Optimal Regulation of Noncompete Contracts[*]

Liyan Shi[†]

Carnegie Mellon University and CEPR

September 2022

Abstract

I study regulation of noncompete employment contracts, assessing the trade-off between restricting worker mobility and encouraging firm investment. I develop an on-the-job search model in which firms and workers sign dynamic wage contracts with noncompete clauses and firms invest in their workers' general human capital. Employers use noncompete clauses to enforce buyout payments when their workers depart, ultimately extracting rent from future employers. This rent extraction is socially excessive, and restrictions on these clauses can improve efficiency. The optimal regulation policy is characterized. In an application to the managerial labor market using a novel contract dataset, I find the optimal policy to be quantitatively close to a ban.

Keywords: On-the-job search, noncompete contract, dynamic contract, labor reallocation, investment holdup

[*]An earlier version of this paper was circulated under the title "The Macro Impact of Noncompete Contracts." I am grateful to the editor and three anonymous referees for their generous and constructive feedback. I am indebted to Hugo Hopenhayn for his invaluable advice. I thank Andy Atkeson, Saki Bigio, Pablo Fajgelbaum, François Geerolf, Francesco Lippi, Ken Miyahara, Facundo Piguillem, Evan Starr, Pierre-Olivier Weill, Liangjie Wu, and the seminar participants at UCLA, NYU Stern, UVA, JHU Carey, UCSB, Penn, CMU, EIEF, ESWM 2018, SED 2018, EUI, Exeter, Tsinghua, and Bocconi for their insightful discussion and comments.

[†]Email: liyans@andrew.cmu.edu

1 Introduction

Noncompete employment contracts, agreements that prohibit employees from joining competing firms for some duration, are prevalent in the U.S. labor market. About 64% of executives in publicly listed firms have signed noncompete contracts. Moreover, these arrangements have permeated into broader labor markets. A survey by Prescott, Bishara, and Starr (2016) indicates that about 30 million workers (roughly 18% of the entire workforce) are subject to such constraints. The anticompetitive effects of such contracts are concerning: restricted labor mobility precludes the reallocation of workers to more productive employment and inhibits the entry of new firms.[1] Employers, conversely, argue that noncompete contracts offer the protection they need to carry out investments. The disagreement over the merits of noncompete contracts has manifested itself in the disparate legal landscape across the country: many states take a permissive stance; others, notably California, ban noncompete contracts altogether. Recent attempts and progress in legal reform have aimed to emulate the California noncompete law, promoting a more mobile labor market.[2]

This paper assesses the efficiency implications of noncompete contracts, considering the beneficial effects of encouraging firm investments and the harmful effects of restricting worker mobility. Despite the two opposing effects being well documented in empirical studies, their overall impact is unexamined. While many theoretical inquiries investigate similar issues (e.g., Moen and Rosen, 2004; Franco and Mitchell, 2008; Heggedal, Moen, and Preugschat, 2017; Cooley, Marimon, and Quadrini, 2020), it is not well understood how employers design noncompete contracts and, if workers willingly enter these contracts, whether there are social gains from intervening in them. Further, the lack of comprehensive contract data poses a challenge to quantitative assessment.

To this end, I develop an on-the-job search model in which firms optimally design dynamic wage contracts with noncompete clauses and invest in their worker's general human capital. As in the model by Postel-Vinay and Robin (2002), workers search while on the job and form matches with potential new employers, who attempt to poach them from their incumbent employers. I adopt their dynamic wage contract as an important way for firms to retain

[1] The White House (2016) and The U.S. Department of Treasury (2016) identify noncompete contracts as a likely cause for the declining labor market fluidity, stagnant wage growth, and declining business dynamism observed in the United States (see Davis and Haltiwanger, 2014).

[2] At the national level, the Obama Administration proposed a nationwide ban. Details can be found at https://obamawhitehouse.archives.gov/sites/default/files/competition/noncompetes-calltoaction-final.pdf. At the state level, some states have made headway in reforming their noncompete laws. In 2018, Massachusetts passed a law that restricts the use of noncompete contracts and caps noncompete duration at one year. Details can be found at https://www.mass.gov/info-details/mass-general-laws-c149-ss-24l. In 2021, the District of Columbia passed a comprehensive ban on noncompete agreements. Details can be found at https://lims.dccouncil.us/downloads/LIMS/43373/Meeting2/Enrollment/B23-0494-Enrollment1.pdf.

workers, but I expand the contract to include (1) a *noncompete clause* restricting the worker's outside employment for some duration, and (2) a *buyout payment* from the worker to be released from the clause. The buyout resembles the damage-payment contract between firms studied by Aghion and Bolton (1987). As in their setting, since the poaching firms privately observe the new match quality, the incumbent employers cannot charge buyout payments contingent on it. Unlike their firm-to-firm contract, the noncompete arrangement arises naturally here: since workers would renege on paying damages, the noncompete clause is essential for firms to enforce the buyout payments.

While employment restrictions may seem unappealing for workers, workers can be enticed with appropriate compensation. I first show that the contract between an incumbent firm and its worker is *bilaterally efficient*. With the firm's commitment to the contract and risk-neutral preferences, the firm aligns the worker's incentive by bidding against poachers and costlessly backloading the wage to retain the worker. However, the additional clause adversely affects future entrant employers, resulting in a *contracting externality*. The incumbent firm and the worker jointly set a noncompete duration and charge a buyout price out of a rent-extraction motive, akin to a textbook monopolist seller who does not observe its buyer's willingness to pay. The buyout price prevents the worker from taking some jobs that are more productive than the current one. As a result, noncompete buyouts distort the allocation of workers and inhibit the entry of new firms.

I introduce *endogenous investment* in the workers' human capital, which is transferable to future employment. For investment incentives, the presence of search frictions breaks the insights of the classical analysis by Becker (1962) in a perfectly competitive labor market. There, because human capital is perfectly priced externally, the problem reduces to bilateral bargaining between the firm and the worker about who pays for the investment. In contrast, given a frictional labor market, the problem here is among three parties. Future employers also have some monopsony power and can partially appropriate the payoff. Therefore, a positive *investment externality* on entrants appears. While the incumbent firm pays the cost, investment is prone to holdup. Consequently, noncompete buyouts allow the incumbent employers to seize a share of the external payoff and undertake more investment.

Noncompete contracts generate an *investment-reallocation trade-off*: a longer noncompete duration alleviates the holdup problem due to the investment externality but aggravates the distortion in the worker allocation due to the contracting externality. Despite being bilaterally efficient, the laissez-faire contract is socially inefficient along this trade-off. The incumbents aim to extract as much rent as possible out of the social surplus from worker reallocation and disregard the share captured by entrant employers. From a social welfare perspective, they overextract rent by setting an excessively long duration and blocking too many outside opportunities. The planner can intervene by capping the noncompete duration to recuperate more reallocation gains. Such an intervention improves welfare despite hurting incumbents' investment incentives. I provide a formula for the optimal duration cap driven by two key model primitives: the *investment elasticity* and the *entrant match quality distribution*.

To fit the institutional setup, the model is augmented structurally by (1) the noncompete legal regime in the form of an enforcement probability and (2) a contracting cost for arranging a noncompete clause. Together, they generate selection into noncompete clauses in the extensive margin, in addition to the duration choice in the intensive margin. In the same vein as excessively long duration, there is excessive selection into noncompete clauses.

I apply the model to the managerial labor market. Using a novel dataset on noncompete arrangements for executives in public-listed U.S. firms, I find empirical patterns aligned with the model's predictions. Overall, 64% of the executives are subject to noncompete clauses with an average duration of 19 months. There is substantial cross-state variation: the prevalence of noncompete clauses is 38% higher in Florida than in California.

The data reveal that noncompete contracts generate a sizable decline in executive mobility and a relatively mild effect on firm investment. Both magnitudes increase with enforceability. In the strongest enforcement states, executives under noncompete clauses are around 1.8% annually less likely to separate from their firms, relative to an otherwise unrestricted separation rate of 8.5%. When a 1% increase in the proportion of executives under noncompete clauses, the firm's investment rate in intangible capital increases by 0.017%. The same effect is absent for physical capital investment.

New evidence emerges on how noncompete clauses interact with wage backloading, confirming the model's mechanism. In the model, when workers sign a noncompete contract, their wage is less backloaded because their employers need to bid less against outside offers for retention in the future. To be precise, the worker starts with a higher wage but experiences lower wage growth. Indeed, the starting wage for executives subject to noncompete clauses is 13% (or $130K in 2010 prices) higher than those without such a clause, but their wage grows 1% less annually over the first ten years of tenure.

Using the empirical patterns above, I calibrate the model and conduct quantitative policy analysis in the managerial labor market. The model primitives key to shaping the intensive-margin duration cap are disciplined by the observed magnitudes of mobility decline and investment increase. In addition, the parameters related to the selection effect are mapped to the cross-state variation. Quantitatively, the social optimum features a duration cap of 1.6 months and very few agents signing noncompete clauses, regardless of the enforcement regime. Underpinning this stringent duration cap is a mild investment elasticity and a substantial amount of lost job-to-job reallocations uncovered by the data. Imposing a complete ban on noncompete clauses would be close to implementing the social optimum. For instance, in a full-enforcement regime resembling Florida, both policies would achieve a 2.25% welfare gain relative to the laissez-faire outcome.

Related literature. This paper extends the on-the-job search literature along the lines of Postel-Vinay and Robin (2002) and Cahuc, Postel-Vinay, and Robin (2006), which represent an efficient turnover benchmark also noted by Pakes and Nitzan (1983), in several dimensions. First, I modify their perfect-information assumption regarding match quality to an asymmetric information one. Instead of their take-it-or-leave-it offers, I use an English auction to preserve the efficient turnover outcome. Second, I enrich their dynamic wage contract with noncompete clauses. This extension generates the effect of damage payments as barriers to entry, as in Aghion and Bolton (1987). Third, I introduce endogenous investment in human capital and its spillover effect to entrants.

This paper contributes to the theoretical literature on employment contracts under worker limited commitment (Diamond and Maskin, 1979; Marimon and Quadrini, 2011; Cooley et al., 2020), in particular concerning the spillover of on-the-job general human capital accumulation (Acemoglu, 1997; Acemoglu and Pischke, 1999; Moen and Rosen, 2004; Lentz and Roys, 2015; Heggedal et al., 2017). Notably, Franco and Mitchell (2008) study the contractual forces of noncompete buyouts in affecting employee spin-outs, aimed at explaining the formation of industry clusters. This paper is the first to rationalize the design of noncompete clauses, including the duration length, as an optimal contract among private parties in a labor search framework and to study the welfare effects of regulating these contracts. The theoretical insight here departs from the classical analysis by Becker (1962) in a perfectly competitive labor market, yet it recasts the optimal patent duration problem going back to Nordhaus (1967) in a monopsonistic labor contract setting.

Through the lens of noncompete contracts, this paper connects to a few broad strands of macro literature. Many studies examine labor market institutions, such as firing costs, that lead to the misallocation of labor (e.g., Hopenhayn and Rogerson, 1993). Here, the source of misallocation comes from the opposite concern of retaining workers. The insights here also relate to the works on knowledge diffusion (e.g., Lucas and Moll, 2014; Perla and Tonetti, 2014). In this regard, worker movements across firms provide a way of spreading knowledge, and noncompete contracts affect the appropriation of rents from knowledge diffusion.

Relating to empirical studies on noncompete contracts, this paper is the first to use a large dataset of actual contracts with information on both whether a noncompete clause is included and its duration. Existing studies have relied on exploring exogenous variations in the legal enforceability over time (e.g., Garmaise, 2009; Marx, Strumsky, and Fleming, 2009; Starr, Balasubramanian, and Sakakibara, 2017; Jeffers, 2018; Starr, 2019), except for Lavetti, Simon, and White (2019), who surveyed noncompete prevalence among physicians. Using the contract data, I provide new evidence on the use and effects of noncompete contracts, on how the effects depend on legal enforceability, and on the effects on wage dynamics.

Finally, this paper relates to studies on competitive market forces in determining executive compensation. Frydman (2019) documents that the increasing importance of general managerial human capital has led to higher executive mobility and compensation over time. My empirical findings suggest that competition also affects the pay structure, confirming retention concerns in dynamic compensation design (Clementi, Cooley, and Wang, 2006).

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 characterizes the equilibrium and studies the optimal noncompete policy. Section 4 presents empirical evidence in the managerial labor market. In Section 5, I calibrate the model and conduct policy evaluations. Section 6 concludes.

2 Model

This section sets up an on-the-job search model built on Postel-Vinay and Robin (2002). To capture the trade-off between labor mobility and firm investment, I allow firms to include noncompete clauses and invest in their workers' general human capital.

2.1 Environment

Time is continuous and infinite, $t \in [0,\infty)$. The economy is populated by a measure-one of workers employed by a corresponding continuum of firms. The firm-worker matches are characterized by their match productivity, z, and produce a flow output equal to their productivity, $y = z$. Each worker dies at rate δ, upon which the firm also exits, and is replaced by a newborn worker matched to a newborn firm.[3] The initial productivity of a newborn match is drawn according to the cumulative distribution function $H(\cdot)$. Agents are risk-neutral. Hence, risk-sharing concerns between firms and workers are absent. Agents discount the future at rate ρ. Therefore, the effective discount rate is $r = \rho + \delta$.

Consider a firm-worker match formed at time 0 with initial match productivity z_0. At subsequent employment time t, its match productivity evolves according to

$$dz_t = \mu_t z_t dt + \sigma z_t dB_t,$$

[3] I simplify the model structure and focus on job-to-job transitions by eliminating the possibilities of worker unemployment and firms replacing poached workers.

where B_t is a standard Brownian motion. The drift μ_t represents an *endogenous investment* chosen by the firm by incurring an expenditure $c(\mu_t)z_t$. The cost function $c(\cdot)$ is strictly increasing, twice continuously differentiable, and convex.

