before trade or separation occurs. In particular, the firm can now match outside offers or allow the worker to leave for an industry competitor in exchange for a buyout payment. If the worker rejects the firm's new offer, the original contract terms still hold. Thus, renegotiation is by mutual consent, as in MacLeod and Malcomson (1993). The timing is as follows:

1. The firm offers an initial contract with a non-compete agreement $(w_1, B_1, \delta = 1)$ and the worker accepts or rejects.

2. The firm chooses an investment level i_1 at cost $\frac{1}{2}i_1^2$.

3. Labor demand conditions $v \sim F$ are realized and *observed by all parties.*

4. The firm offers a renegotiated contract $\{\bar{w}, \bar{\tau}, \bar{\delta}\}$, where:

   - $\bar{w}$ is the new wage if the parties trade,
   - $\bar{\tau}$ is the termination payment from the worker to firm upon separation,
   - $\bar{\delta} \in \{0,1\}$ is the revised non-compete status of the contract. If $\bar{\delta} = 0$, the firm waives the non-compete agreement and the worker's outside option is $v + \rho i_1$; otherwise, it remains v.

5. The worker accepts or rejects the revised offer. If rejected, the original contract governs. The parties then decide whether to trade or separate.

LEMMA 1 (Equilibrium Renegotiation)**.** *In the renegotiation subgame, the firm offers a contract that the worker accepts. This contract implements the efficient action (trade or separation) and ensures the worker obtains flow utility* $\max\{w_1, v\}$.

Proof. After the realization of v, the firm offers a take-it-or-leave-it contract $\{\bar{w}, \bar{\tau}, \bar{\delta}\}$. The worker will accept if the contract yields at least $\max\{w_1, v\}$, which is the best available utility under the original contract where the non-compete is enforced.

Case 1: Trade is efficient. This occurs when

$$ri_1 \geq v + \rho i_1.$$

The firm prefers to trade. It sets $\bar{\delta} = 1$ to enforce the non-compete, so the worker's fallback option remains $\max\{w_1, v\}$. The firm offers:

$$\bar{w} = \max\{w_1, v\}, \quad \bar{\delta} = 1.$$

Separation does not occur, so the termination payment $\bar{\tau}$ is irrelevant. The worker accepts and earns utility $\bar{w}$, and the firm earns profit $ri_1 - \bar{w}$.

Case 2: Separation is efficient. This occurs when

$$v + \rho i_1 > ri_1.$$

The firm sets $\bar{\delta} = 0$ to waive the non-compete and allow the worker to quit and access $v + \rho i_1$. To ensure the worker is indifferent between accepting and rejecting, the firm sets:

$$v + \rho i_1 - \bar{\tau} = \max\{w_1, v\} \quad \Rightarrow \quad \bar{\tau} = v + \rho i_1 - \max\{w_1, v\}.$$

The firm earns $\bar{\tau}$, and the worker earns $\max\{w_1, v\}$. The worker accepts.

Conclusion. In both cases, the firm implements the efficient action and extracts the surplus above $\max\{w_1, v\}$. ■

Proposition 8 (Renegotiation Ensures Efficient Investments and Allocations)**.** *In the model with renegotiation and industry-specific skills:*

1. *Efficient Turnover: For any investment level i_1, there is trade if and only if $v \le (r - \rho)i_1$.*
2. *Efficient Investment: The firm chooses the efficient investment level i^* that solves*

$$(r - \rho)F\left((r - \rho)i^*\right) + \rho = i^*,$$

which maximizes expected total surplus.

Proof. (1) Efficient Turnover. From Lemma 1, the firm compares its profit under trade versus separation:

$$\text{Trade: } ri_1 - \max\{w_1, v\}, \quad \text{Separation: } v + \rho i_1 - \max\{w_1, v\}.$$

The firm prefers trade if and only if:

$$ri_1 \ge v + \rho i_1 \quad \Leftrightarrow \quad v \le (r - \rho)i_1.$$

This implements the socially efficient cutoff rule.

(2) Efficient Investment. The firm chooses i_1 to maximize expected profit:

$$\begin{aligned}\Pi(i_1) = &\int_{-\infty}^{(r-\rho)i_1} \left(ri_1 - \max\{w_1, v\}\right) dF(v) \\ &+ \int_{(r-\rho)i_1}^{\infty} \left(v + \rho i_1 - \max\{w_1, v\}\right) dF(v) - \frac{1}{2}i_1^2.\end{aligned}$$

Let $\Sigma(i_1)$ denote expected total surplus. Then:

$$\Pi(i_1) = \Sigma(i_1) - \mathbb{E}[\max\{w_1, v\}].$$

Since $\max\{w_1, v\}$ does not depend on i_1, the firm maximizes $\Sigma(i_1)$. Differentiating:

$$\frac{d\Sigma}{di_1} = (r-\rho)F((r-\rho)i_1) + \rho - i_1.$$

Setting $\frac{d\Sigma}{di_1} = 0$ yields the efficient investment condition:

$$(r-\rho)F((r-\rho)i^*) + \rho = i^*. \qquad \blacksquare$$

3.2 Expectation Damages

We now analyze the game under a different, common legal remedy: expectation damages. In this scenario, the payment from the worker to the firm upon separation is designed to make the firm whole, as if the contract had been fulfilled (Shavell 1984). We model this by contractually fixing the termination fee at the level of the firm's profit from trade at the original wage, $\bar{\tau} = ri_1 - w_1$. As before, separation requires mutual agreement. The firm must therefore choose its investment level anticipating not only its own incentives to separate but also the worker's willingness to accept these terms.

Proposition 9 (Inefficient Matching and Over-investment under Expectation Damages)**.** *When the termination fee is fixed by expectation damages, both matching and investment are inefficient relative to the social planner's benchmark.*

1. ***Inefficient Matching:*** *The separation rule is inefficient, as it depends on the initial wage w_1 rather than the social returns to the match. This can lead to either over- or under-separation relative to the planner's solution.*

2. ***Over-investment:*** *The firm is incentivized to choose the maximum possible level of investment, $i_1 = r$, which is unambiguously higher than the socially optimal level i^*.*

Proof. The proof proceeds by deriving the conditions for separation and then analyzing the firm's investment decision in light of those conditions.

1. Inefficient Matching. For separation to occur, two conditions must be met: the firm must want to separate (Firm's Incentive Constraint, FIC), and the worker must agree (Worker's Participation Constraint, WPC).

First, we derive the FIC. The firm's profit from separation is the damage payment it receives, $\bar{\tau} = ri_1 - w_1$. Its profit from trading is $ri_1 - \max\{w_1, v\}$. The firm prefers to separate if:

$$ri_1 - w_1 > ri_1 - \max\{w_1, v\} \quad \Leftrightarrow \quad \max\{w_1, v\} > w_1$$

This is true if and only if $v > w_1$. The separation rule under expectation damages is therefore determined by the cutoff $v_{ed} = w_1$.

To see the inefficiency formally, we compare this to the social planner's efficient cutoff, $v_{eff} = (r-\rho)i_1$. The difference is:

$$v_{ed} - v_{eff} = w_1 - (r-\rho)i_1$$

The nature of the inefficiency depends on the sign of this difference, which is determined by the initial contract terms (w_1) rather than by principles of social surplus maximization.

- If $w_1 > (r-\rho)i_1$, the cutoff is inefficiently high, leading to **under-separation**.
- If $w_1 < (r-\rho)i_1$, the cutoff is inefficiently low, leading to **over-separation**.

Finally, we derive the WPC. The worker agrees to separate only if their utility from doing so is greater than or equal to their utility from rejecting the offer.

$$\underbrace{v + \rho i_1 - (ri_1 - w_1)}_{\text{Utility from Accepting Separation}} \quad \geq \quad \underbrace{\max\{w_1, v\}}_{\text{Utility from Rejecting}}$$

Considering the relevant case where $v > w_1$, this simplifies to $w_1 \geq i_1(r-\rho)$. If the firm chooses an investment level $i_1 > \frac{w_1}{r-\rho}$, the WPC is violated, and the worker will never agree to separate. This completely blocks efficient turnover, creating an extreme form of under-separation.

2. Over-investment. The firm chooses i_1 to maximize its profit. As shown in the derivation of the FIC, the firm is perfectly insured by the damage payment: its operational profit is always $ri_1 - w_1$, regardless of whether trade or separation occurs. The firm's optimization problem is therefore:

$$\max_{i_1} \quad \Pi(i_1) = (ri_1 - w_1) - \frac{1}{2}i_1^2$$

To find the optimal investment, we take the first-order condition:

$$\frac{d\Pi}{di_1} = r - i_1 = 0 \quad \Rightarrow \quad i_1 = r$$

The firm's dominant strategy is to invest $i_1 = r$. Comparing to the social optimum i^* (which satisfies $(r-\rho)F((r-\rho)i^*) + \rho = i^*$), it is clear that $i_1 > i^*$. The expectation damages clause creates a moral hazard that leads to the maximum possible level of investment, in excess of the socially efficient level. ■

3.3 Training Repayment Programs

We now analyze a modification to the renegotiation game to incorporate a Training Repayment Agreement Program (TRAP), as studied in, for example, Feess and Muehlheusser (2003). The game structure is as follows: after the firm makes an investment i_1 at cost $\frac{1}{2}i_1^2$ and the worker's outside offer v is realized, the parties can renegotiate. Under the TRAP, if the parties mutually agree to waive the non-compete agreement, the worker must pay the firm a contractually fixed termination fee of $\bar{\tau} = \frac{1}{2}i_1^2$. For this separation to occur, it must be preferable to continued trade for both parties. This creates two critical constraints that must be satisfied simultaneously: a Firm Incentive Constraint (FIC), where the firm will only agree to separate if receiving the fee is more profitable than continuing the match, and a Worker Participation Constraint (WPC), where the worker will only agree to pay the fee if the resulting mobility is sufficiently valuable. The firm must anticipate both of these constraints when choosing its initial investment level i_1.

Proposition 10 (Inefficient Matching and Investment under TRAPs)**.** *Relative to the social planner's benchmark, Training Repayment Agreement Programs (TRAPs) create inefficiently low separation and an inefficient level of investment.*

1. ***Under-separation:*** *TRAPs lead to under-separation. In the regime where separation is possible ($i_1 \leq 2\rho$), the threshold for separation is higher than the socially efficient threshold. In the regime where investment is high ($i_1 > 2\rho$), socially efficient separations are completely foreclosed as the worker will never agree to pay the fee.*

2. ***Inefficient Investment:*** *TRAPs lead to an inefficient level of investment. The firm's chosen investment will either be unambiguously excessive (if it chooses a high-investment strategy to prevent separation) or will be determined by the worker's participation constraint rather than by social efficiency, with the direction of the inefficiency being ambiguous.*

Proof. The proof compares the equilibrium outcomes under the TRAP with the social planner's benchmark, where separation is efficient if $v > v_{eff} = (r-\rho)i_1$ and investment i^* is chosen to maximize expected total surplus.

1. Under-separation. The proof of under-separation first requires establishing the conditions under which separation is possible. Separation requires both the firm's and the worker's participation constraints to be satisfied. We first derive the Worker Participation Constraint (WPC). The worker agrees to the TRAP's separation terms only if their utility from doing so is greater than or equal to their utility from rejecting the offer. Formally:

$$\underbrace{v + \rho i_1 - \frac{1}{2}i_1^2}_{\text{Utility from Accepting Separation}} \geq \underbrace{\max\{w_1, v\}}_{\text{Utility from Rejecting}}$$

For separation to be a relevant consideration, the worker's outside offer v is typically high, so we analyze the case where $v > w_1$. The participation constraint simplifies to:

$$v + \rho i_1 - \frac{1}{2} i_1^2 \geq v \quad \Rightarrow \quad \rho i_1 \geq \frac{1}{2} i_1^2 \quad \Rightarrow \quad i_1 \leq 2\rho$$

This derivation shows that separation is only possible if the firm's investment is within the regime $i_1 \leq 2\rho$. If $i_1 > 2\rho$, the worker will always reject the separation offer, leading to absolute under-separation.

Next, we consider the Firm's Incentive Constraint (FIC), which defines the firm's separation cutoff, $v_c = ri_1 - \frac{1}{2} i_1^2$. For the cases where $i_1 \leq 2\rho$, we compare this firm cutoff to the planner's efficient cutoff, $v_{eff} = (r - \rho) i_1$. The difference is:

$$v_c - v_{eff} = \left(ri_1 - \frac{1}{2} i_1^2 \right) - (r - \rho) i_1 = i_1 \left(\rho - \frac{i_1}{2} \right)$$

Since we are in the regime where $i_1 \leq 2\rho$ (which implies $\rho \geq i_1/2$), the term $(\rho - i_1/2)$ is non-negative. Thus, $v_c \geq v_{eff}$. The firm requires a higher outside offer v to release a worker than is socially optimal, leading to under-separation.

2. Inefficient Investment. The firm chooses i_1 to maximize its own profit by anticipating the outcomes of its two main strategies.

Strategy A (High Investment): Choose $i_1 > 2\rho$. This violates the WPC, making separation impossible. The firm maximizes $\Pi(i_1) = \mathbb{E}[ri_1 - \max\{w_1, v\}] - \frac{1}{2} i_1^2$, which yields the solution $i_1 = r$.