The labor market is frictional. Workers are matched to an entrant firm at rate λ. The entrant match has productivity $z'_t = z_t\theta_t$, which is multiplicative of the incumbent productivity z_t and the entrant match quality θ_t. The entrant match quality, $\theta_t \in [\theta_m,\infty)$, is drawn according to the cumulative distribution function $F(\cdot)$. The function $F(\cdot)$ is continuous, with $\theta_m < 1$ and $1 - F(1) > 0$, suggesting that some draws improve over the current job. The investment is embodied in the worker's general human capital. When workers move to new jobs, they take the accumulated human capital to the new employers, and their incumbent employers exit. Thus, the investment undertaken by incumbent employers has a positive *investment externality* on future employers.

2.2 Information and Contracts

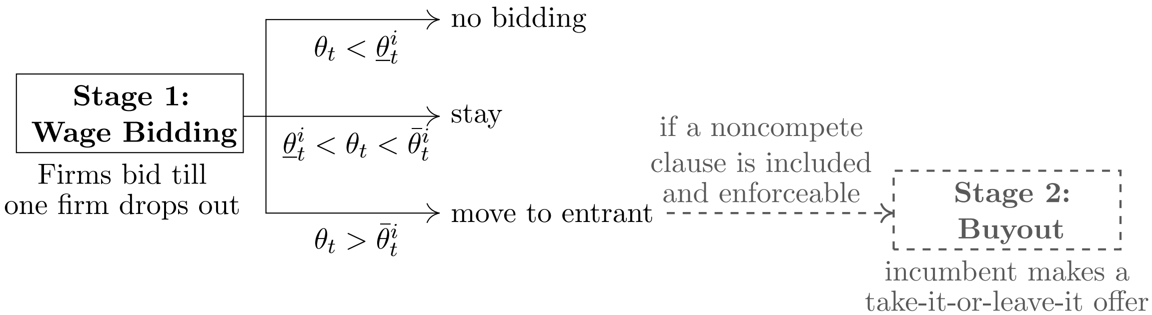
Information. Information is asymmetric: firms do not observe each other's productivity.[4] This information friction is crucial for noncompete clauses to reduce labor mobility. Otherwise, under perfect information, agents would always engage in efficient renegotiation ex post regardless of any ex-ante contract, thus reallocating workers to more productive jobs.

Contractual environment. Firms and workers enter long-term contracts. The contract specifies the process through which employment and the corresponding transfers are determined ex post. While adopting the dynamic wage contract in Postel-Vinay and Robin (2002) as a way for firms to retain workers, I expand the contractual possibilities to include (1) a *noncompete clause* restricting the worker's outside employment for a specified time duration, and (2) a *buyout payment* from the worker to be released from the clause.

These contractual arrangements arise out of two considerations. First, *firms are deep-pocketed* while *workers are hand-to-mouth*. Absent an outside offer, the transfer from the firm to the worker, i.e., the wage payment, has to be positive. However, upon taking a new job, the worker can pay the incumbent employer, financed by the new employer. Second, *firms can commit to the contract*, but *workers cannot*. In particular, workers can renege on their buyout payment obligation. To circumvent the problem of reneging, the firm uses a noncompete threat of excluding the worker from outside employment for a duration of

[4] I assume two-sided information asymmetry between the two competing firms, while the worker is perfectly informed about the two matches. However, as in Aghion and Bolton (1987), only one-sided information asymmetry is needed: the entrant productivity z'_t or, equivalently, the entrant match quality θ_t is private information. The results do not change when the incumbent productivity z_t is also private information. A one-period version of the model in Appendix D explains this equivalence.

Figure 1: Competition for workers in a two-stage game



time. Together with the new employer, the worker can pay the incumbent to avoid the exclusion. From a property-rights perspective, the incumbent firm owns the property right to the worker's future employment during the noncompete period, which it can sell back to the worker or resell to new employers. Thus, the additional clause adversely affects entrant employers that subsequently contract with the worker, resulting in a *contracting externality*.

Contracting cost and noncompete law. To capture the heterogeneity of noncompete prevalence across states, I introduce two additional structural features. These structures however are not essential for the theory.

First, the firm decides whether to include a noncompete clause, which entails a flow cost, κz_t, proportional to its match productivity z_t. Each worker draws a fixed, observable cost type κ according to the cumulative distribution function $\Phi(\cdot)$.[5] This cost represents legal fees, a deadweight loss deducted from social welfare. Appendix B.2 considers an alternative interpretation of the cost as worker disutility due to perceived restricted opportunity.

Second, the legal regime is represented by an enforcement probability. Namely, if a worker is bound by a noncompete clause, after the worker takes a new job, with probability p the noncompete clause turns out to be enforceable and would subsequently require a buyout.[6]

Wage bidding and buyout. When a poaching firm arrives, the competition for the worker occurs in the two-stage game depicted in Figure 1. In the first stage, the incumbent

[5]This contracting cost structure generates three predictions, which are broadly consistent with the data and simplify the analysis. First, a cost proportional to productivity implies that the contractual pattern does not correlate with productivity, consistent with the empirical pattern. Second, the noncompete choice does not change as the match grows more productive over time. Third, given that κ is fixed for a given worker, the contract choice is persistent among job-changers. Some extent of persistence is found in the data.

[6]One could think of the enforcement probability as follows. In a state more permissive toward noncompete contracts, it is more likely that a judge will rule in favor of enforcing them.

and entrant firms bid for the worker in an ascending (English) auction, given the information environment here. Firms have *limited liability*, implying that they can commit to delivering to their workers a promised utility only up to the entire match value. The resulting wage is denoted by $w_t \geq 0$. If the entrant firm poaches the worker and there is an enforceable noncompete clause, excluding the worker for a duration π_t, a second buyout stage ensues. The incumbent firm makes a take-it-or-leave-it offer of a buyout menu $\{\tau_t(\tilde{\pi}) : \tilde{\pi} \in [0,\pi_t]\}$, where $\tau_t(\tilde{\pi})$ is the payment required for reducing the noncompete duration from π_t to $\tilde{\pi}$.

Contract. Taken together, the contract specifies the wage payments and the investments, as well as the noncompete clause and the corresponding buyout menu, for all future instants of time and events:

$$\mathcal{C} = \{w_t,\mu_t,\mathcal{M}_t\}_{t\geq 0}, \text{ where } \mathcal{M}_t = \{\pi_t,\{\tau_t(\tilde{\pi}) : \tilde{\pi} \in [0,\pi_t]\}\}.$$

If a noncompete clause is not included, the clause is null, $\mathcal{M}_t = \emptyset$. All contract terms are fully contingent on the history of observable and revealed information.

2.3 Firm's Problem

Consider the problem of a firm contracting with its worker at time 0. When an entrant firm arrives at time t, the bidding outcome can be characterized by a poaching threshold: if the entrant match quality is above the threshold, the worker moves to the entrant. The poaching threshold is denoted by $\bar{\theta}^c_t$, if a noncompete clause is not included or not enforceable, and $\bar{\theta}^n_t$ otherwise. The match separates at time T, which occurs when an entrant with a match quality above the poaching threshold arrives for the first time, $\theta_T > \bar{\theta}^i_T$, for $i \in \{c,n\}$.

Following the long-term contract approach, I summarize the cost of a contract to the firm by the level of utility promised to the worker. When bidding for the worker, the incumbent and entrant firms compete in utility terms. During the bidding process described earlier, the incumbent will bid up to its match value. Therefore, to poach the worker, the entrant needs to promise the worker a utility fully compensating the value of the destroyed incumbent match.[7] Let $J(z,\kappa)$ denote the joint value of a match with productivity z and type κ. Thus, at time T, the worker receives a promised utility $J(z_T,\kappa)$ from the entrant. To deliver the initial promised utility U_0 at time 0, the firm faces a promise-keeping (PK) constraint:

$$\mathbb{E}\left[\int_0^T e^{-rt} w_t dt + e^{-rT} J(z_T,\kappa)\right] \geq U_0. \tag{1}$$

[7] Business stealing concerns are absent here. As long as employers can counter outside offers, they internalize business stealing by poached workers, as emphasized by Gautier, Teulings, and Van Vuuren (2010).

The firm chooses whether to include a noncompete clause, weighing the two options:

$$V(z_0,U_0,\kappa) = \max\{V^c(z_0,U_0),V^n(z_0,U_0,\kappa)\},$$

where $V^c(z,U)$ is the value function of the firm with productivity z, promised utility U to the worker, absent any noncompete restriction, and $V^n(z,U,\kappa)$ the corresponding value of the firm conditional on signing a noncompete clause.

Absent a noncompete clause, the firm chooses the streams of wage payments and the investments to maximize its value

$$V^c(z_0,U_0) = \max_{\{w_t,\mu_t\}_{t\geq 0}} \mathbb{E}\left[\int_0^T e^{-rt}(z_t - c(\mu_t)z_t - w_t)dt\right], \tag{2}$$

subject to the PK constraint (1).

If a noncompete clause is included, apart from the wage payments and the investments, the firm chooses the noncompete duration and the buyout menu

$$V^n(z_0,U_0,\kappa) = \max_{\{w_t,\mu_t,\mathcal{M}_t\}_{t\geq 0}} \mathbb{E}\left[\int_0^T e^{-rt}(z_t - c(\mu_t)z_t - \kappa z_t - w_t)dt + e^{-rT}\tau_T(\tilde{\pi}_T(\theta_T))\right], \tag{3}$$

subject to the PK constraint (1), as well as the entrant firm's incentive-compatibility (IC) and individual-rationality (IR) constraints

$$\tilde{\pi}_t(\theta_t) = \underset{\tilde{\pi}\in[0,\pi_t]}{\operatorname{argmax}}\ e^{-r\tilde{\pi}}J^n(z_t\theta_t,\kappa) - \tau_t(\tilde{\pi}),\ \forall\theta_t \geq \bar{\theta}_t^n,\ \forall t \tag{4}$$

$$e^{-r\tilde{\pi}_t(\theta_t)}J^n(z_t\theta_t,\kappa) - J^n(z_t,\kappa) - \tau_t(\tilde{\pi}_t(\theta_t)) \geq 0,\ \forall\theta_t \geq \bar{\theta}_t^n,\ \forall t. \tag{5}$$

In equation (2), the flow payoff to the firm is the output net of investment cost and wage payment. In comparison, equation (3) adds the buyout payment at match termination to the firm's payoff. The IC constraint (4) captures that, in the buyout stage, the entrant firm chooses optimally to reduce the noncompete duration from π_t to $\tilde{\pi}_t(\theta_t)$. With a production delay of duration $\tilde{\pi}$, its match value reduces to $e^{-r\tilde{\pi}}$ fraction of the no-delay value $J^n(z_t\theta_t,\kappa)$. The details of this calculation is in Appendix B.1. In the IR constraint (5), the entrant accounts for the promised utility $J^n(z_t,\kappa)$ to the worker and the buyout payment $\tau_t(\tilde{\pi}_t(\theta_t))$.

2.4 Bilateral Joint Maximization Problem

The structure of the economy permits simplification of the firm's problem. Due to the firm's commitment and the risk-neutral preferences, the firm is able to align the worker's incentive by costlessly backloading the wage payments to retain the worker when an outside opportunity arrives. Incorporating the PK constraint (1) into the firm's objectives in (2) and (3), one obtains that $J(z,\kappa) = V(z,U,\kappa) + U$. Further, absent a noncompete clause, $J^c(z) = V^c(z,U) + U$; otherwise, $J^n(z,\kappa) = V^n(z,U,\kappa) + U$. Thus, the firm's optimal choices maximize its joint value with the worker, i.e., their discounted joint payoffs, including the payoffs during the match and any potential buyout payments at separation.[8]

This bilateral efficiency intuition implies that the firm's problem can be separated into two parts. The first part is a *bilateral joint maximization problem*: the firm-worker match chooses the noncompete clause and investments to maximize their joint value. Moreover, it does not matter whether the firm or the worker designs the terms and has to pay any associated cost. Their incentives are perfectly aligned, and hence they would make the same choice. The second part is a *dynamic wage-setting problem*: the firm chooses wage payments to align the worker's incentive and split the maximized joint value. While the firm's problem is stated in its sequential form in order to specify all future contingencies involving the worker and poaching firms, after isolating the bilaterally optimal decisions for the match, the problem can be conveniently stated recursively. Formally,

Lemma 1 (Bilateral Efficiency)**.** *The contract maximizes the bilateral joint value of the firm-worker match. Specifically, the firm-worker match decides whether to include a noncompete clause, assessing which option delivers a higher joint value:*

$$J(z,\kappa) = \max\{J^c(z), J^n(z,\kappa)\}, \tag{6}$$

where, absent a noncompete clause, the match chooses the investment level to maximize the joint value function $J^c(z)$, which follows the Hamilton-Jacobi-Bellman (HJB) equation

$$rJ^c(z) = \max_{\mu}\left\{ z - c(\mu)z + \mu z J^c_z(z) + \frac{1}{2}\sigma^2 z^2 J^c_{zz}(z) \right\}; \tag{7}$$

otherwise, it chooses the noncompete clause $\mathcal{M} = \{\pi, \{\tau(\tilde{\pi}) : \tilde{\pi} \in [0,\pi]\}\}$ in addition to the investment to maximize the joint value function $J^n(z,\kappa)$, which follows the HJB equation

$$rJ^n(z,\kappa) = \max_{\mu,\mathcal{M}}\left\{ z - c(\mu)z - \kappa z + \lambda p \int_{\bar{\theta}^n}^{\infty} \tau(\tilde{\pi}(\theta))dF(\theta) + \mu z J^n_z(z,\kappa) + \frac{1}{2}\sigma^2 z^2 J^n_{zz}(z,\kappa) \right\} \tag{8}$$

subject to the entrant firm's IC and IR constraints (4) *and* (5)*.*

[8] One restriction on the parameters is needed: the arrival rate of outside opportunity λ is low, such that the wage non-negativity constraint, $w_t \geq 0$, never binds. Offsetting forces such as upward drift in productivity help to ensure that the wage non-negativity constraint is slack.

This bilateral problem reveals the incentive behind noncompete clauses. In equation (7), the first two terms on the right-hand side capture the joint flow payoff for the match, i.e., the flow of match output net of investment cost, regardless of how much wage is paid. The last two terms capture the change in match value due to productivity innovations. In comparison, equation (8) adds any potential buyout payments from entrants $\int_{\bar{\theta}^n}^{\infty}\tau(\tilde{\pi}(\theta))dF(\theta)$ to the joint payoff. This extra term shows that the noncompete clause allows the incumbent employer to claim ownership over the worker's future employment during the noncompete period and resell it to entrants. The incumbent and the worker together act like a monopolist toward future entrants by maximizing expected buyout payments. This *monopolist rent-extraction* incentive is identical to a textbook monopolist seller who does not observe its buyer's willingness to pay.

The resulting decision of whether to include a noncompete clause is denoted by $i(z,\kappa) \in \{c,n\}$, with c indicating no clause and n otherwise. In the latter case, the clause is denoted by $\mathcal{M}(z,\kappa) = \{\pi(z,\kappa),\{\tau(\tilde{\pi}|z,\kappa) : \tilde{\pi} \in [0,\pi(z,\kappa)]\}\}$. The poaching thresholds and investment decisions are denoted by $\{\bar{\theta}^c(z),\mu^c(z)\}$ and $\{\bar{\theta}^n(z,\kappa),\mu^n(z,\kappa)\}$, respectively.

2.5 Dynamic Wage-Setting

Since the agents are risk-neutral, the wage can be indeterminate. To pin the wage down uniquely, I assume a constant wage contract following Postel-Vinay and Robin (2002). Namely, the wage stays constant unless the employer needs to bid it up to retain the worker.[9] In a match of productivity z and wage w, the worker's value is denoted by $U^c(z,w)$, if absent a noncompete restriction, and $U^n(z,w,\kappa)$ otherwise.

To set the current wage, the firm accounts for three possible outcomes of future wage bidding described in Figure 1. First, if the entrant match value is below the current promised value, no bidding takes place. Second, if the entrant can offer more than the current promised value but fails to poach the worker, the incumbent firm bids up the wage. Third, if the entrant poaches the worker, it needs to offer the worker a wage that fully compensates the value of the incumbent match destroyed. The resulting wage-bidding thresholds are denoted by $\underline{\theta}^c(z,w)$ if absent a noncompete clause, $\underline{\theta}^n(z,w,\kappa)$ if a noncompete clause exists and is enforceable, and $\underline{\theta}^u(z,w,\kappa)$ if the clause is unenforceable. These bidding thresholds satisfy

$$U^c(z,w) = J^c(z\underline{\theta}^c(z,w)) \tag{9}$$

$$U^n(z,w,\kappa) = e^{-r\pi}J^n(z\underline{\theta}^n(z,w,\kappa),\kappa) = J^n(z\underline{\theta}^u(z,w,\kappa),\kappa). \tag{10}$$

[9] An arbitrarily small amount of risk aversion on the worker side can justify the constant wage contract. Any worker risk aversion implies that the optimal contract offers a constant wage to insure the worker.

Due to the firm's limited liability, the contract optimally embeds firm-initiated wage renegotiation as in Postel-Vinay and Turon (2010). Specifically, when a large negative productivity shock occurs, the promised utility to the worker may exceed the joint match value, resulting in a negative firm value. Under such circumstances, the firm reduces the promised value just to the level of the joint match value by resetting the wage. The resulting upper bounds on wage, $\bar{w}^c(z)$ and $\bar{w}^n(z,\kappa)$, are characterized by the following boundary conditions:

$$U^c(z,\bar{w}^c(z)) = J^c(z) \quad \text{and} \quad U^c_z(z,\bar{w}^c(z)) = J^c_z(z) \tag{11}$$

$$U^n(z,\bar{w}^n(z,\kappa),\kappa) = J^n(z,\kappa) \quad \text{and} \quad U^n_z(z,\bar{w}^n(z,\kappa),\kappa) = J^n_z(z,\kappa). \tag{12}$$

For workers who are free to move, their value function $U^c(z,w)$ follows the HJB equation: $\forall w \in [0,\bar{w}^c(z)]$,

$$\begin{aligned}(r+\lambda)U^c(z,w) &= w + \mu^c(z) z U^c_z(z,w) + \frac{1}{2}\sigma^2 z^2 U^c_{zz}(z,w) \\ &+ \lambda \left\{ F(\underline{\theta}^c(z,w))U^c(z,w) + \int_{\underline{\theta}^c(z,w)}^{\bar{\theta}^c(z)} J^c(z\theta)dF(\theta) + \left(1 - F\left(\bar{\theta}^c(z)\right)\right) J^c(z) \right\}.\end{aligned} \tag{13}$$

Otherwise, the worker's value function $U^n(z,\kappa,w)$ follows the HJB equation: $\forall w \in [0,\bar{w}^n(z,\kappa)]$,

$$\begin{aligned}(r+\lambda)U^n(z,w,\kappa) &= w + \mu^n(z,\kappa) z U^n_z(z,w,\kappa) + \frac{1}{2}\sigma^2 z^2 U^n_{zz}(z,w,\kappa) \\ &+ \lambda p \left\{ F(\underline{\theta}^n(z,w,\kappa))U^n(z,w,\kappa) + \int_{\underline{\theta}^n(z,w,\kappa)}^{\bar{\theta}^n(z,\kappa)} e^{-r\pi} J^n(z\theta,\kappa)dF(\theta) + \left(1 - F\left(\bar{\theta}^n(z,\kappa)\right)\right) J^n(z,\kappa) \right\} \\ &+ \lambda(1-p) \left\{ F(\underline{\theta}^u(z,w,\kappa))U^n(z,w,\kappa) + \int_{\underline{\theta}^u(z,w,\kappa)}^{\bar{\theta}^c(z)} J^n(z\theta,\kappa)dF(\theta) + \left(1 - F\left(\bar{\theta}^c(z)\right)\right) J^n(z,\kappa) \right\}.\end{aligned} \tag{14}$$

In equation (13), the right-hand side of the first line captures the wage payoff and the change in worker value due to match productivity innovations. The second line specifies the revised value under the three outcomes of wage bidding: no bidding, bidding up wage, and job change, respectively. In equation (14), the terms involving wage bidding distinguish two situations depending on whether the noncompete clause turns out to be enforceable.

The *employed workers* play a passive role as the object of bidding between the competing firms, with *an implicit bargaining power of zero.* In (13) and (14), when changing jobs, the employed workers are paid the equivalent amount of the destroyed incumbent match value, while the entrants capture the full surplus from job-to-job reallocation if not for the interference of noncompete clauses. For *newborn workers* in their first jobs, they bargain with their employers to determine the initial promised value, where the worker's bargaining power is $\beta \in (0,1)$. Given the simplifying setup that both sides have zero outside options, they split the maximized joint value according to their bargaining weights. Thus, depending on the noncompete status, the starting wages $w_0^c(z)$ and $w_0^n(z,\kappa)$ satisfy

$$U^c(z_0,w_0^c(z_0)) = \beta J^c(z_0) \quad \text{and} \quad U^n(z_0,w_0^n(z_0,\kappa),\kappa) = \beta J^n(z_0,\kappa), \tag{15}$$

2.6 Equilibrium Definition

To define the equilibrium, I first describe how the distribution of matches evolves. Let $g(z,\kappa,t)$ denote the density of firm-worker matches with productivity z and cost type κ at time t. To capture how contract choice affects the match outcome, let $\bar{\theta}(z,\kappa) \equiv \bar{\theta}^c(z)\mathbf{1}_{\{i(z,\kappa)=c\}} + \bar{\theta}^n(z,\kappa)\mathbf{1}_{\{i(z,\kappa)=n\}}$ and $\mu(z,\kappa) \equiv \mu^c(z)\mathbf{1}_{\{i(z,\kappa)=c\}} + \mu^n(z,\kappa)\mathbf{1}_{\{i(z,\kappa)=n\}}$. The match distribution follows the Kolmogorov Forward (KF) equation:

$$\begin{aligned} g_t(z,\kappa,t) &= -\mu(z,\kappa)zg_z(z,\kappa,t) + \frac{1}{2}\sigma^2 z^2 g^n_{zz}(z,\kappa,t) + \delta[h(z)\phi(\kappa) - g(z,\kappa,t)] \\ &+ \lambda\left\{p\int_{\bar{\theta}(z,\kappa)}^{\infty}\left[g\left(\frac{z}{\theta},\kappa,t\right) - g(z,\kappa,t)\right]dF(\theta) + (1-p)\int_{\bar{\theta}^c(z)}^{\infty}\left[g\left(\frac{z}{\theta},\kappa,t\right) - g(z,\kappa,t)\right]dF(\theta)\right\}. \end{aligned} \tag{16}$$

The first two terms on the right-hand side capture the match productivity innovations. The third term is due to exogenous entry and exit. The second line describes the job-to-job transitions, which are potentially affected by noncompete clauses.

Definition 1 (Equilibrium)**.** An equilibrium consists of contract choice $\{i(z,\kappa), \mathcal{M}(z,\kappa)\}$, joint value functions $\{J(z,\kappa), J^c(z), J^n(z,\kappa)\}$, poaching thresholds and investments $\{\bar{\theta}^c(z), \bar{\theta}^n(z,\kappa), \mu^c(z), \mu^n(z,\kappa)\}$, worker's value functions $\{U^c(z,w) : \forall w \in [0,\bar{w}^c(z)]\}$ and $\{U^n(z,w,\kappa) : \forall w \in [0,\bar{w}^n(z,\kappa)]\}$, wage-bidding thresholds $\{\underline{\theta}^c(z,w), \underline{\theta}^n(z,w,\kappa)), \underline{\theta}^u(z,w,\kappa)\}$, initial wages $\{w_0^c(z), w_0^n(z,\kappa)\}$, and distribution $g(z,\kappa,t)$ such that, given the initial distribution $g(z,\kappa,0)$:

(i) the contract choice and the corresponding poaching thresholds and investments, together with the joint value functions, solve the problem in (6)-(8);

(ii) the wage-bidding thresholds, together with the worker's value functions, satisfy equations (9) to (14); the initial wages for newborn matches satisfy (15); and

(iii) the distribution follows the KF equation (16).

3 Equilibrium and Policy Characterization

In this section, I first characterize the equilibrium contracts and their effects on worker mobility, firm investment, and wage profiles. I then derive comparative statics of the equilibrium with respect to the noncompete legal regime. Finally, I study the optimal noncompete policy.

To characterize the equilibrium, I first solve the joint maximization problem in two steps: the noncompete contract design for rent extraction, and the resulting incentives for investment. I then solve the dynamic wage-setting problem. Before proceeding, I show that the former problem is linear in productivity to simplify it. Inspecting the HJB equations (7) and (8), one can see that productivity z can be factored out.[10] Formally,

Lemma 2 (Linearity)**.** *Regardless of the noncompete status, the poaching threshold and the investment are independent of z: $\bar{\theta}^c(z) = \bar{\theta}^c$, $\mu^c(z) = \mu^c$, $\bar{\theta}^n(z,\kappa) = \bar{\theta}^n$, and $\mu^n(z,\kappa) = \mu^n(\kappa)$. Further, the noncompete duration is independent of z and κ, $\pi(z,\kappa) = \pi$. Finally, the joint value function is linear z, $J^c(z) = j^c z$ and $J^n(z,\kappa) = j^n(\kappa)z$, where*

$$j^c = \frac{1 - c(\mu^c)}{r - \mu^c} \quad \textit{and} \quad j^n(\kappa) = \frac{1 - c(\mu^n(\kappa)) - \kappa}{r - \mu^n(\kappa) - \lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big)}. \tag{17}$$

3.1 Use of Noncompete Clauses

The incumbent match chooses the noncompete clause, considering how it will alter the poaching outcome. In the bidding stage, the noncompete duration π impairs the entrant's ability to bid for the worker. At the poaching threshold $\bar{\theta}^n$, the entrant bids up to its reservation value, $e^{-r\pi} J^n\big(z\bar{\theta}^n,\kappa\big)$, which just beats what the incumbent can offer, $J^n(z,\kappa)$. Using the linearity result in Lemma 2, I obtain a relation between the duration length and the poaching threshold: $\pi = \frac{1}{r}\log\big(\bar{\theta}^n\big)$.

In the buyout stage, the incumbent sets the buyout menu $\{\tau(\tilde{\pi}|z,\kappa) : \tilde{\pi} \in [0,\pi]\}$ and, implicitly, its desired poaching threshold $\bar{\theta}^n$ to maximize the rent $\int_{\bar{\theta}^n}^{\infty} \tau(\tilde{\pi}(\theta)|z,\kappa) dF(\theta)$ in (8), considering entrant's IC and IR constraints (4) and (5). This problem is akin to a monopolist seller conducting second-degree price discrimination. It turns out that the buyout menu bunches to a single price—the payment required for reducing the exclusion from π to zero.[11] Bunching occurs since no useful information is revealed in the bidding stage. Indeed, bidding reveals the entrant match quality θ only up to the poaching threshold: if the quality is below the threshold, its precise value is revealed; otherwise, the incumbent learns

[10] If one were to specify a more general spillover function to entrants, for example a CES form $z' = (z^{\frac{\xi}{\xi-1}} + \theta^{\frac{\xi}{\xi-1}})^{\frac{\xi-1}{\xi}}$, the linearity result in Lemma 2 no longer holds when $\xi \neq 1$. It would imply variations in the noncompete contract and investment choices with respect to productivity level z. Such variations are not first order among the large Compustat firms but can be important in the broad economy.