Strategy B (Low Investment): Choose an investment i_1 in the range $[0, 2\rho]$. In this regime, the firm's expected profit is $\Pi(i_1) = \int_{-\infty}^{v_c} (ri_1 - v)\, dF(v) + \int_{v_c}^{\infty} (\frac{1}{2} i_1^2)\, dF(v) - \frac{1}{2} i_1^2$. To find the optimal investment within this interval, we analyze the first-order condition:

$$\frac{d\Pi}{di_1} = (r - i_1) F \left(ri_1 - \frac{1}{2} i_1^2 \right)$$

For any investment level $i_1 < r$, this derivative is non-negative. Because the profit function is monotonically increasing with respect to investment in this regime, the firm is incentivized to choose the highest possible investment level permitted by the constraint. The profit is therefore maximized at the boundary of the interval, which is precisely $i_1 = 2\rho$.

The firm's final choice is to compare $\Pi(r)$ with $\Pi(2\rho)$. Neither $i_1 = r$ nor $i_1 = 2\rho$ is chosen to satisfy the social planner's first-order condition, so investment is always inefficient. If the firm adopts Strategy A ($i_1 = r$), the result is unambiguously over-investment, as it is known that $i^* < r$. If the firm adopts Strategy B ($i_1 = 2\rho$), the investment level is inefficient, but it could be higher or lower than the social optimum (i^*) depending on the model's parameters. Thus, the TRAP framework distorts the firm's incentives, causing it to deviate from the socially optimal investment level. ■

4 Empirical Set-up

4.1 Data and Descriptive Relationships

We use data from the National Longitudinal Survey of Youth 1997 (NLSY97) to understand the characteristics of non-compete signers and analyze the effects of such agreements on worker outcomes, including wages, job mobility, and employer-provided investment. This data set is a nationally representative panel that tracks the outcomes of individuals aged 12-16 in 1997. The survey runs annually from 1997-2011, and then biannually from 2011-2021. The survey includes information on the workers' employment history, including hourly wages for each job held, as well as detailed information on worker demographics and job information.

Importantly, the NLSY97 starts measuring whether non-compete agreements are used within employment contracts starting in 2017, when survey respondents are between ages 32-36. In 2017, all working respondents are asked whether they currently have a non-compete agreement. In the following survey years, all individuals who obtain *new* jobs are asked about their non-compete status. We assume throughout that non-compete status is fixed for the duration of the employment relationship.[12]

Throughout the analysis, we focus on the 2013-2021 time period and individuals who sign non-compete agreements after 2013, allowing us to estimate the impact of NC's for up to 6 years. We focus on employed workers and remove observations with real hourly wages below 3 or above 200, following Deming (2017).[13] When individuals hold multiple jobs in a survey year, we restrict attention to their primary job which we define as the current or most recent employer as of the interview date. If multiple jobs are current, the main job is the one with the longest tenure.

Using the 2017 cross section, we find that 14% of workers report having a non-compete agreement in their contract. More than 90% of affirmative respondents reported being "Very Confident" in their answer. There is substantial heterogeneity in non-compete usage across the 17 (two-digit) industries considered. Table A2 shows that among industries with more than 100 respondents, non-compete agreements are most commonly used in Professional and Related Services (26%)

[12]As support for this assumption, Starr, Prescott, and Bishara (2021) conducts a large survey that asks about the timing of non-compete agreements and find that in the vast majority of cases a non-compete agreement is signed prior to or immediately after starting the job, with only 2.2% associated with promotions or raises.

[13]We construct real hourly wages by deflating nominal hourly pay by annual CPI indices from BLS, setting 2017 as our base year.

and least commonly used in Public Administration (8%). Figure A1 further shows that NCs are used more frequently in high mobility industries, consistent with our theoretical predictions.

We are interested in the relationships between non-compete agreements and various labor market outcomes. We observe the employment history of each worker, including job identifiers and hourly wages at each job, allowing us to assess the impact of signing an NC on wages, wage growth, and job mobility. We consider log wages and job tenure as our main outcome variables throughout the analysis. We prefer to use job tenure as our main metric for identifying the effects of NC's on job mobility since it does not require defining what constitutes a job transition. As robustness we explore other measures of job mobility, such as using an indicator variable for whether an individual changed main employers between survey years, and come to similar conclusions. The NLSY97 also asks a variety of questions about formal employer-provided training programs. As a default, we report statistics pertaining to whether an individual was involved in a formal training program, but also consider whether this training was paid for and/or provided by the employer.

In Table 1 we report summary statistics for the 2017 cross-section, comparing workers with and without non-compete agreements. Consistent with our theory, we observe that non-compete signers have higher wages, earning 21 log points more. They also have slightly longer job tenures and 4pp lower job mobility rates between 2017 and 2019. Since non-compete agreements legally restrict within-industry job mobility, we also consider whether non-compete signers have lower rates of job mobility within industry. We find that NC signers have 2pp (17%) lower within-industry mobility rates. We note within-industry mobility only accounts for approximately one-third of all job mobility for both groups This statistic is consistent with Parent (2000) who also finds, using NLSY79, that about two-thirds of job changes are between one-digit industries. The frequency of between-industry job mobility is also documented in, for example, Neal (1999) and Kambourov and Manovskii (2008). The prevalence of inter-industry job transitions, especially among younger and more mobile workers, therefore suggests that the constraints of NCs may be less binding than previously believed.

Despite higher wages, there is no significant relationship between signing an NC and wage growth or formal employer training in the cross-section. However, we note that firm investment in human capital is a broader notion than formal training programs and may not be fully captured by our training variables. Indeed, in 2017 only about 11% of workers report having formal training in their current job.[14] There are also substantial differences in the types of workers that have non-compete agreements. Non-compete signers are much more likely to be male and less likely to be Black or Hispanic. They also have characteristics positively associated with higher wages,

[14] In contrast to the firm-level investment measures in Shi (2023), we measure training at the individual-level. Our sample of workers is also approximately 10 years younger than her sample of executives (mean age of 35 in our study versus mean age of 45 in Shi (2023)). Nevertheless, we arrive at similar differences in job tenure among those with and without non-compete agreements (0.12 years in our sample versus 0.10 years among the sample of executives).

Table 1: Respondent Characteristics by Non-Compete Status in 2017

	NC	no NC	Difference	P Value	N: NC	N: No NC
Job Mobility						
Tenure (Yrs)	5.24	5.11	0.12	0.50	699	4185
1(Main Job Separation btwn 2017 and 2019)	0.33	0.37	-0.04	0.04	705	4263
1(Main Job Mobility btwn 2017 and 2019)	0.28	0.31	-0.04	0.05	705	4263
1(Within-Industry Job Mobility btwn 2017 and 2019)	0.10	0.12	-0.02	0.08	686	4176
Wages and Wage Growth						
Log(Starting Wage)	2.94	2.76	0.19	0.00	705	4263
Log(Wage in 2017)	3.21	3.00	0.21	0.00	705	4263
$Log(Wage_{2017}) - Log(Wage_{2015})$	0.13	0.12	0.02	0.22	628	3778
$Log(Wage_{2019}) - Log(Wage_{2017})$	0.11	0.10	0.01	0.56	632	3753
Demographics						
Age	35.03	34.96	0.07	0.25	705	4263
1(Male)	0.58	0.50	0.08	0.00	705	4263
1(High School Degree or Higher)	0.89	0.86	0.03	0.01	699	4224
1(Bachelors Degree or Higher)	0.52	0.42	0.10	0.00	699	4224
ASVAB Percentile	57.50	52.06	5.44	0.00	582	3473
1(Black)	0.14	0.16	-0.02	0.13	705	4263
1(Hispanic)	0.11	0.13	-0.01	0.33	705	4263
Wage Bargaining and Negotiation						
1(Possible to Keep Previous Job)	0.46	0.45	0.01	0.74	304	1848
1(Negotiate Job Offer)	0.40	0.33	0.08	0.02	249	1454
Training						
1(Received Some Training)	0.09	0.11	-0.02	0.12	705	4263
1(Received Training Run by Employer)	0.01	0.03	-0.01	0.03	705	4263
1(Received On-Site Training by Non-Employer)	0.01	0.01	0.00	0.64	705	4263
1(Employer Paid for Training)	0.06	0.08	-0.02	0.08	705	4263
1(Employer Paid for Mandatory Training)	0.03	0.04	-0.01	0.26	705	4263
1(Employer Paid for Voluntary Training)	0.03	0.04	-0.01	0.16	705	4263
Job Tasks						
1(Use Math Skills Frequently)	0.37	0.27	0.10	0.00	661	3808
1(Supervise Frequently)	0.37	0.31	0.06	0.00	662	3802
1(Problem Solve Frequently)	0.85	0.74	0.11	0.00	661	3807
Other Firm Characteristics						
1(Dislike Job)	0.05	0.06	-0.01	0.57	645	3792
1(Unionized Worker)	0.11	0.16	-0.05	0.00	636	3743
Firm Size	986.28	1134.72	-148.43	0.65	595	3377

Note: The sample includes respondents with valid NC status for the main employer in 2017. All wage variables are measured in terms of real dollars earned per hour. Respondents earning real wages below 3 dollars or above 200 dollars are dropped. The training variables capture whether the respondent received training under any employer in 2017. Means weighted by nationally representative sample weights and p-values from a two-sided t-test are reported. Sample sizes vary due to missing values of the outcome variable. For details on variable definitions, refer to Table A1 with 52% having a bachelors degree or higher (relative to 42% for non-compete signers) and higher ASVAB test scores, which we use as a proxy for cognitive ability.[15] Workers that sign non-compete agreements are more likely to perform tasks requiring mathematical skills, leadership, and problem solving, less likely to be unionized, and more likely to negotiate over wages. Interestingly, we find no significant differences in terms of job satisfaction or firm size.

In Table 2 we assess whether these differences are driven by observable worker or job characteristics rather than NCs themselves by estimating the following equation via Ordinary Least Squares

$$Y_i = \beta_0 + \beta_1 * NC_i + \beta_2 * X_i + \varepsilon_i \tag{10}$$

where Y_i is the outcome of interest for worker i, X_i is a vector of observable characteristics for the worker and their current job, and β_1 is the relationship between Y_i and NC usage. We consider dependent variables log wages in 2017, log wage growth, job tenure, indicators for whether the worker changed jobs between 2017 and 2019, whether the worker received formal training, and whether the employer paid for that training. We report results with no controls, "basic" controls which includes sex, education, tenures, and potential experience, and "advanced" controls which further adds ASVAB test score percentiles, firm size, and industry and occupation fixed effects.

The estimated cross-sectional wage premium for signing a non-compete agreement declines as we add control variables, falling from 21.1 to 8.1 log points, which implies that differences in wages are partly attributable to the fact that, on average, workers who sign NCs have characteristics that are positively associated with wages. The relationship between non-compete agreements and the other dependent variables is largely insensitive to the inclusion of observable covariates, still finding that NC signers have slightly lower job mobility rates and insignificant differences in terms of wage growth, formal training, and job tenure. In Table A3 we report results based on the 2019 cross-section and find they are qualitatively similar.

Even in the fully saturated model of Equation (10) we cannot rule out the possibility that there are omitted variables correlated with NC usage and labor market outcomes of interest. For example, if NC signers have higher unobserved ability, then our estimated wage coefficients from Equation (10) will be upward biased. The following subsection outlines our empirical strategy for identifying the causal impact of NC's on worker labor market outcomes.

4.2 Estimating Equations

To isolate the causal effects of signing an NC, we adopt a stacked DiD research design where for each survey year c we construct a "clean" dataset containing only those who we observe first signing a non-compete agreement in year c (the treatment group) and an associated c-specific

[15] The ASVAB is a standardized test on science, math and language skills.

Table 2: Estimated Effects of Non-Compete Agreements using the 2017 Cross-Section

Panel 1: Wages and Wage Growth

Dependent Variables:	Log(Wage)			Wage Growth		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	0.211***	0.144***	0.081***	0.009	0.007	0.004
	(0.027)	(0.022)	(0.024)	(0.014)	(0.014)	(0.018)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	3.04	3.04	3.04	0.088	0.088	0.088
Fit statistics						
Observations	4,968	4,836	3,141	4,968	4,836	3,141
R^2	0.017	0.296	0.456	0.0001	0.0005	0.026

Panel 2: Training

Dependent Variables:	1(Any Training)			1(Emp Paid for Training)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	-0.019	-0.025*	-0.017	-0.018*	-0.026**	-0.022
	(0.013)	(0.013)	(0.017)	(0.010)	(0.011)	(0.014)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	0.112	0.112	0.112	0.071	0.071	0.071
Fit statistics						
Observations	4,968	4,836	3,141	4,968	4,836	3,141
R^2	0.0005	0.007	0.048	0.0006	0.012	0.063

Panel 3: Job Mobility

Dependent Variables:	Tenure (Yrs)			1(Job Mobility 2017-2019)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	0.125	0.002	-0.267	-0.036*	-0.026	-0.032
	(0.197)	(0.198)	(0.234)	(0.020)	(0.020)	(0.024)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	5.08	5.08	5.08	0.304	0.304	0.304
Fit statistics						
Observations	4,884	4,836	3,141	4,968	4,917	3,177
R^2	9.34×10^{-5}	0.017	0.083	0.0008	0.011	0.039

Notes: Standard errors are heteroskedasticity-robust. The sample restricts to individuals who report NC status and have real wages between 3 and 200 in 2017. Basic controls include sex, education, tenure, and potential experience. Advanced controls further add industry and occupation fixed effects, ASVAB percentile, and firm size. Tenure controls not included in the job mobility panel. All regressions are weighted so as to be nationally representative. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

control group. Specifically, for each cohort c, both the treated and the control group consist of workers who transitioned to a new job with known NC status between year c and the previous survey year. The treated are the job movers in year c who first sign an NC in year c, and the control group are the job movers in year c who do not sign an NC over the sample period (the never-treated). Denote G_c as the set of treated workers in cohort c.