[11] Stronger conditions are necessary for screening to be profitable (see Anderson and Dana, 2009). Appendix D.5 explores an extension with human capital depreciation when workers are excluded from employment. Price discrimination arises in this extension: the incumbent employers offer a continuum buyout menu, and partial exclusion occurs in equilibrium. This outcome is akin to the "damaged goods" phenomenon (e.g., Deneckere and McAfee, 1996), where a monopolist intentionally damages goods (or "versioning") to price discriminate. Here, exclusion leads to a "damaged" versions of human capital.

that it is above the threshold. Further, the linear structure here also implies that quantity screening is not profitable. Thus, all entrants that can poach the worker buy out the entire exclusion in (4). Finally, a binding IR constraint (5) at the poaching threshold suggests that the incumbent charges a buyout payment $\tau(0|z,\kappa) = j^n(\kappa)z\big(\bar{\theta}^n - 1\big)$. Combining these arguments, setting the poaching threshold to maximize expected rent, $\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big)$, boils down to trading off the "markup," $\bar{\theta}^n - 1$, for the probability of selling, $1 - F\big(\bar{\theta}^n\big)$. These insights facilitate the following proposition.

Proposition 1 (Private-Optimal Contract)**.** *The firm-worker match includes a noncompete clause, $i(z,\kappa) = n$, if and only if the contracting cost is below a cutoff:*

$$\kappa \leq \bar{\kappa} = j^c \lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big). \tag{18}$$

Absent a noncompete clause or its enforcement, the poaching threshold $\bar{\theta}^c = 1$. Otherwise, the poaching threshold is characterized by

$$\bar{\theta}^n = 1 + \frac{1 - F\big(\bar{\theta}^n\big)}{f\big(\bar{\theta}^n\big)}; \tag{19}$$

the noncompete duration is $\pi = \frac{1}{r}\log\big(\bar{\theta}^n\big)$, and the buyout price is $\tau(0|z,\kappa) = j^n(\kappa)z\big(\bar{\theta}^n - 1\big)$.

The proposition first states that firm-worker matches with a low contracting cost include a noncompete clause. The cutoff type $\bar{\kappa}$ is exactly indifferent between the two options. This result captures the observed binary contract choice, which I refer to as the *selection* channel in the *extensive margin*.

Absent the noncompete threat, the wage bidding leads to a Bertrand competition outcome: workers take the jobs with the better firms. Although this outcome is identical to the one in Postel-Vinay and Robin (2002), the bargaining protocol is modified. In their setup with perfect information, firms each make a take-it-or-leave-it offer to the worker; here, under asymmetric information, firms bid for the worker through an ascending (English) auction.

In contrast, if a noncompete clause is included and enforced, the poaching threshold in equation (19) is distorted upward. The expression is a monopoly markup pricing formula: the monopolist sets a "markup" which equals the inverse of the hazard rate, $\big(1 - F\big(\bar{\theta}^n\big)\big)/f\big(\bar{\theta}^n\big)$, over the efficient level. This poaching threshold is achieved by the noncompete duration π. I refer to this choice as the *intensive margin*. The buyout price $\tau(0|z,\kappa)$ fully extracts rent from the poaching-threshold entrant in addition to the wage payments to the worker. Under mild regularity conditions on the match quality distribution discussed in Appendix A.2, there exists a unique solution to equation (19). We restrict our attention to such distributions.

3.2 Effects of Noncompete Clauses

Building on the contract characterized in Proposition 1, I now assess its effects. Depending on whether bound by noncompete clauses, the workers experience job-to-job transition rates:

$$\eta^c = \lambda(1 - F(1)) \quad \text{and} \quad \eta^n = \lambda p\big(1 - F\big(\bar{\theta}^n\big)\big) + \lambda(1-p)(1 - F(1)). \tag{20}$$

The incumbents' investment decisions also follow immediately. The optimality conditions in (7) and (8) suggest that the investment incentive is such that the marginal cost of investment is equalized to the marginal joint match value:

$$c'(\mu^c) = j^c \quad \text{and} \quad c'(\mu^n(\kappa)) = j^n(\kappa). \tag{21}$$

To see the investment holdup problem, recall the expressions for the marginal joint match value in (17). Consider first the workers who are free to move. Their employers disregard the spillovers to future entrants when calculating the benefits of investment and, therefore, underinvest relative to the first-best level. The details for this comparison are presented in Lemma E.1 in Appendix E.4. For workers under noncompete clauses, their employers partially internalize the spillover effects as a byproduct of rent extraction and thus undertake more investments. To delineate this effect, I define the investment elasticity $\varepsilon \equiv \frac{c'(\mu)}{c''(\mu)(\mu - \frac{1}{2}\sigma^2)}$. If the marginal benefit j increases by 1%, the investment $\mu - \frac{1}{2}\sigma^2$ increases by ε%.[12]

Formally, the next proposition captures the *investment-reallocation trade-off* associated with noncompete clauses: they alleviate the holdup problem due to the investment externality but aggravate the distortion in worker allocation due to the contracting externality.

Proposition 2 (Investment-Reallocation Trade-off)**.** *Workers subject to noncompete clauses experience a lower job-to-job transition rate relative to those free to move by a magnitude of*

$$\frac{\eta^c - \eta^n}{\eta^c} = p\frac{F\big(\bar{\theta}^n\big) - F(1)}{1 - F(1)}. \tag{22}$$

These clauses, however, enable their employers to increase investment by:

$$\frac{\mu^n(\kappa) - \mu^c}{\mu^c - \frac{1}{2}\sigma^2} \approx \varepsilon\frac{\lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big) - \frac{\kappa}{j^c}}{r - \mu^c}. \tag{23}$$

The mobility distortion in equation (22) follows directly from the job-to-job transition rates in (20). The expression $\frac{F(\bar{\theta}^n) - F(1)}{1 - F(1)}$ captures the fraction of lost worker reallocations

[12] The elasticity is defined according to the volatility-adjusted drift $\mu - \frac{1}{2}\sigma^2$.

The magnitude of the investment increase in (23) follows from the rent-extraction nature of noncompete clauses. Intuitively, rent extraction allows an incumbent match to partially appropriate the external payoff to its investment, thus alleviating the holdup by the amount of extracted rent. To be precise, the buyout extracts a rent of $\lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big)$ for the incumbent, translating into a higher marginal value from investment in discounted present value terms. This calculation adjusts for the contracting cost incurred. Hence, the investment response is lower for matches with higher contracting costs, to the point that the cutoff type $\bar{\kappa}$ has a zero response: $\mu^n(\bar{\kappa}) = \mu^c$. Importantly, this response depends on the investment elasticity ε. The more elastic the investment is, the larger the response.

Following Propositions 1 and 2, I obtain some comparative statics, which are useful when mapping the model to the cross-state variation in the data.

Lemma 3 (Cross-Regime Variation)**.** *In a higher-enforcement regime p, a higher proportion of firm-worker matches $F\big(\bar{k}\big)$ use a noncompete clause. Noncompete clauses reduce the job-to-job transition rate η^n and increase investment $\mu^n(\kappa)$ by larger magnitudes.*

The intuition for these comparative statics is straightforward. When it is more likely that a noncompete clause can be enforced, the profit of including the clause increases, and hence a higher proportion of matches use it. Moreover, the clauses allow firms to extract more rent, reducing worker mobility more considerably and spurring more investment.

3.3 Wage Patterns

Noncompete clauses tend to reduce the extent of wage backloading. The mechanism is simple: the clauses reduce the extent of outside competitive pressure and in turn the amount of wage backloaded for retention. To be precise, wage growth over a worker's tenure within a match is due to bidding by entrants who are unable to poach the worker. For a worker subject to a noncompete clause, the reservation value of unsuccessful poachers is reduced. Thus, the incumbent needs to bid up the wage to a lesser extent to retain the worker. Specifically, in the HJB equation (14), wage bidding raises the promised utility to the worker to an $e^{-r\pi}$ fraction of what it would be otherwise. In anticipation of less wage bidding, to deliver the initial promised utility, the worker starts with a higher wage but experiences a lower wage growth. However, there are countervailing forces affecting wage growth: noncompete clauses improve future productivity growth due to higher investment, which further increases future match value. This force can make the overall effect on the wage pattern ambiguous.

Overall, workers are more than compensated for signing noncompete clauses. As equation (15) suggests, they bargain with their employers for proper compensation before signing the contracts. A concern often raised is that noncompete clauses can depress wages and harm workers. While this distributional concern does not play out here, it can materialize once we depart from the bilateral efficiency result in Lemma 1. Bilateral efficiency breaks down when wage backloading has limits such that the wage nonnegativity constraint binds, and firms can no longer align their workers' incentives perfectly. Further, additional general-equilibrium forces can adversely affect workers, which individual agents fail to internalize when signing the contracts. The *free-entry* extension in Appendix C.3 contemplates such a force.

3.4 Optimal Noncompete Policy

Despite being bilaterally efficient, the laissez-faire contracts are in general socially inefficient. To characterize the optimal noncompete policy, I consider a planner who designs the noncompete contracts.[13] Naturally, the investment decisions are left in the hands of the firms, as is standard for problems concerning the provision of investment incentives. This problem is equivalent to one where the planner chooses the allocation subject to the constraint that incentivizing firm investments inevitably generates distortions in reallocation. Formally, the planner makes these choices to maximize social welfare, defined as the discounted present value of aggregate output net of investment and contracting costs. Let $S(z,\kappa)$ denote the social value associated with a worker of cost type κ employed at productivity z. The planner decides whether to include a noncompete clause:

$$S(z,\kappa) = \max\{S^c(z), S^n(z,\kappa)\},$$

where the social values in the absence and with the inclusion of a noncompete clause satisfy

$$\begin{aligned}
\rho S^c(z) = \max_{\bar{\theta}^c,\mu^c} \Bigg\{ & z - c(\mu^c)z + \mu^c z S^c_z(z) + \frac{1}{2}\sigma^2 z^2 S^c_{zz}(z) + \lambda \int_{\bar{\theta}^c}^{\infty} [S^c(z\theta) - S^c(z)] dF(\theta) \\
& + \delta \left[\iint S(z,\kappa) dH(z) d\Phi(\kappa) - S^c(z) \right] \Bigg\}
\end{aligned} \tag{24}$$

$$\begin{aligned}
\rho S^n(z,\kappa) = \max_{\bar{\theta}^n,\bar{\theta}^c,\mu^n} \Bigg\{ & z - c(\mu^n)z - \kappa z + \mu^n z S^n_z(z,\kappa) + \frac{1}{2}\sigma^2 z^2 S^n_{zz}(z,\kappa) \\
& + \lambda \left[p \int_{\bar{\theta}^n}^{\infty} [S^n(z\theta,\kappa) - S^n(z,\kappa)] dF(\theta) + (1-p) \int_{\bar{\theta}^c}^{\infty} [S^n(z\theta,\kappa) - S^n(z,\kappa)] dF(\theta) \right] \\
& + \delta \left[\iint S(z,\kappa) dH(z) d\Phi(\kappa) - S^n(z,\kappa) \right] \Bigg\}
\end{aligned} \tag{25}$$

subject to the investment incentives in (21).

[13] The analysis considers solely policies intervening in noncompete contracts. It leaves out other instruments, such as investment subsidies, which could have limits if investments are difficult to observe. However, if investment subsidies were feasible, they could be less costly and fully substitute noncompete contracts.

When including a noncompete clause, the planner would choose the terms in (25) differently from the private contracting parties. Along the investment-reallocation trade-off, the planner would like to implement a poaching threshold such that the marginal social benefit from improved investment equals the marginal social cost from lost reallocation:

$$\varepsilon\Delta[1 - F(\bar{\theta}^n) - (\bar{\theta}^n - 1)f(\bar{\theta}^n)] = (\bar{\theta}^n - 1)f(\bar{\theta}^n). \tag{26}$$

where $\Delta \equiv \frac{\lambda\left[p\int_{\bar{\theta}^n}^{\infty}\left(\theta-\bar{\theta}^n\right)dF(\theta)+(1-p)\int_1^{\infty}(\theta-1)dF(\theta)\right]}{r-\mu^n-\lambda p\left(\bar{\theta}^n-1\right)\left(1-F\left(\bar{\theta}^n\right)\right)}\frac{\mu^n-\frac{1}{2}\sigma^2}{r-\mu^n-\lambda p\left(\bar{\theta}^n-1\right)\left(1-F\left(\bar{\theta}^n\right)\right)}$. In mathematical terms, in the benefit calculation, Δ is the product of the discounted present value of investment spillovers captured by entrants and the discounted present value of investment. Loosely speaking, the former factor captures the extent of spillovers to entrants not internalized in the agent's investment decision; the latter factor captures how an additional unit of rent translates into incumbents' investment incentive. In the cost calculation, at the margin $f(\bar{\theta}^n)$ amount of workers would have taken new jobs, generating a value proportional to $(\bar{\theta}^n - 1)f(\bar{\theta}^n)$. Recall that the incumbents' rent extraction motive is such that at the margin no more rent can be extracted, i.e., $1 - F(\bar{\theta}^n) - (\bar{\theta}^n - 1)f(\bar{\theta}^n) = 0$. From the social welfare perspective, they overextract rent by setting an excessively long noncompete duration and blocking too many outside opportunities. With these insights, I summarize the social-optimal contract in the following proposition.

Proposition 3 (Social-Optimal Contract)**.** *The planner finds it less appealing to include a noncompete clause: $i^*(z,\kappa) = n$ if and only if the contracting cost is*

$$\kappa < \bar{\kappa}^* < \bar{\kappa}. \tag{27}$$

Absent a noncompete clause, the social optimum coincides with the private one: $\bar{\theta}^{c*} = \bar{\theta}^c = 1$ and $\mu^{c*} = \mu^c$. Otherwise, it features more reallocation and less investment: $1 < \bar{\theta}^{n*} < \bar{\theta}^n$ and $\mu^{n*}(\kappa) < \mu^n(\kappa)$; specifically, the poaching threshold is characterized by

$$\bar{\theta}^{n*} = 1 + \frac{\varepsilon\Delta}{\varepsilon\Delta + 1}\frac{1 - F(\bar{\theta}^{n*})}{f(\bar{\theta}^{n*})}.\text{[14]} \tag{28}$$

This proposition characterizes the social optimum both in the intensive and extensive margins. In the extensive margin, from the planner's perspective, noncompete clauses should be used less frequently, since the social value of including these clauses is lower than the private one after accounting for the distortionary effect on entry.

[14]To be precise, the planner's choice of poaching threshold should be denoted by $\bar{\theta}^{n*}(\kappa)$, accounting for how the agents' investment incentive $\mu^n(\kappa)$ depends on the contracting cost κ. I omit this dependency here for ease of notation and show later that it is quantitatively negligible.

When not resorting to noncompete clauses, the planner can do nothing other than leaving the market as it is. Indeed, ruling out the possibility of noncompete arrangements, the equilibrium featuring the Bertrand competition outcome in the Postel-Vinay and Robin (2002) framework is constrained efficient, even when investment spillover is present.

In the intensive margin, the planner finds it desirable to intervene to capture more reallocation gains. Such an intervention improves welfare despite hurting incumbents' investment incentives. To understand why, consider a thought experiment of perturbing the laissez-faire outcome. Recall that the incumbents' ex-ante investment always responds in proportion to their ex-post rent extraction. In the private optimum, the incumbents' rent peaks, and so does their incentive for investment. That is, the private optimum obtains the highest level of investment among all candidate allocations, and the planner cannot provide a stronger incentive for investment. The only potential welfare-improving intervention is to lower the poaching threshold and recuperate some reallocation gains. Locally, the intervention initially inflicts minimum harm on the incumbents: the marginal decline in incumbent rent is zero, and thus the investment loss is zero too. The optimal intervention features a poaching threshold characterized in formula (28), which balances the cost-benefit calculation in (26).

Two key model primitives drive how far the social-optimal formula (28) moves away from the private-optimal one (19): the *investment elasticity* and the *entrant match quality distribution*. The former formula reduces the "markup" $\frac{1-F(\theta)}{f(\theta)}$ by an intervention factor $\frac{\varepsilon\Delta}{\varepsilon\Delta+1}$. Naturally, the less elastic the investment is, the larger the intervention. In one extreme, when investment is perfectly inelastic, $\varepsilon \to 0$, the holdup concern disappears, so it is never optimal to tolerate any incumbent rent extraction. The planner chooses to realize the reallocation gains fully by always assigning workers to better jobs, $\bar{\theta}^{n*} \to 1$. In the other extreme, when investment is infinitely elastic, $\varepsilon \to \infty$, the planner allows the agents to extract as much rent as possible to incentivize investment, $\bar{\theta}^{n*} \to \bar{\theta}^{n}$. On the reallocation side, how much gains can be recuperated depends on the entrant match quality distribution, as captured by the hazard rate $\frac{f(\theta)}{1-F(\theta)}$. For instance, with a constant hazard rate, a constant proportion of reallocation opportunities can be realized regardless of the degree of intervention. However, with a decreasing hazard rate, more and more reallocation opportunities can be realized as the degree of intervention increases, thus pushing for a larger intervention.

Next, consider a policy tool that caps the noncompete duration. To implement the poaching threshold in equation (28), one could impose a cap $\pi^* < \pi$. Building on the proceeding discussions, a simple approximation of the duration cap can be obtained.

Corollary 1 (Duration Cap). *If the hazard rate for entrant matches* $\frac{f(\theta)}{1-F(\theta)}$ *is constant, the* *optimal cap can be approximated by:*

$$\pi^* \approx \frac{\varepsilon\Delta}{\varepsilon\Delta + 1}\pi.$$

If the hazard rate is decreasing, the approximation provides an upper bound. If the hazard rate is increasing, the approximation is a lower bound.

The duration cap does not fully implement the social optimum in Proposition 3. It corrects the excessively long duration in the intensive margin. As the restrictive cap makes the clauses less profitable, it partially fixes the excessive usage in the extensive margin.

3.5 Discussion: Theoretical Insights

To take stock, I connect the results above to the existing literature, how they depart from or recast the established insights. First, in terms of the efficiency properties, the presence of search frictions breaks the insights of the classical analysis by Becker (1962) in a perfectly competitive labor market. There, because human capital is perfectly priced externally, the problem reduces to bilateral bargaining between the firm and the worker about who pays for the investment. In contrast, in an imperfectly competitive labor market, the problem is among three parties. Future entrant employers also have some monopsony power and can partially appropriate the payoff. Therefore, a positive *investment externality* on entrants appears. While the incumbents pay for the cost, investment is prone to holdup. Consequently, they undertake more investment in response to rent extraction from the noncompete buyout.

In essence, noncompete clauses create "barriers to entry," isomorphic to the effect of the damage payment contracts studied by Aghion and Bolton (1987), whereby an incumbent seller stipulates a damage payment from its buyer for switching to entrant sellers. However, it is worth noting that, instead of directly specifying the payment, the noncompete buyout arrangement has an additional appeal in this setting: the incumbent firm does not necessarily need to specify or commit to the buyout payment ex ante, since it would ask the same amount ex post in the buyout stage. This finding aligns well with the observation that some contracts specify buyout payments while others are bargained ex post in actual practice.

More broadly, workers' movement across firms presents an important form of knowledge diffusion. Thus, the insights here connect to the literature on innovation and knowledge diffusion. Indeed, job transitions are a type of "meetings" in which knowledge diffusion takes place (e.g., Lucas and Moll, 2014; Perla and Tonetti, 2014).[15] In particular, the distinction

[15]The model setup that incumbent firms exit after their workers quit is innocuous for the efficiency insights: it merely sets the incumbent's outside option to zero, simplifying the accounting. One could extend the model to a general setting where the incumbents retain some productive knowledge. In the extreme, the incumbents

between rivalry and excludability in the use of knowledge, emphasized by Romer (1990), is relevant here. *Rivalry* refers to the use of knowledge by one firm precluding the use by others; *excludability* refers to preventing others from using the knowledge. The key tension here is not the extent of rivalry but rather the extent of excludability. Precisely, the incumbents' ability to exclude entrants from employing the workers alters the appropriation of the surplus from knowledge diffusion and in turn the investment incentives.

Lastly, the intuition for the optimal noncompete duration cap resembles the one from the literature on optimal patent duration going back to Nordhaus (1967). An analogous trade-off exists. A longer patent duration encourages a higher level of investment at the expense of a more severe distortion due to additional incumbent monopoly power. Here, the distortion is due to the monopoly power of the incumbent employers over entrants.

4 Empirical Evidence in the Managerial Labor Market

I apply the model to the managerial labor market, where noncompete arrangements are pervasive. In connection with the model's predictions, I first present the empirical patterns of noncompete contracts across states and their effects.

4.1 Data

I assembled a novel dataset of noncompete contracts for executives in public-listed U.S. firms. This data is constructed from a large sample of contracts scraped from company filings in the SEC's EDGAR database using textual-analysis tools. I then merged the contract data with Compustat firm-level data and ExecuComp and BoardEx data.[16] Overall, 64% of the executives in the sample are subject to noncompete restrictions. The average noncompete duration is 1.6 years or, equivalently, 19 months.

4.2 State Laws and Use of Noncompete Contracts

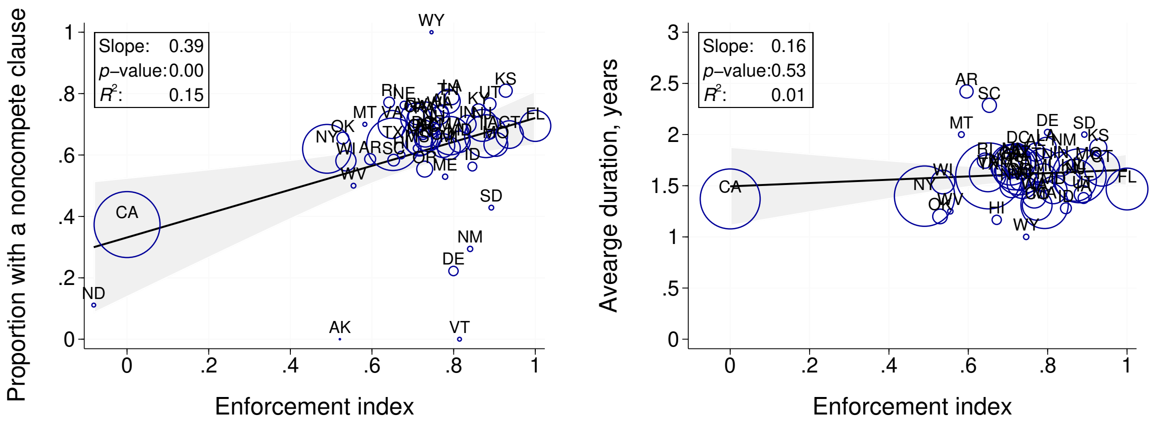
To measure noncompete laws across states, I use the Bishara enforcement index, following previous empirical studies (e.g., Prescott et al., 2016; Lavetti et al., 2019). Bishara (2011) scores the enforceability of noncompete contracts in each state based on legislation and case

are unaffected, as in models of knowledge diffusion by Lucas and Moll (2014). Or, firms could search and replace quits, as in Heggedal et al. (2017). As long as there are gains from labor reallocation and new employers capture some of the gains in a monopsonistic labor market, incumbent employers can write more complex contracts to extract rent, which inevitably distorts worker allocation due to the information friction.

[16] The details for data construction are in Appendix F. The final sample includes 12,679 executives, 2,157 firms, and 13,363 firm-executive matches from 1992 to 2015. The summary statistics appear in Table F.1.

Figure 2: Noncompete law and contracts across states

(a) Prevalence of noncompete clauses (b) Duration of noncompete clauses



Notes: Panel (a) plots the proportion of executives with a noncompete clause against the normalized Bishara enforcement index in 2009. Panel (b) plots the average duration of noncompete clauses against the normalized Bishara enforcement index in 2009. The size of the circles represents the total number of firm-executive matches in the headquarters' state.

law.[17] I borrow the state-level weighted indices constructed by Starr (2019) for the years 1991 and 2009. The raw indices are plotted in Figure F.5 in Appendix F.2. Given that the noncompete law is stable over the time period, I focus on the cross-state variation.

Figure 2 shows the relation between the noncompete law and the use of noncompete clauses across states. Panel (a) plots the proportion of executives with a noncompete clause against the enforcement index normalized to California at 0 and Florida at 1. As expected, the proportion increases with the enforcement index. Panel (b) plots the average noncompete duration against the enforcement index. The duration does not seem to vary with enforceability. These patterns are consistent with the model's prediction of the private-optimal contract in Proposition 1 and the comparative statics in Lemma 3.

Formally, I use the following regression to examine how the use of noncompete contracts varies with the enforceability:

$$NC_{ijst} = \beta \cdot Enforce_s + \gamma Z_{ijt} + \varepsilon_{ijst},$$

where whether executive i who starts working at firm j in state s in year t signs a noncompete contract, $NC_{ijst} \in \{0,1\}$, depends on the enforcement index in state s, $Enforce_s$, and other observable characteristics of the executive and the firm, Z_{ijt}. For the subsample of executives

[17] Bishara (2011) looks at the following dimensions across jurisdictions: whether a state statute of general enforceability exists, scope of employer's protectable interest, plaintiff's burden of proof, consideration provisions, modification of overly broad contracts, and enforceability upon firing.

Table 1: Use of noncompete clauses

	Noncompete (Y/N)					Duration (Years)
	Baseline	Job-Changers		Cross-State Enforce		
	(1)	(2)	(3)	(4)	(5)	(6)
Enforce (State)	0.380***	0.267***	0.265***	0.368***		0.017
	(0.038)	(0.071)	(0.045)	(0.037)		(0.059)
Enforce (Industry)				0.471***	0.405***	
				(0.140)	(0.152)	
Noncompete (Previous Job)			0.131**			
			(0.054)			
Year FEs	√	√	√	√	√	√
Industry FEs	√			√		√
Firm FEs					√	
Executive FEs		√				
Observations	11,092	11,092	540	10,794	10,794	5,914

Notes: Standard errors clustered by state in columns 1, 2, 3, and 6, by industry in column 5, and by state and industry in column 4 are in parentheses. Four-digit SIC codes are used in all specifications. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

with a noncompete clause, I also look at their noncompete duration as the dependent variable in the same specification. The control variables Z_{ijt} include the age and gender of the executive, whether the executive is the CEO, and the firm's asset.

Column 1 of Table 1 reports the regression result controlling for year and industry fixed effects. It suggests that moving from the enforceability level in California to the level in Florida, the likelihood of executives entering noncompete clauses increases by 38%. In column 6, the same variation is absent for the duration length. To mitigate concerns of unobserved executive heterogeneity, I look at the sample of job-changers, namely, those with multiple employment spells. Column 2 shows that, after controlling for year and executive fixed effects, when moving from a state with the enforceability level of California to a state with the Florida level, an executive is 27% more likely to sign a noncompete contract. Column 3 uses the subsample of job-changers with two consecutive jobs. The state enforcement index is still significantly positive. Moreover, an executive's contract in the previous job is predictive of the current contract, suggesting some persistence in the contract status.