We focus on years 2013-2021 and cohorts $c \in \{2015, 2017, 2019, 2021\}$ to understand the effects of non-compete agreements over a reasonable time horizon without pushing our assumption that NC status is invariant over the employment relationship too far.[16] We then "stack" the data for each cohort c and estimate

$$Y_{itc} = \alpha_{ic} + \lambda_{tc} + \sum_{k \in \{-6,-4,0,2,4,6\}} \beta^k d_{i,t-k,c} + \varepsilon_{itc} \tag{11}$$

where Y_{itc} is the outcome variable of interest and d_{itc} is an event indicator equal to 1 for all $t \geq c$ and workers i who we first observe signing a non-compete agreement at time $t = c$ ($i \in G_c$).

For ease of presentation, and to generate more precise estimates, we also estimate the effects of NC's aggregated over the pre- and post-treatment time periods by replacing the dynamic indicator variables $d_{i,t-k,c}$ in equation (11) with a single treatment indicator for the post-treatment period

$$Y_{itc} = \alpha_{ic} + \lambda_{tc} + \beta^{Agg} d^{Agg}_{i,t,c} + \varepsilon_{itc} \tag{12}$$

where $d^{Agg}_{i,t,c}$ equals one for treated individuals i in years $t \geq c$ and β^{Agg} is our coefficient of interest. In all of our estimates we cluster our standard errors at the individual level. Equations (11) and (12) form our main empirical specifications.

Our approach has a number of advantages. First, the inclusion of cohort-specific individual (α_{ic}) and time (λ_{tc}) fixed effects ensures that workers who were first treated in other years are never implicitly used as the control group, bypassing the "bad comparison problem" of the standard two-way fixed effects (TWFE) estimator (e.g. Baker, Larcker, and Wang 2022; Sun and Abraham 2021).

Second, while other difference-in-difference approaches also restrict the control group to the never-treated (e.g., Callaway and Sant'Anna (2021)), our approach permits the additional flexibility needed to isolate the effect of NC signage. Note that a challenge to constructing a suitable control group in our context is that we do not observe within-job variation in the treatment vari-

[16] We note that NC status is unobserved for jobs ending prior to 2017. This implies that treated workers in cohort 2015 are necessarily job stayers between 2015 and 2017. We impose the same restriction for the control group. Unobserved pre-2017 NC status also implies that some of the jobs held prior to year c for both the treatment and control group may have had a non-compete agreement. We confirm our results are not sensitive to restricting to later cohorts (that are unaffected by this issue), giving confidence that this issue is not of consequence (see section 5.3.2).

able. This implies that any worker who moves from $NC_{i,t-1} = 0$ to $NC_{i,t} = 1$ (and vice versa) is necessarily a job mover in our data, so that a change in treatment status is always accompanied by job mobility.[17] Due to the well-known fact that job mobility is associated with changes in labor market outcomes, the estimated coefficients from equation (11) or (12) using all never-treated observations as the control group would pick up both the effects of NCs and the effects of job mobility. Our procedure allows us to address this concern by flexibly defining the control group for each cohort such that we always compare movers to movers.

Finally, the inclusion of individual-cohort fixed effects also addresses the concern of selection into non-compete agreements based on time-invariant unobservable characteristics by focusing on within-worker changes. Similar stacked research designs have been used in a number of contexts, including firm responses to liability risk (Gormley and Matsa (2011)), the effects of minimum wage increases (Cengiz et al. 2019), and the effects of state-level changes to NC enforceability (Johnson, Lavetti, and Lipsitz (2023)), among others.

4.3 Identifying Assumptions

The key assumption for interpreting the coefficient estimates from equation (11) $\hat{\beta}^k, k \geq 0$ as the causal effect of signing an NC is that, for each cohort c, NC signers and those in their cohort-specific control group (the set of individuals who never sign an NC between 2013 and 2021 and who also move jobs in year c) must have similar trends in potential outcomes (i.e., a parallel trends assumption). Formally, we assume that

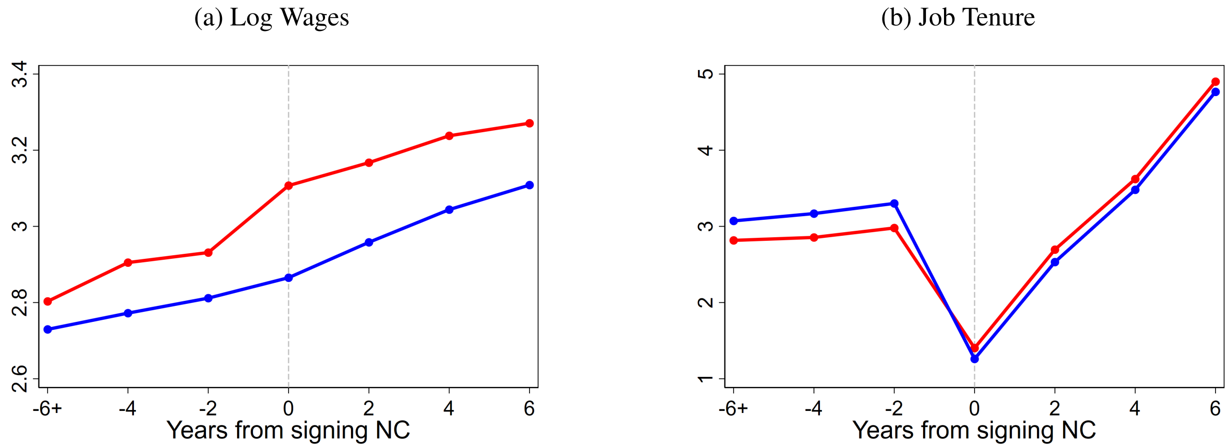
$$E[\varepsilon_{itc} | d_{itc}, \alpha_{ic}, \lambda_{tc}] = 0. \tag{13}$$

Under this assumption, the coefficients $\beta^k, k \geq 0$ from equation (11) and β^{agg} from equation (12) represent the causal effect of signing a non-compete agreement.

Since NC status is not randomly assigned, but rather is selected into based on the optimal decisions of the worker and firm, the key issue for identification is whether the non-compete dummy variable d_{itc} is uncorrelated with the error term conditional on the fixed effects. As pointed out by Ghanem, Sant'Anna, and Wüthrich (2022), parallel trends can still be justified in settings with selection into treatment based on time-invariant and time-varying unobservables but requires assumptions both on the time-series properties of the error term and the nature of the underlying selection mechanisms. Since the individual fixed effects in our specifications control for selection

[17] This problem is not simply due to the structure of the NLSY97 (which does not ask about NC status across survey years within the same job), but due to the standard timing of NC signage. NC's are most often signed upon starting a new job (Starr, Prescott, and Bishara (2021)), so we would expect very little within-job variation in the treatment variable and a high correlation with job mobility in either case.

Figure 4: Means Relative to Event Time



Note: Figure reports means of log wages and job tenure aggregated over all cohorts in the stacked data. See text for data construction. Red lines correspond to NC signers (treatment group) and blue lines to non-NC signers (control group).

based on time-invariant worker characteristics, it is selection based on time-varying unobservables that could potentially invalidate the identifying assumption given in Equation (13).

We now consider two types of selection based on time-varying unobservables and discuss how they relate to Equation (13). The first is selection based on job-level characteristics. Intuitively, certain types of jobs may be more likely to include non-compete agreements in their workers contracts, such as jobs that involve accessing a firms intangible capital, developing client relationships, managing teams, or where on-the-job training is important. If these job-level characteristics are associated with higher wages, for example, the wage estimates from equation (11) or (12) could be upward biased. In Section 5.3.1 we re-estimate our results controlling for industry, occupation, and firm size deciles, all of which are theoretically correlated with job productivity and empirically correlated with wages (Manning 2013). We find that our results are nearly identical, offering assurance that unobservable characteristics about a workers job are not biasing our estimates.

A second source of selection are shocks to worker characteristics. For equation (13) to hold, we need to rule out that workers are subject to shocks, observable to potential employers but unobservable to the econometrician, that form the basis of selection into NCs and that would have led to higher wages even in the absence of an NC. The main shock we have in mind are shocks to the workers productivity or shocks that otherwise signal productivity to employers. A worker may have just obtained a certification or formal credential that makes the worker more marketable, or may have had a good performance (e.g., high sales, favorable client reviews, etc.) that signals skill and competence to potential employers. Such shocks could make such a worker more desirable for jobs using non-compete agreements while simultaneously increasing their potential untreated wages, introducing a positive correlation between the error term and treatment dummy and thus leading to upward biased wage estimates.

We do not think this type of unobservable shock is biasing our estimates for two reasons. First, if the shock was something that affected wages in the pre-period, we would expect higher wage growth of NC signers between $t = -4$ and $t = -2$. We do not observe this pattern in our event studies. We also plot the means of our main outcome variables separately for treatment and control groups and find that both groups have similar pre-trends (Figure 4). Second, if such shocks are associated with promotions (e.g., moving into management) then we should expect that part of our baseline estimates would be explained by workers changing industries or occupations. The fact that NC signers do not have faster wage growth prior to signing and that our results hold when controlling for job-level characteristics such as occupation and industry (which partially controls for between-firm promotions) suggests that this form of selection is not of first-order importance.

As further robustness, we also try alternative empirical specifications, such as the standard two-way fixed effects estimator or using the later-treated as the control group. We leave the details of these exercises and their results to 5.3.3, but note here that our results are highly robust in each case.

5 Results

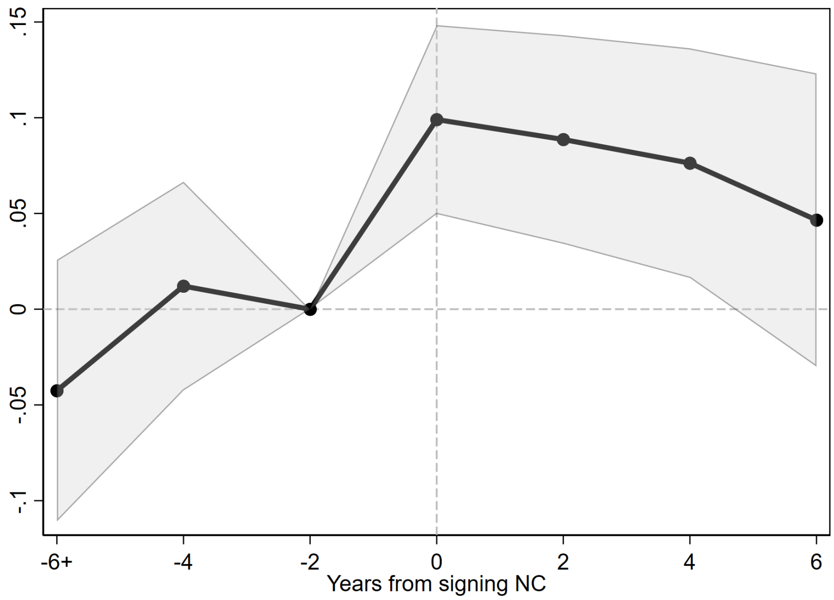
5.1 The Effect of Signing an NC on Labor Market Outcomes

We present our main results in figure 5. Panel (a) plots the dynamic wage effects following equation (11), finding that NC's raise wages sharply at the time of signing but that this effect declines monotonically with time. Specifically, NC's raise wages by 9.9 log points at the time of signing and 4.7 log points by 6 years post-signing. This result indicates that while NC signers enjoy an upfront wage premium, their annual wage growth is about 1 log point lower. This statistic is almost identical to Shi (2023)'s descriptive wage patterns for executives. Panel (b) likewise reports our dynamics estimates for job tenure. Consistent with NC's reducing job mobility, we find that NC's increase job tenure by about 0.35 years (4 months) and that this effect accumulates over time. Six years later NC signers have job tenure about 0.5 years (6 months) longer.

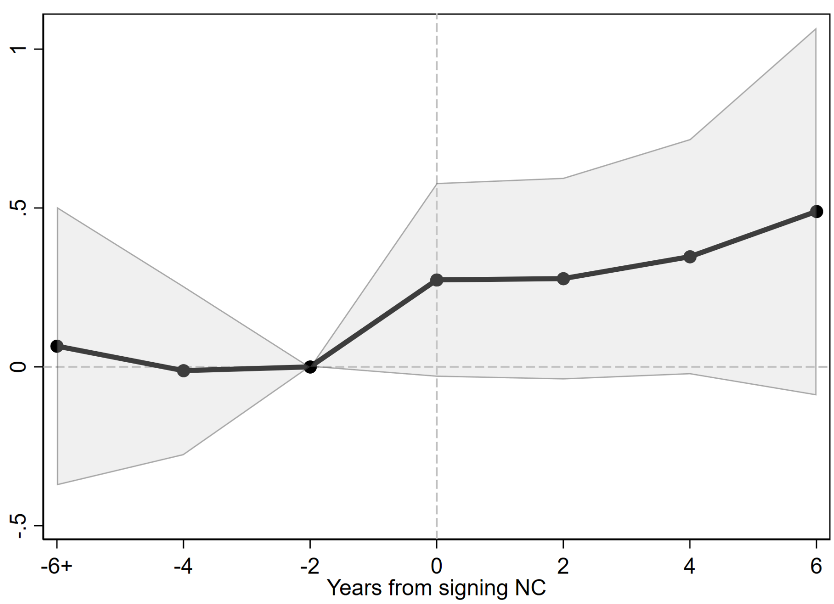
In Table 3 we report aggregated estimates from equation (12) for log wages, job tenure, and an indicator for job mobility. Aggregating across post-periods is useful as it facilitates comparisons across many outcomes and specifications and improves the precision of our estimates. Consistent with our theory and Figure 5 we find that non-compete agreements increase wages (by 9.4 log points), increase job tenure (by about 0.29 years or 3.4 months) and decrease the bi-annual rate at which workers change main employers (by 3.6 percentage points). The wage estimate is significant

Figure 5: The Dynamic Effects of Signing an NC

(a) Log Wages



(b) Job Tenure



Note: Estimates are from stacked difference-in-differences estimation (equation (11) in the text) over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who never held a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

at the 1% level, and the job mobility effects are significant at the 10% level.

These effects are also economically significant. To interpret the magnitude of these estimates, note that a wage increase of 9.4 log points is almost the same expected wage growth that the average worker would expect to receive over two years (see Table 2) or from one additional year of schooling (Card (1999)). In terms of mobility, NC's increase tenure by about 6% and decrease the instances of bi-annual changes in main employer by about 12% relative to the 2017 average. Surprisingly, we find no effect on the rate at which workers move to another employer within the same industry, though we note that the sample size of treated within-industry job movers is quite small.[18]

Table 3: The Aggregate Effects of Signing an NC

(a) Wages and Mobility

	(1) Log Wages	(2) Tenure	(3) Change Main Emp.	(4) Change Main Emp., Within Ind.
Treat × Post	0.094***	0.287*	-0.036*	0.006
	(0.022)	(0.126)	(0.016)	(0.018)
Observations	22394	22040	21614	22004
Dependent Variable Mean	2.888	2.692	0.458	0.165
Unique Treated Workers	682	680	681	679
Unique Control Workers	3300	3263	3296	3285
R^2	0.770	0.588	0.598	0.388

(b) Other Outcomes

	(1) Hours/Wk	(2) Job Dissat.	(3) Training	(4) Employer-Paid Training
Treat × Post	1.025	0.026	-0.023	-0.022
	(0.624)	(0.016)	(0.017)	(0.015)
Observations	22159	17686	22394	22394
Dependent Variable Mean	37.950	0.072	0.130	0.078
Unique Treated Workers	682	636	682	682
Unique Control Workers	3293	3039	3300	3300
R^2	0.511	0.401	0.459	0.455

Notes: This table reports estimates from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who never held a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. Standard errors are clustered by worker and reported in parenthesis. Significance codes: ***: 0.01, **: 0.05, *: 0.1.

Having established that NC's raise wages and reduce job mobility, the next panel explores

[18] Specifically, there are about 150 instances of workers with NC's changing main employers after signing an NC (after time 0). This falls by about 2/3's (to about 50 instances) when conditioning on of within-industry changes.

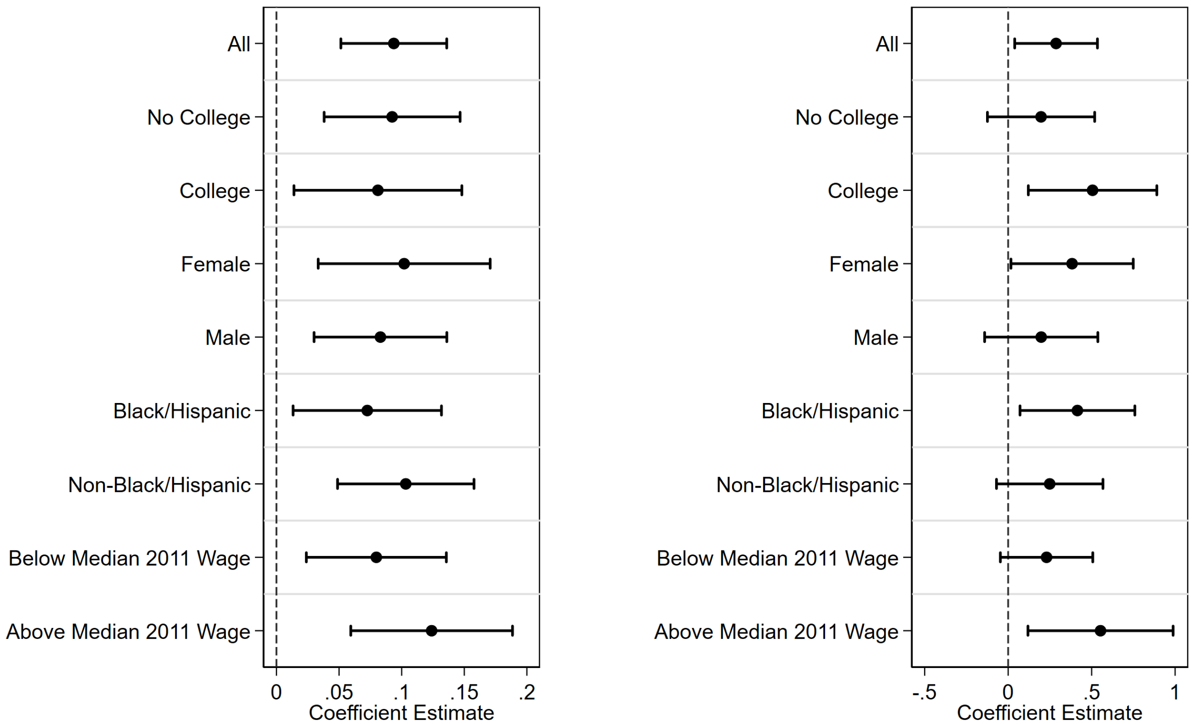
whether NC's cause other changes to a workers labour market situation, including hours worked, an indicator for self-reported job dissatisfaction, an indicator for formal training, and an indicator for whether that training was paid for by the employer.

We find no significant effect on hours worked or job satisfaction. Somewhat surprisingly, we also find that non-compete agreements have no impact on the incidence of employer-provided training. This result runs contrary to the theoretical expectation that non-compete agreements mitigate the hold-up problem, thereby *increasing* employer-provided investments. There are two ways to rationalize this result. It could be the case that firms use NC's as a way to avoid outside competition without investing in worker productivity. But it could equally be the case that non-compete agreements do raise employer provided investments, just in ways that are difficult to measure. For example, firms may invest in their workers through informal on-the-job training where workers learn and develop skills through the tasks they are assigned and interactions with their team. Since investment in human capital is unobserved, it is not clear to what extent this variable accurately captures the total investments firms are making in their workers. The fact that less than 10% of workers report receiving any kind of formal training in 2017 (see Table 2) suggests this may not be a holistic measure of firm investment. Moreover, formal training is reported as an indicator (extensive margin), which abstracts from any notion of the intensity of training (intensive margin).

Since measuring firm investment directly is potentially difficult, our theory suggests an alterative: That one can infer the effects of NCs through observed wage dynamics. Specifically, if workers receive no training from an NC and are not compensated for restrictions on future mobility, then NCs should have no effect on period 0 wages and should decrease future wage growth, as workers are less able to command wage increases through credible outside offers. If workers receive no training from an NC but receive a compensating wage differential for the restrictions on future mobility, then NCs should raise wages in period 0 but still decrease future wage growth. If, on the other hand, NCs encourage human capital investments, then the effect of NCs on wage growth is ambiguous. The post-signing wage profile will be less negative if firms respond to NCs by investing in worker human capital and share those rents with workers (see Kodama, Kambayashi, and Izumi (2025) for a related discussion). The fact that wages are still 4.7 log points higher even 6 years after signing seems to suggest that a pure compensating differential story is unlikely.

Figure 6: The Effect of Signing an NC: Heterogeneity Across Worker Groups

(a) Log Wages (b) Tenure



Note: Coefficient estimates are from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who never held a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

5.2 Heterogeneity

5.2.1 Worker Demographics

A policy relevant question is whether these average effects are experienced equally by all workers. For example, one may be concerned that while NC's raise wages for workers on average, they harm certain subgroups. This is especially relevant in light of the discussion and enactment of banning non-compete agreements for low-skill or low-wage worker (e.g., Lipsitz and Starr (2022)).[19]

Figure 6 reports aggregated estimates for different subgroups of workers, grouping workers by education, sex and race. In light of the emphasis in the political sphere surrounding NC's and low-wage workers, we also group workers by whether they had above/below median wages in 2011

[19] Articles in the popular press also often claim that non-compete agreements are exploitative for low-income workers. See for example this article about non-compete agreements in the fast-food industry: https://www.nytimes.com/2014/10/15/upshot/when-the-guy-making-your-sandwich-has-a-noncompete-clause.html

(just prior to our sample window).

The estimated wage effects are remarkably stable across subgroups, ranging from 7.3 log points (Black/Hispanic) to 12.4 log points (workers with above median pre-sample wages). While the estimated tenure effects are more pronounced for certain subgroups, most notably comparing by education or pre-sample wages, these tables give little evidence that non-compete agreements have systematically adverse implications for certain subgroups.

However, these aggregate wage effects hide important dynamics. In Figure 7 we run our dynamic event study by worker subgroup and find that, while NC's lead to higher wage *levels* for all types of workers over the first 6 years, there are systematic differences in the relative wage *trajectories* across subgroups. For example, male workers tend to have a larger up front wage premium than females (11.0 log points vs 8.6 log points), but lower subsequent wage growth (the wage effect 6 years later is 1.0 log point for males and 9.5 log points for females). More concerning is that we find strong negative wage growth effects for workers with no college, low pre-sample wages, or who are black/hispanic. In contrast, college-educated, high-wage and non-black/hispanic workers have flat (or even increasing) wage profiles.

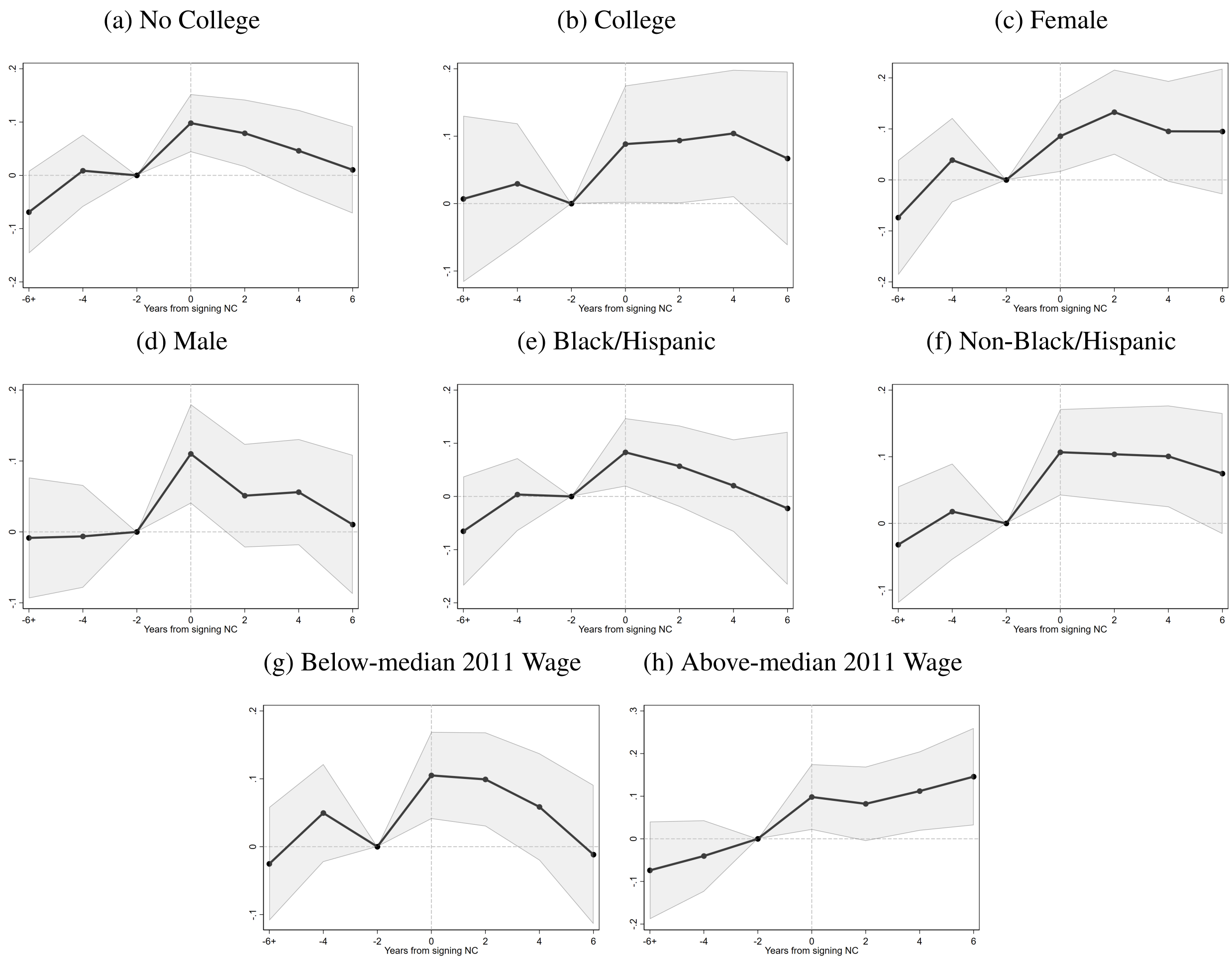
5.2.2 Movers vs Stayers

To better understand the mechanisms driving these wage patterns (upfront wage premia followed by lower wage growth) we separately analyze NC signers who were job-stayers vs job-movers in the post-period. In particular, a worker is a treated-stayer in cohort c if they sign an NC at time c and remain in their $t = c$ job for all observed periods $t > c$. Similarly, a worker is a treated-mover in cohort c if they sign an NC at time c but we observe them leaving their $t = c$ job in the post-period. We compare these two groups of treated workers to the entire control group (all never-treated workers who are also movers at time c), but we note that the results are very similar if we define the control group as having the same mobility patterns (i.e. use control-movers and control-stayers as the comparison groups).[20]

We find that both the treated-movers and the treated-stayers experience positive wage effects, but that these effects are larger among the stayers. Workers who sign an NC at time 0 but leave that job in the post period (the treated-movers) have wages 4.3 log points higher at the time of signing and 4.4 log points higher 6 years later relative to the control group. Moreover, there is no clean break in the trend at the time of signing. In contrast, those who sign an NC at time 0 and remain in that job for the observed post-period have wages 12.1 log points higher at the time of signing and 3.3 log points higher 6 years later. Therefore, job stayers do experience lower wage growth

[20]Note that there is no observed post-period for the 2021 cohort. As a default, we include the 2021 cohort in the stayers group to retain sample size. However the results are again very similar if we simply exclude the 2021 cohort from this exercise.