Cross-state enforcement. One puzzling fact is that firms in California still sign noncompete contracts with their workers despite the ban there. One potential explanation is

Table 2: Effect of noncompete clauses on executive mobility

	Separation (Y/N)			Job-to-Job Transition (Y/N)		
	(1)	(2)	(3)	(4)	(5)	(6)
Noncompete	-0.009*			-0.004**		
	(0.005)			(0.002)		
Noncompete × Enforce (State)		-0.018***			-0.006**	
		(0.005)			(0.003)	
Noncompete × Enforce (Industry)			-0.098**			-0.056***
			(0.047)			(0.017)
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✓	✓		✓	✓	
Firm-Executive FEs			✓			✓
Observations	107,986	107,986	106,294	107,986	107,986	106,294

Notes: Standard errors clustered by state in columns 1, 2, 4, and 5 and by industry in columns 3 and 6 are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

jurisdictional arbitrage: these firms might be able to enforce the clause when their employees move to other states. If more industry peers are located in higher-enforcement states, it is more likely that the clause can be enforced. To examine this possibility, I construct a location-weighted enforceability measure at the industry level: $Enforce_{jt} = \frac{\sum_s Enforce_s N_{jst}}{\sum_s N_{jst}}$, where N_{jst} is the number of firms in industry j in state s in year t.

The results in columns 4 and 5 suggest that cross-state enforcement does explain the contract choice: in a given industry, increases in the industry enforcement index are associated with increased prevalence of noncompete contracts. In column 4, controlling for year and industry fixed effects, the industry enforcement index is significant on top of the state one. In column 5, this index is significant after controlling for year and firm fixed effects.

4.3 Labor Mobility

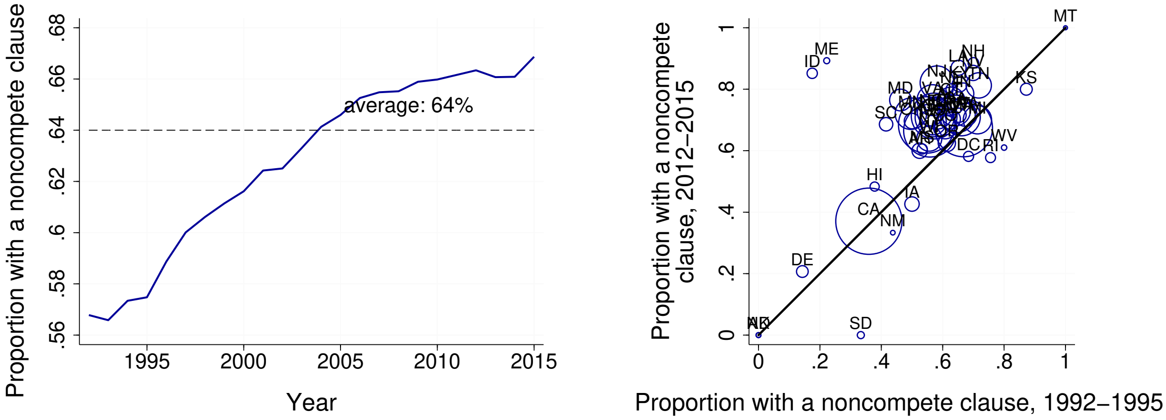
To examine the effect of noncompete clauses on mobility, I consider the following regression:

$$SEP_{ijst} = \beta NC_{ij} + \gamma Z_{ijt} + \varepsilon_{ijt},$$

where the separation event for executive i at firm j in state s in period t, SEP_{ijst}, depends on whether the executive signed a noncompete contract with the firm, NC_{ij}, and other observable characteristics of the executive and the firm, Z_{ijt}. I also look at the job-to-job transition event as the dependent variable. The control variables include the age and gender

Figure 3: Increasing noncompete prevalence over time

(a) Nationwide (b) By state



Notes: In panel (b), the size of the circles represents the number of matches in the firm's headquarter state.

of the executive, whether the executive is the CEO, the firm's asset, and return on asset.

Table 2 reports the regression results for separation events and job-to-job transition events. Column 1 shows that executives with a noncompete clause are associated with a 0.9% lower separation rate annually than those without such clauses. Column 2 shows this magnitude is larger in higher-enforcement states. For example, in a high-enforcement state like Florida, the magnitude of mobility decline amounts to 1.8% annually. Both regressions control for year and firm fixed effects. Cross-state enforcement also reduces executive mobility. Column 3 shows that increases in industry-level enforceability also result in decreases in separation probability, after controlling for firm-executive fixed effects.

Column 4 shows that the mobility restriction effect also shows up in the job-to-job transition rates. Columns 5 and 6 show that the effect is larger in states and industries with higher enforcement. While job-to-job transition is usually the appropriate measure of mobility, in this case, it is less reliable. The sample includes only top executive jobs in Compustat firms satisfying regulatory disclosure requirements; therefore, the job-to-job transition rate is systematically undermeasured due to executives moving out of the sample. For this reason, in the quantitative assessment, I rely on the separation rate to measure mobility distortion.

The rise of noncompete clauses is a likely culprit for the declining U.S. labor market fluidity. I perform a simple back-of-the-envelope calculation to assess this possible cause in my dataset. Panel (a) of Figure 3 shows that the prevalence of noncompete contracts has been on the rise. The overall proportion of executives under noncompete clauses increased from 57% in the early 1990s to 67% in the mid-2010s. Panel (b) shows that this increase occurred in most states. If each noncompete contract lowers the separation rate by 0.9%, a

Table 3: Effect of noncompete clauses on firm investment

	Intangible Capital			Physical Capital		
	(1)	(2)	(3)	(4)	(5)	(6)
Noncompete	0.012***			-0.003		
	(0.003)			(0.003)		
Noncompete × Enforce (State)		0.017***			-0.001	
		(0.005)			(0.004)	
Noncompete × Enforce (Industry)			0.019***			-0.002
			(0.005)			(0.005)
Year FEs	√	√	√	√	√	√
Firm FEs	√	√	√	√	√	√
Observations	19,673	19,673	19,477	19,673	19,673	19,477

Notes: Standard errors clustered by state in columns 1, 2, 4, and 5 and by industry in columns 3 and 6 are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

10% increase in noncompete contracts can contribute to a 0.09% decline in separation rate.

4.4 Firm Investment

Since the model treats firms as single-worker firms for simplicity, Proposition 2 measures a firm's investment response depending on whether its worker is subject to a noncompete clause. However, in the data, investment is reported at the firm level not at the match level. To connect the model to the firm-level data, I redefine a firm as a collection of linearly additive firm-worker matches. Thus, for a given firm, there can be variations in the fraction of executives subject to noncompete clauses over time due to turnover. Along this rationale, I specify the following regression for firm-level investment:

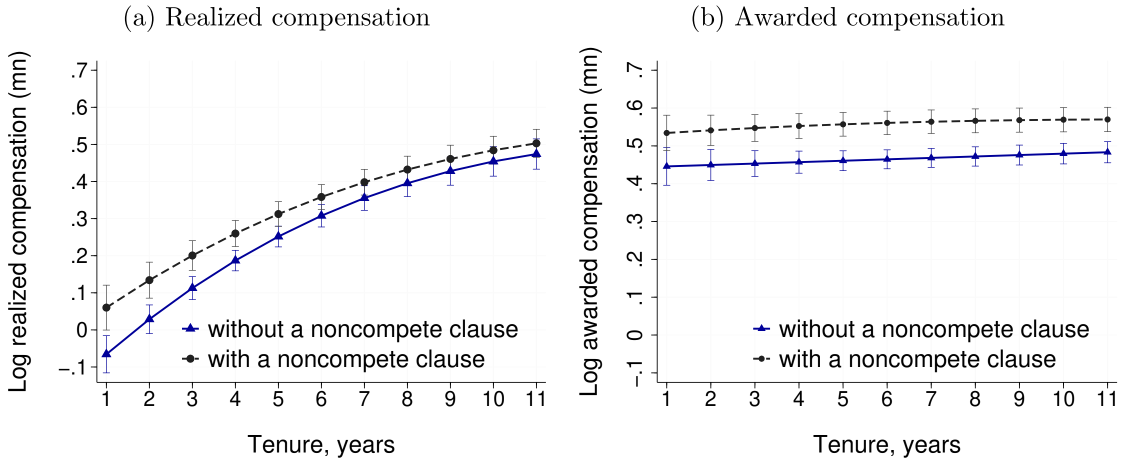
$$INV_{jt} = \beta \bar{NC}_{jt} + \gamma Z_{jt} + \varepsilon_{jt},$$

where firm j's investment rate in period t, INV_{jt}, depends on the proportion of executives in the firm subject to noncompete clauses, $\bar{NC}_{jt}$. I look at both the physical capital investment rate and the intangible capital investment rate as the dependent variables.[18] I include the standard control variables for investment, such as Tobin's Q and cash.

Table 3 reports the investment regression results. Column 1 shows that, when the percentage of executives subject to noncompete clauses increases by 1%, the investment rate in

[18]Intangible capital investment is defined as R&D expenses plus 30% of SG&A expenses. Intangible capital stock is the estimated replacement cost of intangible capital, calculated by Peters and Taylor (2017).

Figure 4: Noncompete contract and wage-tenure profile



Notes: Panel (a) is based on the marginal effects at means according to column 1 of Table F.2 in Appendix F.6. Panel (b) is based on the marginal effects at means according to column 3 of the same table. The bars display 95% confidence intervals.

intangible capital increases by 0.012%, controlling for year and firm fixed effects. Columns 2 and 3 show that the investment effect in intangible capital is stronger in states and industries with higher enforceability. For example, in a high-enforcement state like Florida, the magnitude is 0.017%. Columns 4, 5, and 6 show that the same investment effect is absent for physical capital. This differential pattern suggests that the holdup problem indeed concerns investment activities such as R&D that relate to human capital.

4.5 Wage Backloading

To examine how noncompete contracts interact with wage backloading, I use the following wage regression equation:

$$W_{ijt} = \beta_1 NC_{ij} + \sum_{k=1}^{3} \beta_{2,k} T_{ijt}^k + \sum_{k=1}^{3} \beta_{3,k} \cdot T_{ijt}^k \times NC_{ij} + \gamma Z_{ijt} + \varepsilon_{ijt},$$

where the wage for executive i at firm j in period t, W_{ijt}, depends on whether the executive signed a noncompete contract with the firm, NC_{ij}, the tenure of the executive, T_{ijt}, and other observable characteristics of the executive and the firm, Z_{ijt}. To allow for the tenure effect to depend on the contract, I include the interaction of tenure with the noncompete contract choice, $T_{ijt} \times NC_{ij}$. To allow for a nonlinear tenure effect due to the wage bidding, I also include higher-order polynomials of tenure, T_{ijt}^2 and T_{ijt}^3, and their interactions with the noncompete contract choice, $T_{ijt}^2 \times NC_{ij}$ and $T_{ijt}^3 \times NC_{ij}$. To allow for differential effects due to enforceability, I allow for the interaction between the noncompete contract status and the state-level enforcement index. The control variables Z_{ijt} contains the firm's asset, Tobin's Q, return on asset, whether the executive is the CEO, and the gender of the executive.

The distinction between two compensation measures—awarded compensation and realized compensation—is relevant here. Awarded compensation tends to be more in line with the executive's current productive value. A large part of the awarded pay is in the form of restricted equity, which is deferred to future dates contingent on the executive staying with the firm. Deferred compensation is exactly how firms backload wage for retention. Thus, realized compensation is the appropriate measure for gauging the extent of wage backloading.

The wage-tenure patterns in Figure 4 confirm the wage backloading mechanism. Panel (a) plots realized compensation over tenure by whether the executive is subject to a noncompete clause. It shows that an executive with a noncompete clause is associated with a starting wage that is 13% (or \$130K in 2010 prices) higher than one who is free to move. However, the executive experiences a 1% lower average annual wage growth over the first ten years of tenure than their counterparts. Panel (b) shows that, in contrast, the awarded compensation is flat over tenure regardless of the contract, much flatter than the actual take-home pay.

5 Quantitative Application

Next, I leverage the empirical patterns discussed above to calibrate the model in the managerial labor market. I then evaluate noncompete policies quantitatively in that context.

5.1 Calibration

Broadly, the calibration strategy ties the model predictions closely to their empirical counterparts. First, I consider a full-enforcement regime of the model, i.e., $p = 1$, and map it to states such as Florida on the extreme high end of the enforcement index. Implicitly, I normalize the enforcement probability in these states to one. Second, I map the model-implied variation in the prevalence of noncompete clauses across enforcement regimes in Lemma 3 to the cross-state variations in the data.

As a first step, I specify the following functional forms. The entrant match quality follows the Pareto distribution $F(\theta) = 1 - \left(\frac{\theta_m}{\theta}\right)^{\alpha}$, $\forall \theta \in [\theta_m, \infty)$, which ensures that there exists a unique solution to the poaching threshold. This distribution implies that higher quality matches come along less often. The investment cost function is $c(\mu) = \frac{\varphi}{1+1/\varepsilon}\left(\mu - \frac{1}{2}\sigma^2\right)^{1+\frac{1}{\varepsilon}}$. Thus, the investment elasticity is ε and the investment cost elasticity is $\varepsilon + 1$. The contracting cost follows the log-normal distribution, $\log(\kappa) \sim N(\mu_\kappa, \sigma_\kappa^2)$. Lastly, the productivity

Table 4: Calibrated parameters

Parameter	Symbol	Value	Moment	Data	Model
Discount rate	ρ	0.05	Interest rate	5%	5%
Brownian motion std dev	σ	0.24	Pareto right tail	1.16	1.15
Bargaining weight (newborn)	β	0.5	Peak-to-initial wage ratio	1.8	4
Outside opportunity					
Exogenous death rate	δ	0.058	Average duration (months)	19.2	19.2
Entrant arrival rate	λ	0.14	Separation rate	8.5%	8.5%
Distribution shape	α	6.3	Separation rate decline	1.8%	1.8%
Distribution lower bound	θ_m	0.77	Wage growth (first ten years)	5.4%	5.4%
Investment cost function					
Level	φ	24.6	Intangible investment rate	13.8%	13.8%
Elasticity	ε	6.8	Intangible investment increase	1.7%	1.7%
Contract cost					
Distribution mean	μ_κ	-4.3	Noncompete prevalence ($p = 1$)	70%	70%
Distribution std dev	σ_κ	0.99	Variation of prevalence	38%	38%

distribution for newborn matches is normalized to a mass point at 1.

The model is calibrated at an annual frequency: one unit of time corresponds to one year in the data. For convenience, the noncompete duration is presented in months. Table 4 displays the calibrated parameters and the targeted moments. The discount rate ρ is set to 0.05 to match the interest rate. For the remaining parameters, I discuss the welfare-relevant and irrelevant ones separately. The bilateral efficiency result in Lemma 1 implies that two parameters, β and θ_m, relate only to the dynamic wage-setting in Section 2.5 and do not shape the investment-reallocation trade-off. Specifically, the bargaining parameter β applies only to the *newborn* workers in their first jobs. It determines how they split the match surplus.[19] In a similar vein, the outside matches relevant for efficiency improvement have quality $\theta \geq 1$, and those in the interval $[\theta_m, 1)$ only bid up the wage. Thus, a sufficient statistic for welfare is the unrestricted job-to-job transition rate $\lambda(1 - F(1))$.

Among the welfare-relevant parameters, I first calibrate the two model primitives key to the intensive-margin duration choices, utilizing the results in Proposition 2. The magnitude of mobility decline reflects the amount of the outside opportunities blocked by noncompete clauses and is informative of the entrant match quality distribution, and the magnitude of investment increase helps to discipline the investment elasticity.

Entrant match quality distribution. As discussed in Section 4.3, the data does not

[19]To be precise, β is welfare irrelevant as long as it is not too small such that the wage non-negativity constraint never binds. Quantitatively, with the calibrated β, this constraint is far from binding.

provide a good direct measure of job-to-job transition rates, so I reply on the separation rates to measure mobility distortion. For executives who are free to move, the separation rate is 8.5%. According to column 2 of Table 2, in a full-enforcement regime, noncompete clauses reduce the rate by 1.8%.

In the model, the separation rates only differ from the job-to-job transition rates in equation (20) by the exogenous death rate δ. To back out the job-to-job transition rates, I use the private-optimal noncompete duration $\frac{1}{\rho+\delta}\log\left(\frac{\alpha}{\alpha-1}\right)$, which averages 19 months in the data, as an additional moment. The three moments jointly pin down the death rate δ, the distribution shape parameter α, and the unrestricted job-to-job transition rate $\lambda(1-F(1))$ (2.7%). These numbers uncover a large drop in mobility and many lost reallocation opportunities:[20]

$$\frac{\eta^c-\eta^n}{\eta^c}=\frac{\lambda\big(F(\bar{\theta}^n)-F(1)\big)}{\lambda(1-F(1))}=\frac{1.8\%}{2.7\%}.$$

Investment elasticity. I use the intangible investment rates to measure investment spending. Borrowing the regression result in column 2 of Table 3, I compute that noncompete clauses increase the investment rate by 1.7% in a full-enforcement regime, relative to an average rate of 13.8%. Compared to the mobility decline, this investment increase is mild.

To calibrate the investment elasticity ε, I rewrite equation (23) in terms of the investment expenditure and account for the selection margin:

$$\frac{\mathbb{E}[c(\mu^n(\kappa))]-c(\mu^c)}{c(\mu^c)}\approx(\varepsilon+1)\frac{\lambda\big(\bar{\theta}^n-1\big)\big(1-F\big(\bar{\theta}^n\big)\big)-\frac{1}{j^c}\mathbb{E}[\kappa|\kappa\leq\bar{\kappa}]}{r-\mu^c}=\frac{1.7\%}{13.8\%},$$

which implies an elasticity of 6.8. Further, the level parameter φ is calibrated to match the average investment rate.

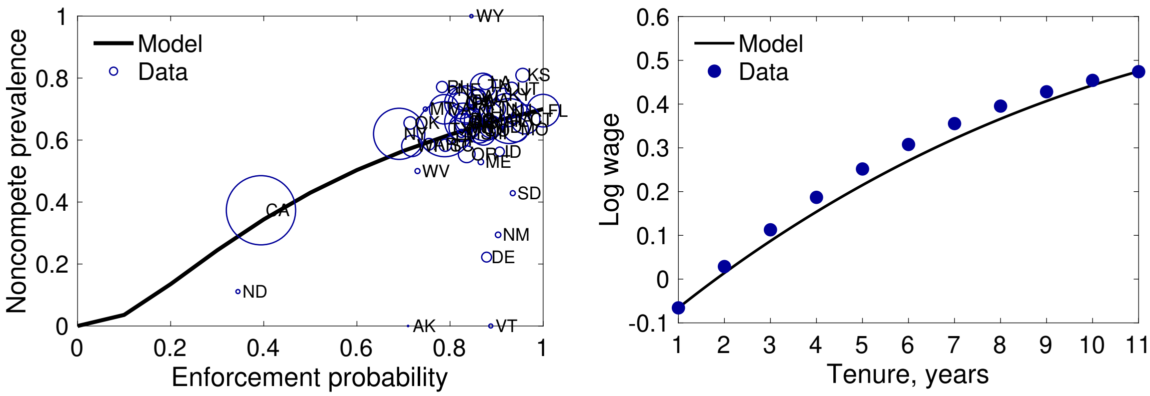
Contracting cost. In the selection margin, the variation in the prevalence of noncompete contracts across states helps to discipline the distribution of contracting costs. In states such as Florida, which resemble a full-enforcement regime, the percentage of executives subject to a noncompete clause is 70%. As reported in column 1 of Table 1, the slope at which noncompete prevalence increases with enforcement probability is 0.38. Together, the two moments pin down μ_κ and σ_κ. The calibrated distribution has a mean of 0.022. In a full-enforcement regime, the matches selected into noncompete clauses have an average cost amounting to 0.01 fraction of their match output.

Panel (a) of Figure 5 plots the model-generated variation in the noncompete prevalence

[20] A sufficiently large exogenous death rate $\delta>\underline{\delta}$ is required for a steady state to exist. This parameter restriction puts a lower bound, $\frac{1.8\%}{8.5\%-\underline{\delta}}$, on the mobility distortion.

Figure 5: Model and data fit

(a) Cross-state variation (b) Wage growth absent noncompete clauses



with respect to the enforcement probability. While the correlation between the two is not exactly linear, it is approximately linear at high levels of enforcement probability. Fitting the noncompete prevalence in California, the implied enforcement probability is around 0.4.

Productivity process. The stationary productivity distribution exhibits a Pareto right tail. The Pareto index is linked to the standard deviation of the Brownian motion σ. I fit an empirical distribution of firm size measured in terms of employment in a given year and obtain an average right-tail index of 1.16 for the years 1992 through 2015. This data moment implies a standard deviation of 0.24.[21]

Welfare-irrelevant parameters. The bargaining weight for *newborn matches* β is set to 0.5. It is not easy to directly measure the value of an executive in the data. To check whether this bargaining parameter is reasonable, I use the peak-to-initial wage ratio. In the model, at the peak wage, an executive obtains a promised utility equal to the entire match value; at the initial wage, the executive has a promised utility equal to the bargained level. Hence the peak-to-initial wage ratio maps to the share of the match value the executive gets. The peak-to-initial wage ratio in the data is 1.8. The model-implied level is 4. While further improvement can be made, this parameter does not affect the welfare analysis.

The lower bound of match quality distribution θ_m is closely tied to the wage-tenure profile. To see why, consider an executive who can move freely. The wage growth is generated by bidding against job offers with match quality in the interval $[\theta_m, 1]$. If $\theta_m = 1$, the wage growth would be zero. To match the average annual wage growth of 5.4% for executives who

[21] This calibration strategy of identifying the stochastic component of the productivity process from the cross-sectional firm distribution follows Luttmer (2007) and Atkeson and Burstein (2010).

can move freely, I obtain a lower bound of 0.77. Panel (b) of Figure 5 plots the wage-tenure profile generated by the model, which fits well with the one in the data. As the last step, I separate out the arrival rate of outside offers λ, which is 0.14, from the probability $1 - F(1)$,

The model implies that the average buyout payment is about ten times the starting wage, or around \$12 million in 2010 prices. Although there is no comprehensive buyout data available, the prices paid in a few noncompete buyout cases suggest that the model-implied magnitude is in a reasonable range.[22]

5.2 Policy Evaluation

Three policy tools can be deployed to restrict noncompete contracts: (1) imposing a cap on the duration, (2) limiting the extent of their prevalence, and (3) weakening the enforceability p. These restrictions have all been frequently proposed or implemented in reforming noncompete laws. I consider several policies that involve one or a combination of these tools.

Social optimum. The first policy experiment considers implementing the constrained social optimum characterized in Proposition 3, which provides an upper bound on potential welfare gains. Recall that this outcome can be achieved by capping the duration in the intensive margin and limiting the use of noncompete clauses to low cost types in the extensive margin. Columns 1 and 2 in Table 5 report the results in low and high levels of enforcement.

Quantitatively, the duration cap is 1.6 months across all enforceability regimes.[23] This cap is very stringent when put in perspective. It is much lower than the average 19-month duration set by the private contracting parties. In recent policy changes, a new law in Massachusetts caps the duration at one year. Underpinning this stringent duration cap is a mild investment elasticity and a substantial amount of lost job-to-job reallocations, which we uncovered from the data. The parameterized entrant match distribution exhibits a decreasing hazard rate. Thus, the approximation in Corollary 1 provides an upper bound. The approximated cap of 1.8 months is a close one, suggesting that the shape of the hazard rate plays a relatively minor role in driving a low cap. With this very short duration cap, the fraction that the planner finds desirable to use noncompete clauses $F(\bar{\kappa}^*)$ is close to zero.

[22]Buyout payments for executives are usually in the magnitudes of millions. In the case of Mark Hurd, a former CEO of Hewlett-Packard poached by Oracle in 2010, the new employer paid a \$14 million buyout. Figure F.3 in Appendix F.1.2 shows a contract including a buyout option requiring a multi-million payment.

[23]This welfare calculation accounts for the transition path, which differs from the steady-state welfare. The latter objective would prescribe a more lax restriction: quantitatively, a duration cap of around 10 months and a prevalence of roughly 40%. This discrepancy is due to the time discounting in the transition-path welfare calculation. To check the sensitivity of the policy is the discount rate, Appendix B.6 considers an experiment imposing a zero discount rate, which favors more investment protection. The recalibrated model still suggests a short duration cap of 2 months according to both criteria.

Table 5: Policies restricting noncompete clauses

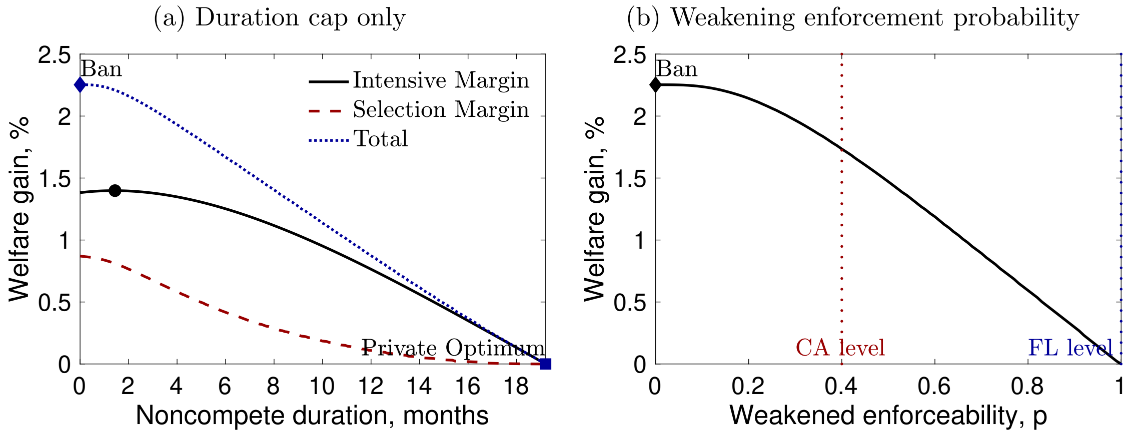
Policy	Social Optimum		Duration Cap Only	Ban	CA-level $p = 0.4$
Regime	CA-level	FL-level	FL-level	FL-level	FL-level
	(1)	(2)	(3)	(4)	(5)
Current enforceability, p	0.4	1	1	1	1
Equilibrium					
Duration (months), π	19.2	19.2	19.2	19.2	19.2
Prevalence, $F(\bar{\kappa})$	34%	70%	70%	70%	70%
Contract restriction					
Duration cap (months), π^*	1.6^a	1.6^a	1.6^a	0	19.2
Prevalence, $F(\bar{\kappa}^*)$	$\approx 0\%$	$\approx 0\%$	$13\%^b$	0%	$34\%^b$
Policy outcome					
ΔSeparation rate	0.25%	1.26%	1.23%	1.26%	1.01%
ΔInvestment rate	-0.17%	-1.19%	-1.17%	-1.19%	-1.02%
Welfare gain (transition)	0.49%	2.25%	2.21%	2.25%	1.73%
Decomposition: Total					
= Reallocation	0.29%	1.53%	1.53%	1.55%	0.92%
+ Investment	-0.03%	-0.13%	-0.13%	-0.16%	-0.08%
+ Selection	0.22%	0.85%	0.81%	0.87%	0.89%
Welfare gain (steady state)	0.87%	2.30%	2.38%	2.30%	1.42%

Notes: The superscript a indicates that the optimal duration cap $\pi^*(\kappa)$ depends on the cost type κ, but the variation is quantitatively negligible. The superscript b indicates that the contracting parties are free to choose the contractual term. The welfare gain (transition) computes the gain along the transition path after imposing the policy in the laissez-faire steady state. The decomposition follows the order of imposing the reallocation, investment, and selection outcomes resulting from the policy prescribed. The welfare gain (steady state) compares the welfare outcome of the new steady state relative to the laissez-faire level.