Figure 7: The Dynamic Wage Effects of Signing an NC by subgroup

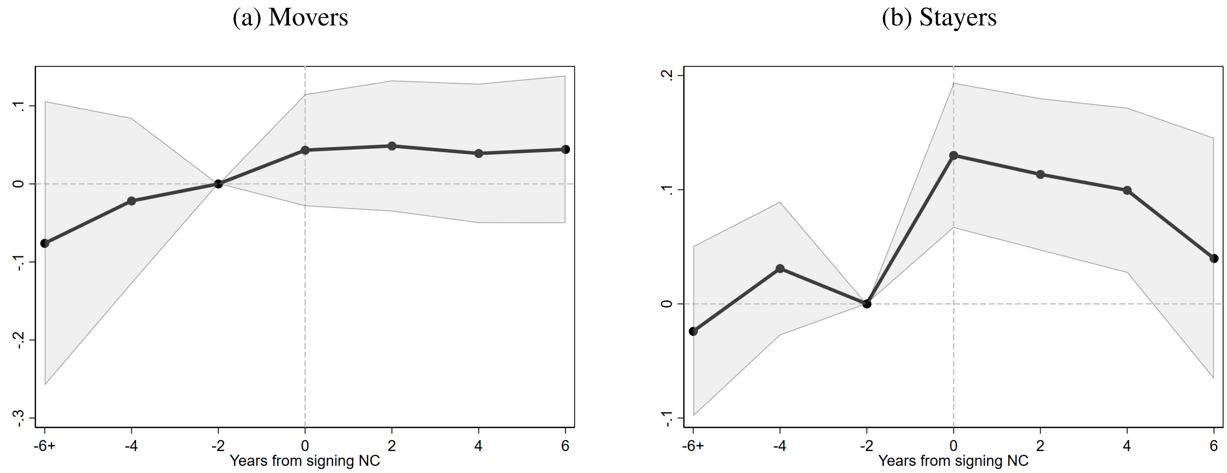


Note: Estimates are from stacked difference-in-differences estimation (equation (11) in the text) over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who never held a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

than the control group (the difference is smaller when comparing to control-stayers), yet still have higher wages 6 years later.

The fact that positive wage effects are more concentrated among those who remain in their jobs is interesting as it seems to contradict the notion that NC's trap workers in low-paying jobs.

Figure 8: The Effect of Signing an NC: Movers vs Stayers



Note: Coefficient estimates are from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who never held a NC during the event window and who also changed jobs between year c and the preceding survey year. For each cohort c, movers are workers who change main employer again the post-period. Stayers are those who remain in their $t = 0$ job in the post-period. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

5.3 Robustness

5.3.1 Job productivity as an omitted variable

Our main identifying assumption is that the error term in equations 11 and 12 are uncorrelated with the treatment dummy. One concern with this assumption is that, while we may be controlling for systematic differences in NC usage across *workers*, we are not doing so across *jobs*. NC usage could be correlated with firm productivity, introducing an omitted variable problem.

While our worker-level data prevents us from controlling for firm productivity directly, we re-estimate our aggregate effects from Table 3 sequentially controlling for industry, occupation, and firm size decile fixed effects. The industry and occupation fixed effects control for the possibility that non-compete agreements are used more intensively in certain high-paying sectors. Firm size is strongly correlated with firm productivity in standard labor market models (e.g., Manning (2013)), and we confirm it is strongly correlated with wages in the NLSY97 data (see Figure A2). We plot the results in Figure A3, where the black circle markers in Figure A3 report our baseline estimates, while the next three lines report estimates sequentially adding industry, occupation, and then finally firm size decile fixed effects.

We find that controlling for these detailed job-level characteristics hardly changes our results. The first panel reports our wage estimates. We find that our estimated wage effect falls only slightly, from 9.4 to 8.5 log points in the most saturated model. The fact that our results hardly change even with this rich set of controls gives confidence that the potential omitted variable problem (of NC's being correlated with other job-level characteristics that positively effect wages) is not driving our wage estimates.

In the second and third panel we see that our job mobility estimates are also robust to controlling for these job-level characteristics. The tenure effect only changes from 0.29 to 0.24 years and the effect on the rate at which workers change main employers changes from -3.6 to -4.1 percentage points. Overall, we conclude that our baseline estimates are unlikely to be driven by unobserved job-level characteristics.

5.3.2 Data limitations on NC usage

Another possible objection is that our assumptions on the timing of NC signage is invalid. As discussed in Section 4.1, since we only observe NC status starting in 2017, we assume that the NC was signed at the beginning of the employment relationship, imposing that NC status does not change with job tenure. A potential violation of this would be if non-compete clauses were tied to promotions or raises within the same job. Starr, Prescott, and Bishara (2021) find that this happens very infrequently, with almost all non-compete agreements being signed at the beginning of the employment relationship.

A related data limitation is the fact that, as discussed in Section 4.2, we do not observe NC status in the pre-period for cohorts 2015 and 2017. To address this issue formally, we sequentially remove cohorts 2015 and 2017 from the sample and observe how our estimates change. Specifically, we re-calculate our aggregate estimates (1) using only cohorts 2017-2021, and (2) using only cohorts 2019-2021. In the latter case, restricting to these years and cohorts means we only use observations for which we observe NC status before and after the job move, providing more transparent estimates. The results from this exercise are given in Figure A4. Reassuringly, we find that our wage and job mobility rate estimates are not significantly different and if anything increase as we remove cohorts 2015 and 2017. Similarly, the point estimates for tenure are nearly identical. This exercise demonstrates that our results are not driven by measurement error in NC status and also gives confidence that our results are quite stable across cohorts.

Finally, non-compete agreements are often bundled with other employment restrictions, such as non-disclosure agreements (NDAs) (Balasubramanian, Starr, and Yamaguchi (2024)). To the extent this is true in our data, we acknowledge that our estimates identify the causal effects of all of these restrictions simultaneously rather than NCs in isolation.

5.3.3 Alternative estimation methods: Later-treated and TWFE

Even though we control for individual fixed effects, one may still have concerns about selection. For example, workers who sign NC's may have higher returns on employer-provided investment, and this might not be fully captured by an additively separable worker fixed effect. To address this potential concern, we re-estimate equation 11, this time defining the control group for each cohort c as job-movers at time c who do not have an NC at time c but who do sign an NC in a later survey year $t > c$ (later-treated job-movers). In this comparison, we compare NC signers to NC signers, exploiting only variation in the timing of signage. We plot the results in Figure A5.

Relative to our baseline estimates (Figure 7), we observe a larger initial wage effect but stronger negative wage growth in the post-period. Given that the later-treated are necessarily workers who move into NC contracts in the post-period, we would expect them to have larger wage increases and therefore the sharper negative wage growth in this alternative set-up in unsurprising. Although the wage effects after time zero are difficult to interpret, the fact that the initial wage effect is even stronger in this set-up gives assurance that our main estimates are not being driven by some fundamental difference between those who do and do not sign non-compete agreements.

Finally, for completeness we present two sets of estimates from the standard two-way fixed effect estimator (TWFE). Here, we step away from our stacked research design and do not restrict attention to job movers. We then estimate the following equations

$$w_{it} = \alpha_i + \lambda_t + \beta^{TWFE-d} d_{it}^{Agg} + \varepsilon_{it} \tag{14}$$

$$w_{it} = \alpha_i + \lambda_t + \beta^{TWFE-NC} NC_{it} + \varepsilon_{it} \tag{15}$$

where w_{it} is log wages for individual i in year t, NC_{it} is the NC status in individual i's main employer at time t, and as before d_{it}^{Agg} is an indicator variable equal to one beginning in the first year the worker signs an NC, and zero otherwise.

The fundamental difference between equation 14 and our main specification in equation 12 is that here the control group is effectively any worker not currently holding an NC, as opposed to restricting to the never-treated job movers in 12. Both of these regressions use d_{it}^{Agg} as the independent variable, which is an *absorbing* treatment variable. Equation 15 further differs in that it uses current NC status NC_{it} as the independent variable, exploiting within-worker transitions both in and out of jobs with non-compete agreements. We focus on the 2017-2021 time period where such variation in NC_{it} is observed.

We report the estimates from equation 14 for the entire sample and across subgroups and find nearly identical results (see Figure A6a). The aggregate wage effect of signing an NC is 9.5 log points (relative to 9.4 in our baseline case, see Table 3) and there are similar patterns across subgroups. Specifically, as in our baseline estimates, workers with a college degree, who are non-black/hispanic or who had above-median wages in 2011 appear to experience larger wage gains from signing and NC than their counterparts. For example, the NC's increase wages by 11.0 log points for high-wage workers and 8.8 log points for low-wage workers. Finally, we find a smaller yet still significantly positive wage effect using equation 15. The aggregate wage effect under this specification is about 5.8 log points. Again, we find this estimate is larger for high-wage workers (8.9 log points) than low-wage workers (4.2 log points).

6 Conclusion

Economists have long been interested in the factors that promote human capital development. Schooling is often considered as an important determinant of an individual's productivity, but there are many skills that can only be learned on the job. The market for employer-provided training, however, suffers a well-known failure: employers do not have an incentive to provide transferable skills if they later need to compensate workers for their increased productivity (e.g. Becker 1962; Acemoglu and Pischke 1999). In this paper, we develop a model illustrating how non-compete agreements can be used to mitigate this market failure, at the risk of generating ex-post allocative inefficiencies. We explicitly characterize the conditions under which workers will sign a non-compete agreement, an important omission in the theoretical literature to date.

While previous empirical research has examined the causal effects of non-compete regulation, we study the causal effects of signing a non-compete agreement on various labor market outcomes. As expected, we find that signing a non-compete agreement lowers job mobility, raising job tenures by 6% and lowering rates of job-to-job transitions by 12%. In contrast to the negative wage effects of stricter enforcement of non-compete agreements, we show that signing a non-compete agreement raises wages by 9% within one year and that these positive effects persist up to six years after the agreement is signed. Workers across socio-economic backgrounds gain higher wages from signing non-compete agreements, consistent with our theoretical framework that non-compete agreements are only used if they are mutually beneficial to workers and firms. Our findings highlight an important distinction between signing a non-compete agreement and broader enforcement policies, similar to the well-studied union literature where the effects of Right-to-Work laws differ from the effects of joining a union.

Overall, we find that signing a non-compete agreement leads to higher career earnings, aligning with both a compensating wage differential and returns to greater human capital accumulation. However, despite theoretical predictions that non-compete agreements should encourage employer investment in worker training, we find no evidence of increased formal training. This observation raises the question of whether non-compete signers become more productive through less observable channels, such as receiving more mentoring or building stronger relationships with managers.

Understanding these mechanisms could provide deeper insight into how non-compete agreements influence long-term worker productivity and career trajectories.

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A Appendix

A.1 Social Planner's Solution: Existence, Uniqueness, Comparative Statics

We show that for every parameter set (r,ρ,λ) where $r>\rho$, the surplus function $\mathscr{S}(i)=-\frac{1}{2}i^2+ri+\frac{e^{-\lambda\Delta i}}{\lambda}$ admits exactly one maximizer $i^\star>0$. The first derivative of the surplus function is $\mathscr{S}'(i)=r-i-\Delta e^{-\lambda\Delta i}$. At the origin, the derivative is $\mathscr{S}'(0)=r-\Delta=\rho>0$, implying that zero investment is never optimal. As $i\to\infty$, the exponential term vanishes and $\mathscr{S}'(i)\sim r-i\to-\infty$. Since $\mathscr{S}'(i)$ is continuous and changes sign from positive to negative, it must equal zero at least once for some $i>0$.

To prove uniqueness, we examine the second derivative, $\mathscr{S}''(i)=-1+\lambda\Delta^2e^{-\lambda\Delta i}$. This second derivative is strictly decreasing in i.

- If $\lambda\Delta^2\leq 1$, then $\mathscr{S}''(i)<0$ for all $i\geq 0$. This means $\mathscr{S}(i)$ is globally strictly concave, and the critical point identified by the first-order condition is the unique global maximizer.

- If $\lambda\Delta^2>1$, then $\mathscr{S}''(i)$ starts non-negative at $i=0$ and crosses zero exactly once at an inflection point $i_0>0$. For all $i>i_0$, the function $\mathscr{S}(i)$ is strictly concave. Because $\mathscr{S}'(0)=\rho>0$ and $\mathscr{S}'(i)$ is non-decreasing on the interval $[0,i_0]$ (since $\mathscr{S}''(i)\geq 0$ on this interval), any solution to $\mathscr{S}'(i)=0$ must lie in the region (i_0,∞) where the function is strictly concave.

Thus, in all cases, there is a single critical point which is the unique global maximizer, $i^\star$.

Corollary 2. *At the optimal investment level $i^\star$, the surplus function must be locally concave. We prove that the second-order condition is strictly satisfied, i.e., $\mathscr{S}''(i^\star)<0$.*

Proof. Suppose for contradiction that $\mathscr{S}''(i^\star)=-1+\lambda\Delta^2e^{-\lambda\Delta i^\star}\geq 0$. As shown in Appendix A.1, the function $\mathscr{S}''(i)$ is strictly decreasing in i. This implies that for all $i\in[0,i^\star)$, it must be that $\mathscr{S}''(i)>\mathscr{S}''(i^\star)\geq 0$. Therefore, the first derivative $\mathscr{S}'(i)$ must be strictly increasing on the interval $[0,i^\star]$. This leads to a contradiction, since we know $\mathscr{S}'(0)=\rho>0$ and $\mathscr{S}'(i^\star)=0$. A function cannot start at a positive value and be strictly increasing to a value of zero. Hence, the premise is false and it must be that $\mathscr{S}''(i^\star)<0$. ∎

We now analyze how the optimal investment and quit probabilities respond to changes in the economic environment.

Proposition 11 (Comparative Statics of Investment)**.** *The optimal investment $i^\star$ responds to parameter changes as follows: (i) it is strictly increasing in internal productivity, $\partial i^\star/\partial r>0$; (ii) it is strictly increasing in the outside option parameter, $\partial i^\star/\partial\lambda>0$; and (iii) its response to external productivity ρ is ambiguous, with $\partial i^\star/\partial\rho\gtreqless 0$ if and only if $\lambda\Delta i^\star\lesseqgtr 1$.*

Proof. Let $\phi:=\lambda\Delta i^\star$. Applying the implicit function theorem to Equation 2, we have $\partial i^\star/\partial x=-F_x/F_i$, where $F(i,x)=r-i-\Delta e^{-\lambda\Delta i}$. As shown in Corollary 2, the second-order condition ensures that the denominator $F_i=\mathscr{S}''(i^\star)$ is strictly negative. The signs of the comparative statics are therefore determined by the signs of the partial derivatives $F_x=\partial F/\partial x$:

$$\begin{aligned}F_r&=1-e^{-\phi}(1-\phi)>0,\\ F_\lambda&=\Delta^2i^\star e^{-\phi}>0,\\ F_\rho&=e^{-\phi}(1-\phi).\end{aligned}$$

Since $F_i<0$, the signs of $\partial i^\star/\partial r$ and $\partial i^\star/\partial\lambda$ are positive. The sign of $\partial i^\star/\partial\rho$ depends on the term $(1-\phi)$, proving the proposition. ∎

Higher internal productivity (r) and a less favorable distribution of outside options (higher λ, meaning lower mean $1/\lambda$) both unambiguously increase the incentive to invest. The effect of higher external productivity (ρ) depends on whether quits are common ($\phi < 1$) or rare ($\phi > 1$).

Corollary 3 (Comparative Statics of the Quit Probability)**.** *The equilibrium quit probability, $q^\star = e^{-\lambda \Delta i^\star}$, is strictly decreasing in internal productivity r and in the outside option parameter λ. The effect of external productivity ρ is ambiguous.*

Proof. Let $\phi := \lambda \Delta i^\star$. The derivative is $dq^\star/dx = -q^\star(d\phi/dx)$, so its sign is opposite to that of $d\phi/dx = d(\lambda \Delta i^\star)/dx$.

- For r: $d\phi/dr = \lambda\Delta(\partial i^\star/\partial r) + \lambda i^\star > 0$. Thus, $dq^\star/dr < 0$.
- For λ: $d\phi/d\lambda = \lambda\Delta(\partial i^\star/\partial \lambda) + \Delta i^\star > 0$. Thus, $dq^\star/d\lambda < 0$.
- For ρ: $d\phi/d\rho = \lambda\Delta(\partial i^\star/\partial \rho) - \lambda i^\star$. The sign is ambiguous as it involves the difference of two terms, with $\partial i^\star/\partial \rho$ itself having an ambiguous sign.

∎

A.2 Necessary and Sufficient Conditions for a Non-Zero Wage with a Non-Compete

We analyze the conditions under which the firm offers a strictly positive wage, $w_1 > 0$, as part of an optimal contract with a non-compete agreement. Let $\Sigma_1(w_1)$ denote the joint surplus. Since $\Sigma_1'(0) = 0$, any move from $w_1 = 0$ raises surplus only if $\Sigma_1''(0) > 0$. Equivalently, if we define $H(w_1) \equiv \frac{d\Sigma_1}{dw_1}(w_1)$, then $H(0) = 0$ and local convexity at zero requires $H'(0) > 0$.

Recall that the firm's investment schedule is

$$i_1(w_1) \;=\; r\big(1 - e^{-\lambda w_1}\big),$$

so in particular $i_1(0) = 0$ and hence $\Sigma_1(0) = 0$. The first-order condition for an interior optimum is

$$H(w_1) = (\beta - 1)\big(1 - e^{-\lambda w_1}\big) + \lambda\left(r\, i_1(w_1) - w_1\right) e^{-\lambda w_1},$$

with $H(0) = 0$.

Proposition 12 (Condition for a Positive Wage with a Non-Compete)**.**

(a) A strictly positive equilibrium wage, $w_1^* > 0$, exists if and only if

$$\beta - 2 + \lambda r^2 \;>\; 0, \quad \textit{i.e.} \quad \beta > 2 - \lambda r^2.$$

(b) A sufficient condition for a positive wage for any $\beta \geq 0$ is

$$\lambda r^2 > 2.$$

Proof. Substitute $i_1(w_1) = r(1 - e^{-\lambda w_1})$ into $H(w_1)$:

$$H(w_1) = (\beta - 1)\big(1 - e^{-\lambda w_1}\big) + \lambda\left(r^2 - r^2 e^{-\lambda w_1} - w_1\right) e^{-\lambda w_1}.$$

Differentiate with respect to w_1:

$$H'(w_1) = \lambda(\beta-1)e^{-\lambda w_1} + \lambda\left(r^2\lambda e^{-\lambda w_1} - 1\right)e^{-\lambda w_1} + \lambda\left(r^2 - r^2 e^{-\lambda w_1} - w_1\right)\left(-\lambda e^{-\lambda w_1}\right).$$

Evaluating at $w_1 = 0$:

$$\begin{aligned} H'(0) &= \lambda(\beta-1) + \lambda(\lambda r^2 - 1) + \lambda(r^2 - r^2 - 0)(-\lambda) \\ &= \lambda\beta - \lambda + \lambda^2 r^2 - \lambda \\ &= \lambda\left(\beta - 2 + \lambda r^2\right). \end{aligned}$$

Since $\lambda > 0$, $H'(0) > 0$ iff $\beta - 2 + \lambda r^2 > 0$, proving part (a).

For part (b), we require $\beta > 2 - \lambda r^2$ to hold even for the minimum possible value of patience, $\beta = 0$. This gives the condition $0 > 2 - \lambda r^2$, which simplifies to $\lambda r^2 > 2$. This ensures $H'(0) > 0$ for all $\beta \geq 0$, completing the proof. ■

A.3 Existence of the Boundary Wage

Here, we formally prove the existence of the boundary wage, w_{bound}. This is the wage satisfying the fixed-point condition $w = r\, i_0(w)$, where $i_0(w)$ is the firm's optimal investment response.

Proposition 13 (Existence and Positivity of the Boundary Wage)**.**

1. *There exists at least one non-negative boundary wage* $w_{\text{bound}} \geq 0$ *solving the equation* $w = r\, i_0(w)$.
2. *A strictly positive solution* $w_{\text{bound}} > 0$ *exists if and only if* $r\lambda\,(r-\rho) > 1$.

Proof. We define the function $\Phi(w) = r\, i_0(w)$ and seek a fixed point where $w = \Phi(w)$.

(a) Existence of a non-negative fixed point.

The firm's optimal investment $i_0(w)$ is the unique root of the first-order condition $H(i_0, w) = 0$, where

$$H(i,w) = r\left(1 - e^{-\lambda(w-\rho i)}\right) - (r i - w)\,\lambda\rho\, e^{-\lambda(w-\rho i)} - i.$$

The function $H(i,w)$ is twice continuously differentiable. Strict concavity of the firm's profit with respect to i is confirmed by the sign of $\partial H/\partial i$:

$$\frac{\partial H}{\partial i} = -2\lambda\rho r e^{-\lambda(w-\rho i)} - (ri - w)(\lambda\rho)^2 e^{-\lambda(w-\rho i)} - 1 < 0.$$

Given that $H(0,w) > 0$ for $w > 0$ and $H(i,w) \to -\infty$ as $i \to \infty$, the concavity of H in i guarantees a unique positive root $i_0(w)$ for any $w > 0$. The Implicit Function Theorem then ensures that $i_0(w)$ is a continuous function. Hence, $\Phi(w) = r\, i_0(w)$ is also continuous.

To prove the existence of a fixed point, we use Brouwer's Fixed Point Theorem. Let $i_{\text{bench}} \geq 0$ be the unique solution to $i = r(1 - e^{-\lambda(r-\rho)i})$. Define the set $S = [0, W_{\max}]$, where $W_{\max} = r\, i_{\text{bench}}$. This set is non-empty, compact, and convex. A rigorous analysis of the properties of $H(i,w)$ shows that for any $w \in S$, the root $i_0(w)$ satisfies $0 \leq i_0(w) \leq i_{\text{bench}}$, which ensures that Φ maps the set S into itself. Since $\Phi : S \to S$ is a continuous function on a compact, convex set, a fixed point $w_{\text{bound}} \in S$ must exist. This establishes part (a).

(b) Condition for a strictly positive fixed point.

We know $w = 0$ is always a fixed point since $i_0(0) = 0$ and thus $\Phi(0) = 0$. A strictly positive fixed point

$w_{\text{bound}} > 0$ is guaranteed to exist if there is another fixed point besides zero. Since $W_{\max} = r\, i_{\text{bench}}$ is also a fixed point, a positive solution exists if and only if $W_{\max} > 0$, which requires $i_{\text{bench}} > 0$.

A positive solution $i_{\text{bench}} > 0$ to the equation $i = r(1 - e^{-\lambda(r-\rho)i})$ exists if and only if the slope of the right-hand side is greater than the slope of the left-hand side (which is 1) at the origin $i = 0$. The slope of the right-hand side at $i = 0$ is:

$$\frac{d}{di} r\left(1 - e^{-\lambda(r-\rho)i}\right)\bigg|_{i=0} = r\lambda\,(r-\rho).$$

Hence, $i_{\text{bench}} > 0$ if and only if $r\lambda\,(r-\rho) > 1$. This is the necessary and sufficient condition for the existence of a strictly positive boundary wage, which completes the proof of part (b). ■

A.4 Properties of the Unconstrained Optimum Without a Non-Compete When $\beta = 1$

This section proves two key properties of the unconstrained optimal wage without a non-compete, w^*_{unc}, for the case of a perfectly patient worker ($\beta = 1$).

Proposition 14. *At any unconstrained optimal wage w^*_{unc} that maximizes the joint surplus:*

1. *The slope of the investment response function is strictly positive: $\frac{di_0}{dw_0} > 0$.*
2. *The optimal wage exceeds the worker's marginal product: $w^*_{unc} > ri_0(w^*_{unc})$.*

The proof for the first point proceeds by contradiction. The second point follows directly from the first.

Proof. The firm's choice of investment i_0 for a given wage w_0 is defined implicitly by the first-order condition of its own profit-maximization problem, which we can write as $G(i_0, w_0) = 0$:

$$G(i_0, w_0) \equiv r\left(1 - e^{-\lambda(w_0-\rho i_0)}\right) - \lambda\rho(ri_0 - w_0)e^{-\lambda(w_0-\rho i_0)} - i_0 = 0 \tag{16}$$

By the Implicit Function Theorem, the slope of the investment response function, $i_0(w_0)$, is:

$$\frac{di_0}{dw_0} = -\frac{\partial G/\partial w_0}{\partial G/\partial i_0} \tag{17}$$

The denominator, $\partial G/\partial i_0$, is the second derivative of the firm's profit with respect to investment. The second-order condition for a maximum requires $\partial G/\partial i_0 < 0$. Therefore, the sign of the slope is determined by the sign of the numerator:

$$\text{sign}\left(\frac{di_0}{dw_0}\right) = \text{sign}\left(\frac{\partial G}{\partial w_0}\right)$$

Calculating the numerator yields:

$$\frac{\partial G}{\partial w_0} = \lambda e^{-\lambda(w_0-\rho i_0)}\left[r + \rho + \lambda\rho(ri_0 - w_0)\right] \tag{18}$$

Thus, the sign of the slope $\frac{di_0}{dw_0}$ is determined by the sign of the term in the brackets. We now prove by contradiction that an unconstrained optimum cannot exist where $di_0/dw_0 < 0$. An unconstrained optimum w^*_{unc} must satisfy the first-order condition for maximizing the joint surplus. For $\beta = 1$, this condition is:

$$\lambda(ri_0 - w^*_{unc}) + \rho\left(\frac{di_0}{dw_0}\right)\bigg|_{w^*_{unc}} = 0 \tag{19}$$

Let us hypothesize that an unconstrained optimum w^*_{unc} exists at a point where the slope of the investment curve is negative, i.e., $\frac{di_0}{dw_0} < 0$. Two conditions would have to be met simultaneously at this point.

We can rearrange the first-order condition:

$$\lambda(ri_0 - w^*_{unc}) = -\rho\left(\frac{di_0}{dw_0}\right)$$

Since we hypothesized $\frac{di_0}{dw_0} < 0$ and we know $\rho > 0$, the right-hand side of the equation must be strictly positive. This implies the left-hand side must also be positive. Since $\lambda > 0$, we must have:

$$ri_0 - w^*_{unc} > 0$$

The mathematical condition required for the slope $\frac{di_0}{dw_0}$ to be negative is that the following term is negative:

$$r + \rho + \lambda\rho(ri_0 - w^*_{unc}) < 0$$

We have reached a contradiction. Therefore, our initial hypothesis is false. Any unconstrained optimum must satisfy $\frac{di_0}{dw_0} \geq 0$.

Proof that $w^*_{unc} > ri_0$ This result now follows directly from the first-order wage equation. Rearranging to solve for w^*_{unc} gives:

$$w^*_{unc} = ri_0 + \frac{\rho}{\lambda}\left(\frac{di_0}{dw_0}\right) \tag{20}$$

Therefore, the unconstrained optimal wage is equal to the worker's marginal product plus a strictly positive term, which proves that $w^*_{unc} > ri_0$.

■

A.5 Appendix Tables and Figures

Table A1: Variables Dictionary

Variable	Definition
Job Mobility	
Tenure (Yrs)	Time in years working at a job
1(Main Job Separation btwn 2017 and 2019)	Worker transitions to a new main job, becomes unemployed, or exits the labor force
1(Main Job Mobility btwn 2017 and 2019)	Worker transitions to a new main job
1(Within-Industry Job Mobility btwn 2017 and 2019)	Worker transitions to a new main job within the same industry
Wages and Wage Growth	
Log(Starting Wage)	Log of starting wage for 2017 main job
Log(Wage in 2017)	Log of wage in 2017 for main job
$Log(Wage_{2017}) - Log(Wage_{2015})$	Difference between log of wage in 2017 and log of wage in 2015 for 2017 main job
$Log(Wage_{2019}) - Log(Wage_{2017})$	Difference between log of wage in 2019 and log of wage in 2017 for 2017 main job
Demographics	
Age	Computed as the survey year minus birth year
1(Male)	The respondent is male
1(High School Degree or Higher)	The respondent has attended at least 12 years of school
1(Bachelors Degree or Higher)	The respondent has attended at least 16 years of school
ASVAB Percentile	Percentile achieved on ASVAB test
1(Black)	The respondent is Black
1(Hispanic)	The respondent is Hispanic
Wage Bargaining and Negotiation	
1(Possible to Keep Previous Job)	The respondent was able to keep previous job when offered their main job
1(Negotiate Job Offer)	The respondent negotiated their main job offer
Training	
1(Received Some Training)	Received training in a survey year
1(Received Training Run by Employer)	Received training ran by employer in a survey year
1(Received On-Site Training by Non-Employer)	Received training on-site by non-employer in a survey year
1(Employer Paid for Training)	Employer paid for training in a survey year
1(Employer Paid for Mandatory Training)	Employer paid for mandatory training in a survey year
1(Employer Paid for Voluntary Training)	Employer paid for voluntary training in a survey year
Job Tasks	
1(Use Math Skills Frequently)	Respondent claims to use math at least once a week at main job
1(Supervise Frequently)	Respondent claims to supervise more than half the time at main job
1(Problem Solve Frequently)	Respondent claims to problem solve at least once a week at main job
Other Firm Characteristics	
1(Dislike Job)	Respondent claim to 'Dislike it somewhat' or 'Dislike it very much' when asked about main job
1(Unionized Worker)	Respondent's contract was negotiated by a union or employee association for main job
Firm Size	Number of employees at respondent's main job

Table A2: Confidence in Non-Compete Status by Industry

Industry	NC Confidence			Total	Share Very Confident
	Very Confident	Somewhat Confident	Not Confident		
AGRICULTURE, FORESTRY AND FISHERIES	33	0	1	34	0.97
CONSTRUCTION	293	14	4	311	0.94
OTHER SERVICES	152	9	2	163	0.93
TRANSPORTATION AND WAREHOUSING	211	12	7	230	0.92
EDUCATIONAL, HEALTH, AND SOCIAL SERVICES	1169	93	8	1270	0.92
ACS SPECIAL CODES	191	16	1	208	0.92
UTILITIES	29	3	0	32	0.91
INFORMATION AND COMMUNICATION	86	8	0	94	0.91
FINANCE, INSURANCE, AND REAL ESTATE	312	29	3	344	0.91
ENTERTAINMENT, ACCOMODATIONS, AND FOOD SERVICES	422	38	3	463	0.91
PUBLIC ADMINISTRATION	232	21	1	254	0.91
MANUFACTURING	412	42	4	458	0.90
MINING	24	3	0	27	0.89
WHOLESALE TRADE	104	12	1	117	0.89
RETAIL TRADE	458	49	5	512	0.89
PROFESSIONAL AND RELATED SERVICES	560	64	7	631	0.89
TOTAL	4688	413	47	5148	0.91

Note:
The sample consists of NLSY97 respondents who report non-compete, non-compete confidence, and industry status in their 2017 main job. Rows are organized by share “Very Confident” in response to the non-compete confidence question. Active duty military respondents are dropped.

Table A3: Estimated Effects of NCs using the 2019 Cross-Section

Panel 1: Wages and Wage Growth

Dependent Variables:	Log(Wage)			Wage Growth		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	0.305***	0.220***	0.145***	0.005	0.006	0.028
	(0.051)	(0.044)	(0.052)	(0.033)	(0.033)	(0.043)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	3.14	3.14	3.14	0.111	0.111	0.111
Fit statistics						
Observations	1,638	1,585	762	1,638	1,585	762
R^2	0.034	0.302	0.574	2.96×10^{-5}	0.004	0.060

Panel 2: Training

Dependent Variables:	1(Any Training)			1(Emp Paid for Training)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	0.011	-0.002	-0.028	0.015	-0.002	-0.031
	(0.029)	(0.029)	(0.043)	(0.024)	(0.024)	(0.038)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	0.120	0.120	0.120	0.078	0.078	0.078
Fit statistics						
Observations	1,638	1,585	762	1,638	1,585	762
R^2	0.0001	0.007	0.108	0.0004	0.020	0.139

Panel 3: Job Mobility

Dependent Variables:	Tenure (Yrs)			1(Main Job Mobility btwn 2019 and 2021)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
1(NC)	0.256	0.237	0.116	-0.051	-0.050	-0.064
	(0.184)	(0.187)	(0.226)	(0.036)	(0.037)	(0.052)
Controls	None	Basic	Advanced	None	Basic	Advanced
Weighted Dependent Variable Mean	5.64	5.64	5.64	0.249	0.249	0.249
Fit statistics						
Observations	1,616	1,585	762	1,638	1,607	771
R^2	0.003	0.008	0.098	0.001	0.010	0.068

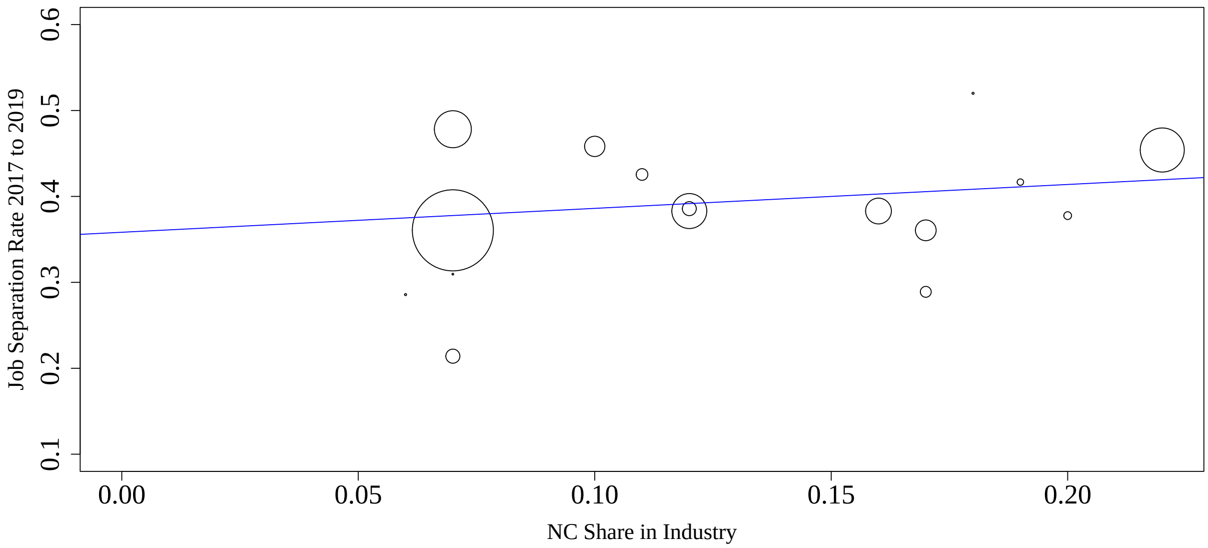
Notes: Standard errors are heteroskedasticity-robust. The sample restricts to individuals who report NC status and have real wages between 3 and 200 in 2019. Basic controls include sex, education, tenure, and potential experience. Advanced controls further add industry and occupation fixed effects, ASVAB percentile, and firm size. All regressions are weighted so as to be nationally representative. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A4: Wage Growth in Job Stayers vs Job Movers, by Non-Compete Status

Job Separation Condition	Wage Growth	Observations
Wage Growth Between 2017 and 2019		
Moved: No NC to NC	0.20	98
Moved: NC to NC	0.16	46
Moved: NC to No NC	0.12	100
Stayed: NC	0.11	458
Moved: No NC to No NC	0.11	839
Stayed: No NC	0.08	2595
Wage Growth Between 2019 and 2021		
Moved: No NC to NC	0.29	74
Moved: NC to NC	0.29	36
Moved: NC to No NC	0.22	80
Moved: No NC to No NC	0.13	716
Stayed: No NC	0.13	2519
Stayed: NC	0.11	442

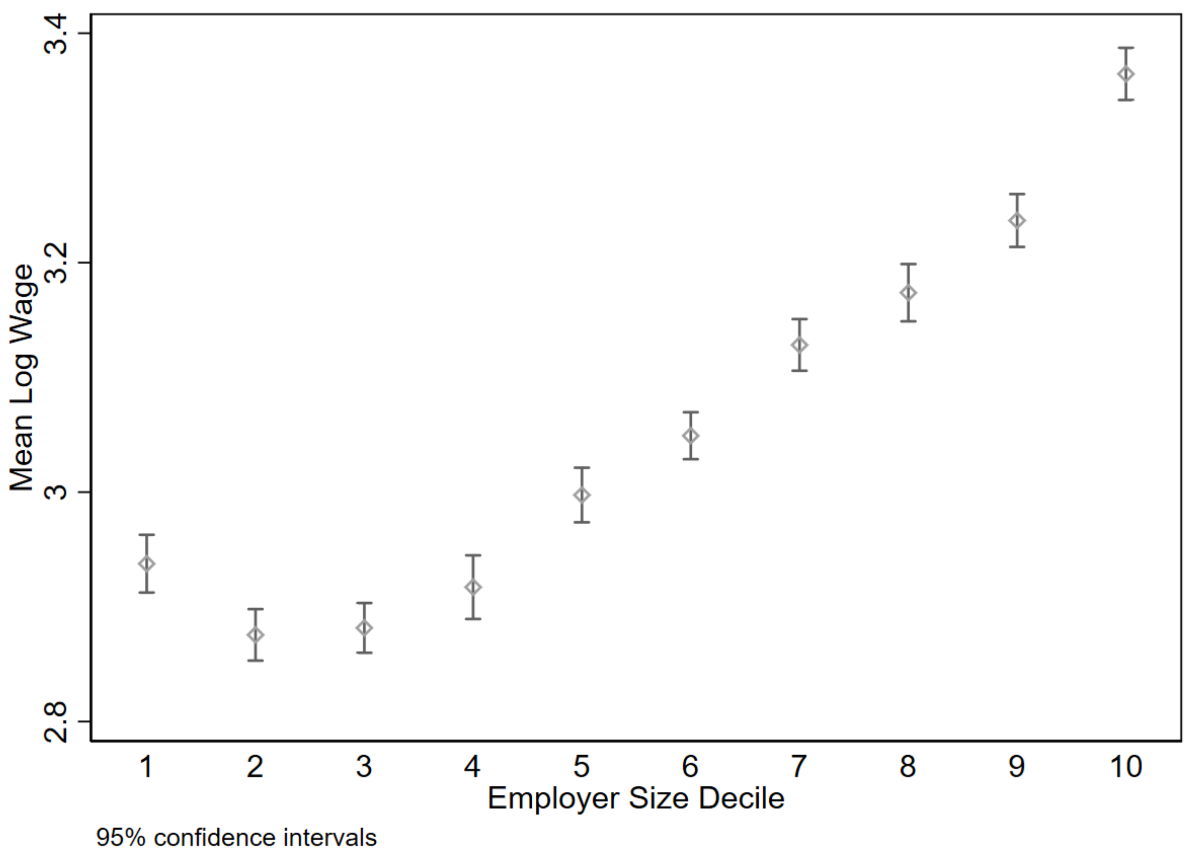
Note:
Wage growth based on condition of main job separation in the given period. The wage is measured for the main employer and in terms of dollars earned per hour. NC status in 2019 is only given if a job separation occurred between 2017 and 2019. If no separation occurred, the 2017 NC status was used in 2019. Similarly, NC status is provided in 2021 only if a job separation occurred between 2019 and 2021. If no separation occurred, the 2019 NC status was used in 2021.

Figure A1: Job Mobility vs Non-Compete Usage by Industry



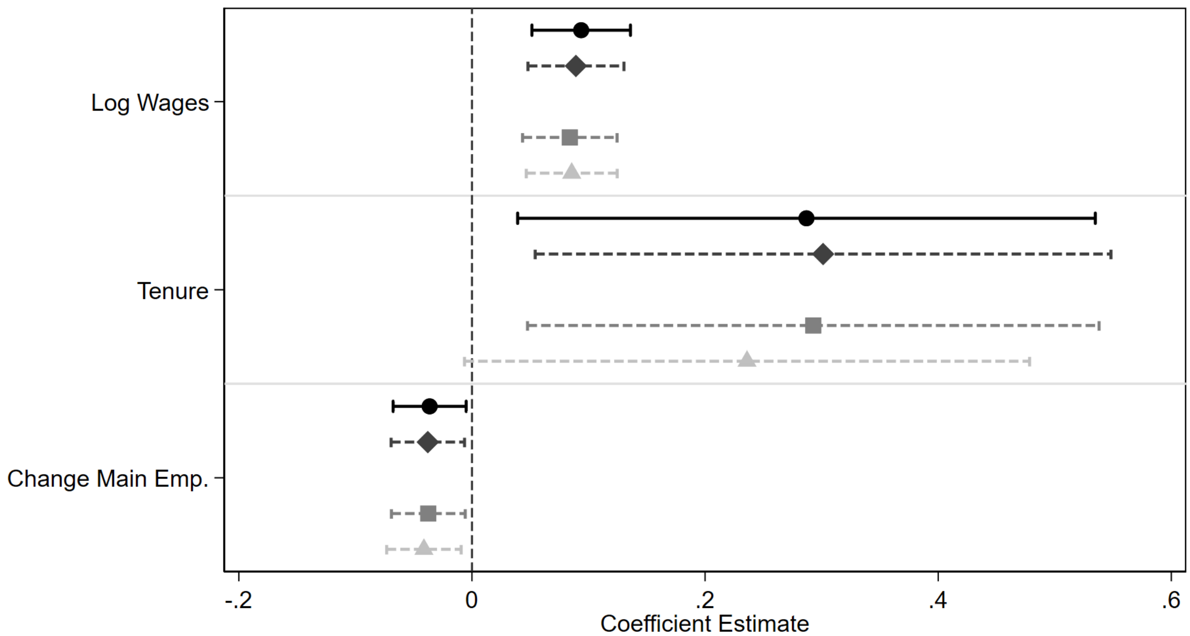
Note: The figure presents the rate of job separations in each industry between 2017 and 2019 versus non−compete usage by industry in 2017. The size of the circles are proportional to industry size and the line of best fit is weighted by industry size. The intercept is 0.36 and the slope is 0.28

Figure A2: Relationship Between Log Wages and Firm Size



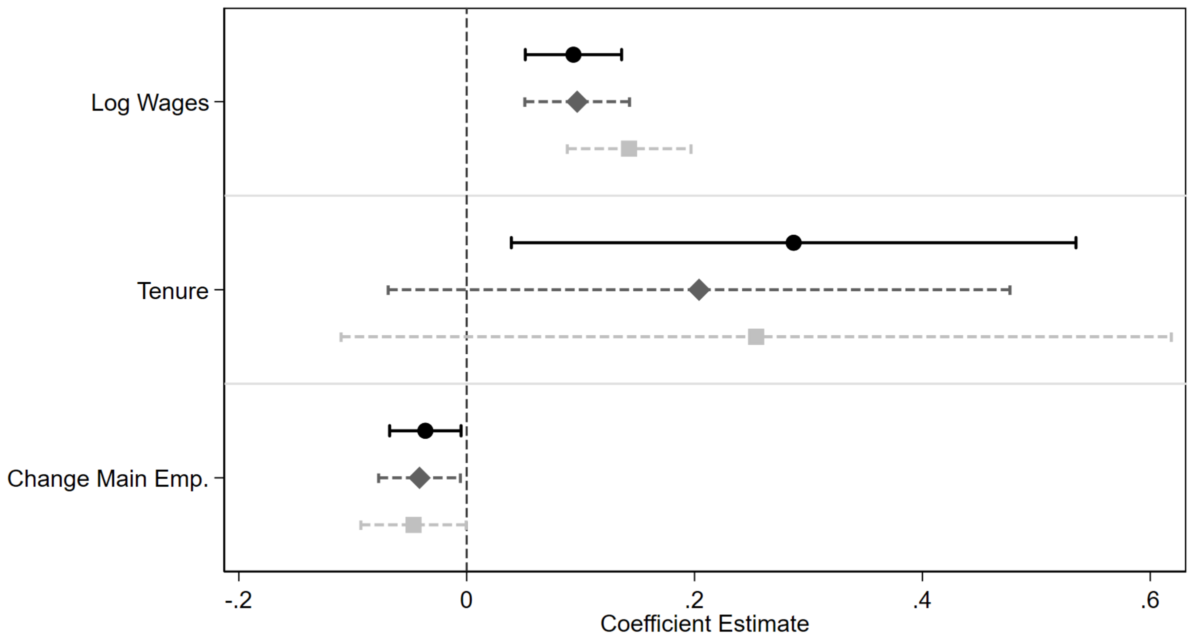
Note: Based on 2017 cross-section.

Figure A3: The Effect of Signing a Non-Compete Agreement: Robustness to Firm-Level Covariates



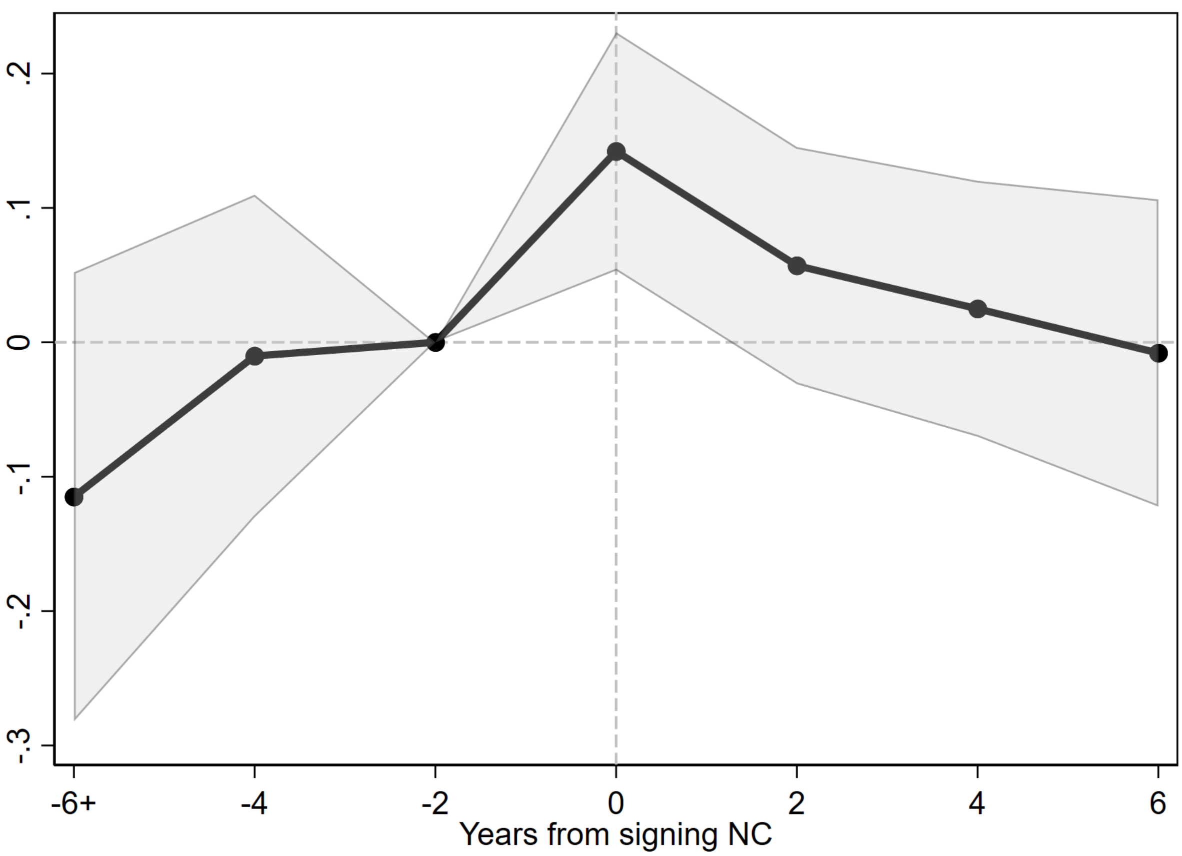
Note: Coefficient estimates are from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers whom we do not observe holding a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. The black circle markers report baseline estimates from the main text. The gray diamond markers with dashed lines report estimates controlling for industry fixed effects. The square markers further add occupation fixed effects, and the triangle markers further add firm size decile fixed effects. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

Figure A4: The Effect of Signing a Non-Compete Agreement: Robustness to Different Samples



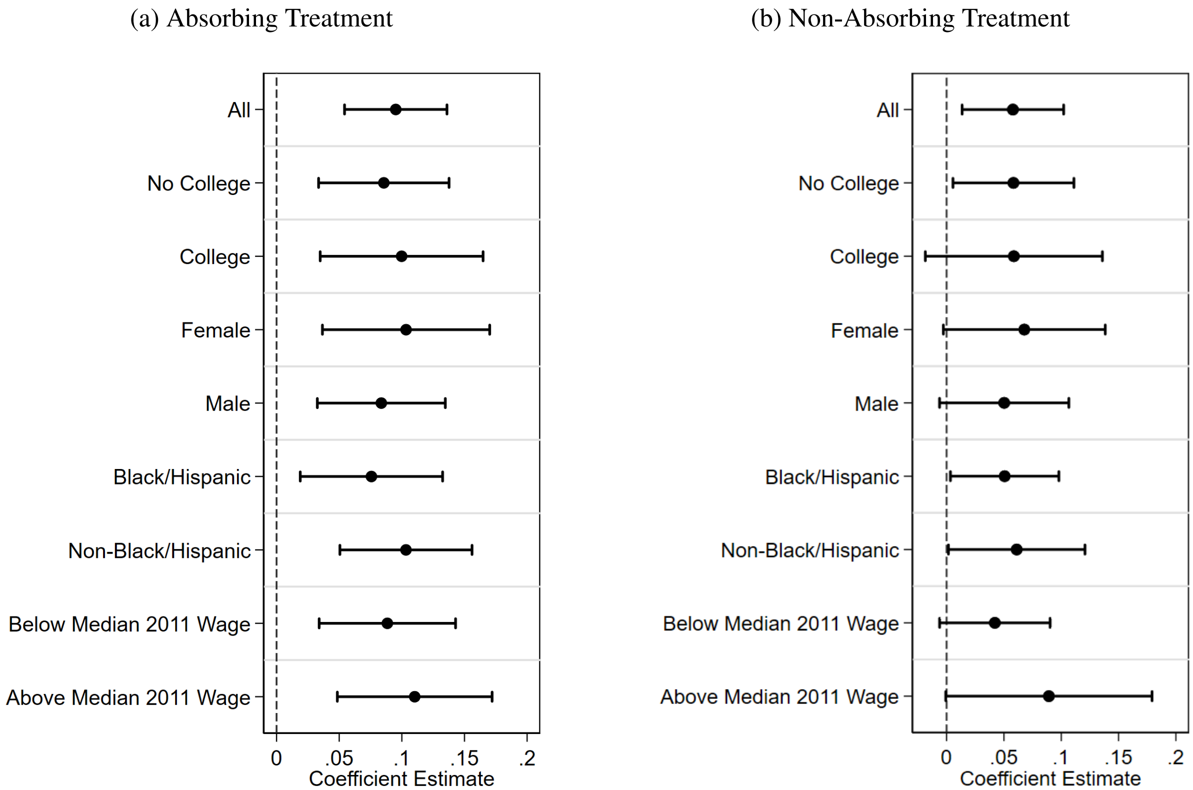
Note: Coefficient estimates are from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers whom we do not observe holding a NC during the event window and who also changed jobs between year c and the preceding survey year. Job mobility is defined as changing main employers between the current and preceding survey year. The black circle markers report baseline estimates from the main text. The gray diamond markers with dashed lines report coefficient estimates when we restrict attention to years 2015-2021 and cohorts $\{2017, 2019, 2021\}$. The square markers further restrict attention to years 2017-2021 and cohorts $\{2019, 2021\}$. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

Figure A5: The Effect of Signing a Non-Compete Agreement on Wages: Later-treated as Control Group



Note: Coefficient estimates are from stacked difference-in-differences estimation, aggregated over post-treatment years, over a bi-annual sample period of 2013-2021 and using cohorts $c \in \{2015, 2017, 2019, 2021\}$. The treatment group for cohort c are those who we observe first signing an NC in year c. The control group consists of workers who (a) changed jobs between year c and the preceding survey year, (b) do not hold an NC in year c, and (c) sign an NC at some $t > c$ (the later-treated job movers). Standard errors are clustered by worker and confidence intervals are reported at the 95% level.

Figure A6: Wage Effects of Signing an NC: Two-way Fixed Effects (TWFE) Models



Note: Coefficient estimates are from two-way fixed effect (TWFE) models. Panel (a) reports coefficient estimates from equation 14 over a bi-annual sample period of 2013-2021. Panel (b) reports coefficient estimates from equation 15 over a bi-annual sample period of 2017-2021. Standard errors are clustered by worker and confidence intervals are reported at the 95% level.