The resulting welfare gains are sizable. In a Florida-level full-enforcement regime, i.e., $p = 1$, implementing the social optimum leads to a welfare gain of 2.25% along the transition path relative to the laissez-faire outcome. This scenario will be the main case for analysis. In terms of labor mobility, the overall separation rate or job-to-job transition rate increases by 1.26% annually, while the investment rate declines by 1.19%. A welfare decomposition shows that the selection channel contributes 0.85%, around one third of the total gains. In a California-like regime, i.e., $p = 0.4$, the same policy leads to a welfare gain of 0.49%.

Duration cap. In implementing the social optimum discussed above, it is straightforward to impose a duration cap as some states have done, but it is less so when we attempt to limit the usage to low-cost types. Therefore, the following policy considers a duration-cap-only policy for its appeal of simple implementation. That is, the contracting parties can freely

Figure 6: Welfare gain



Notes: The welfare gains are calculated in a full-enforcement regime, i.e., $p = 1$.

include a noncompete clause subject to a duration cap.

I first consider a policy imposing a cap of 1.6 months calculated in the previous policy in the Florida-level enforceability regime. Column 3 reports the outcome. Given such a short duration cap, many agents find it unprofitable to incur the costs of signing noncompete clauses. Indeed, the model implies that the proportion of private contracting parties that willingly sign noncompete contracts reduces substantially from 70% to 13%. The policy achieves a welfare gain of 2.21%, which is close to the 2.25% gain in the social optimum.

The duration cap examined above is intended to address only the intensive-margin distortion, and, as noted earlier, the intensive margin is inextricably linked to the extensive margin. Thus, it naturally prompts us to see how much further the duration-cap-only policy can go. Panel (a) of Figure 6 plots the overall welfare gains and the decomposition when we vary the duration cap from zero to the private-optimal level. In the intensive margin alone, the solid line in black traces out the trade-off between labor reallocation and investment. The intensive-margin gain peaks at a duration cap of 1.6 months. However, reducing the duration cap further leads to additional extensive-margin gains, as even fewer agents find it appealing to incur the costs to include the clause. After accounting for the indirect effect of the duration cap through the selection channel, the welfare-maximizing duration cap can go almost all the way to zero, which is essentially a ban.

Ban. Bans on noncompete contracts have recently been enacted locally and proposed nationally. In terms of the policy tools, if the duration cap goes to zero, if the prevalence reduces to zero, or if noncompete clauses are impossible to enforce, the outcomes are effectively a ban. Regardless of the policy tool deployed, a complete ban achieves an almost identical outcome to implementing the social optimum. This result is unsurprising, given that the latter features a short duration cap and a noncompete prevalence close to zero.

Weakening enforcement. The last policy assesses the effects of weakening the enforceability of noncompete contracts. Figure 6 panel (b) shows the welfare outcomes when weakening the enforceability from 1 to varying levels. The social welfare is maximized when noncompete clauses are made almost completely unenforceable, achieving an outcome similar to a very short duration cap or a ban.

While making noncompete contracts entirely unenforceable is appealing, there could be limits for a single state to do so due to cross-state enforcement and other legal constraints. Indeed, as discussed in Section 4.2, despite the explicit ban in California, noncompete contracts are still prevalent rather than nonexistent, as rationalized by the possibility of enforcing them across states. Thus, a relevant policy scenario is weakening the enforceability from a Florida-level regime to a California-level regime. The result of is summarized in Column 5 of Table 5. As noncompete clauses become less likely to be enforced, the proportion of agents that want to use them reduces from 70% to 34%, and the overall welfare gain is 1.73%.

5.3 Discussion and Robustness

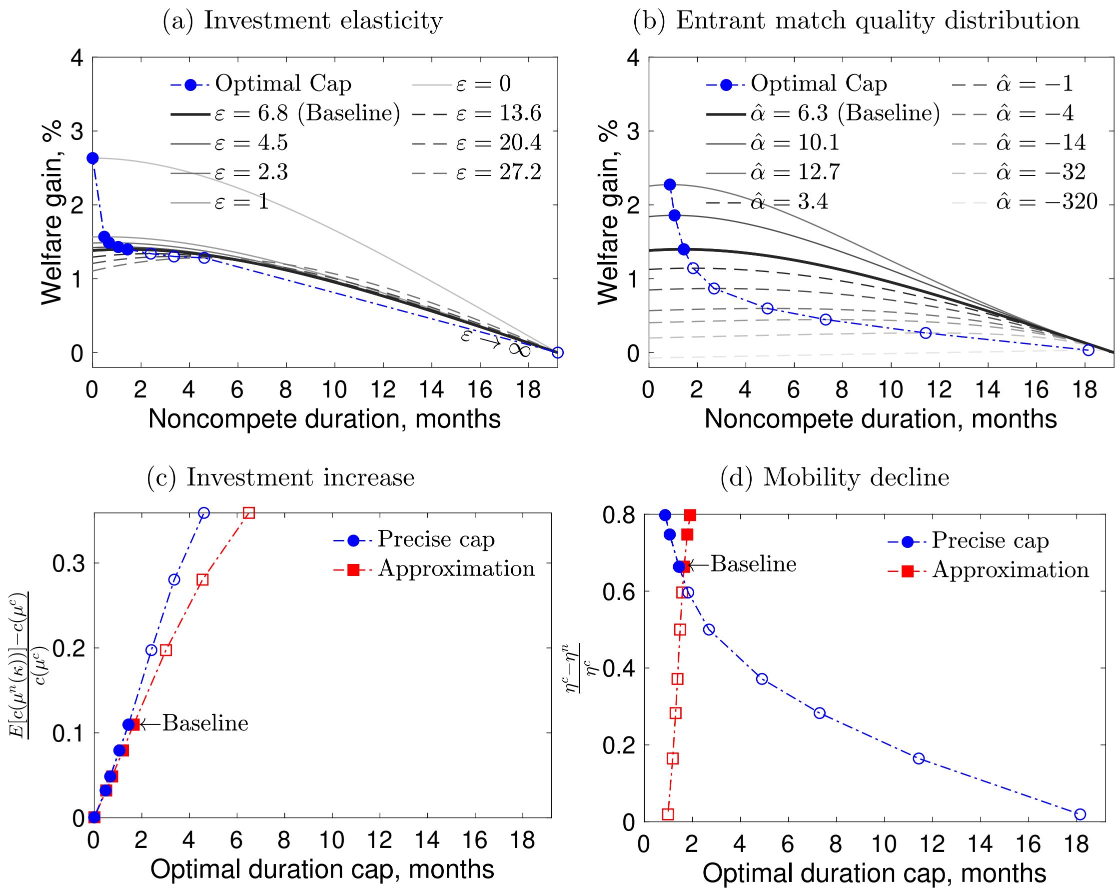
I discuss several modifications and extensions to the baseline model. These exercises illustrate the driving forces behind the policy prescriptions above and assess their robustness.

Key model primitives. The first exercise shows how the observed data moments discipline the calibration of key model primitives and shape the policy results. To do so, I vary the investment elasticity and recalibrate the model to match the data except for the investment response.[24] The pattern in Figure 8(a) aligns with Proposition 3: a higher investment elasticity implies a higher duration cap. Panel (c) shows that different elasticity parameters imply different investment increases and duration caps. With larger investment increases, the duration cap only goes up mildly. For instance, with an investment response almost three times the level observed in the current data, the duration cap is still as low as 3 months. In all cases, the simple upper bounds are close approximates of the precise duration caps.

Similarly, I impose a different the entrant match quality distribution and recalibrate the model. The baseline parameterization assumes a Pareto distribution, which has limited ability capturing the extent of mobility decline. For illustration, I instead impose a double Pareto distribution, where the right shape parameter is α, and the left shape parameter is $\hat{\alpha}$. This distribution nests the baseline one when $\alpha = \hat{\alpha}$. Supplementary details are included

[24] The calibrated elasticity of 6.8 is at the higher range found in the literature, which centers around unity.

Figure 7: How the key model primitives shape the optimal duration cap



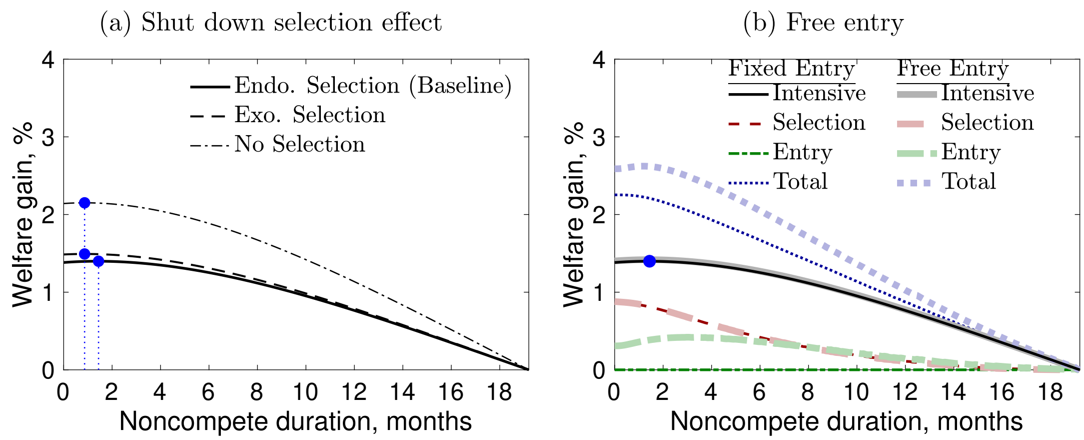
Notes: Panels (a) and (b) plot the intensive-margin welfare gains in a full-enforcement regime, i.e., $p = 1$.

in Appendix C.1. Panels (b) and (d) plot how different entrant match quality distribution implies different mobility distortion and optimal duration cap. It shows that, as long as noncompete clauses generate substantial mobility distortion, the duration cap remains low. For instance, when the mobility decline is half the magnitude in the current data, the cap is still low at 3 months. However, if the mobility decline is tiny, as in the case of a very thin left tail $\hat{\alpha} = -320$, almost no intervention is necessary.

This exercise also serves the following purpose. Suppose one observes different magnitudes of mobility decline or investment increase in other data or labor markets. The patterns in Figure 7 suggest some plausible ranges for the model primitives and policy interventions.

Selection effect. To isolate the intensive margin from the extensive one, I consider two alternative specifications: a *no-selection* economy, by assuming away the contracting costs, and an *exogenous-selection* economy, by imposing an alternative two-point cost distribution $\kappa \in \{0,\infty\}$. The no-selection version shuts down the selection channel completely, while the

Figure 8: Extensions and alternative specifications



Notes: Panel (a) plots the intensive-margin welfare gains in a full-enforcement regime, i.e., $p = 1$.

exogenous-selection version fixes the selection channel.

The two alternative specifications both imply a lower calibrated investment elasticity and, therefore, prescribe a lower optimal duration cap. Panel (a) of Figure 8 shows that the cap reduces from 1.6 to 0.8 months. Given there is no selection effect, the policy outcome is due to the intensive-margin consideration only. Appendix C.2 contains the details.

Free entry. The final exercise relaxes the fixed entry and endogenizes the arrival rate of outside offers λ. A random search market is a fitting setup given the ex-post wage-bidding protocol. Specifically, suppose there is a measure-one of potential entrants each of whom decides to post v vacancies by incurring a cost $K(v)$. The arrival rate of outside opportunity is $\lambda(v) = \lambda_0 v^{\omega}$, where $\omega \in [0,1]$ captures the extent of entry congestion. If entry is fully congested and job postings are costless, i.e., $\omega = 0$ and $K(v) = 0$, the extension converges to the baseline fixed-entry model. Appendix C.3 includes the additional details.

The holdup of investment is now two-sided: apart from the positive external effect of the investment by the incumbent matches, there is also a positive external effect of new firms' investment to enter. The Hosios (1990) insight applies here. The constrained efficient outcome is obtained when the surplus division between the two sides equals their respective contributions to matching. Noncompete contracts shift that surplus division in favor of the incumbents. If entry is less congested, i.e., higher ω, it is more desirable to restrict noncompete contracts and shift the surplus division toward entrants.

Consider an economy with no entry congestion, i.e., $\omega = 1$. This economy is a suitable basis for introducing noncompete contracts and the trade-off involved, because it features efficient turnover and entry otherwise. Panel (c) of Figure 8 shows the welfare effects of capping noncompete duration in this recalibrated economy. Since the agents do not internalize that the arrival rate is endogenous, an entry margin arises in addition to the intensive and selection margins. This entry margin amplifies the welfare gains from a banning by 0.3%.

6 Conclusion

The paper studies policies restricting noncompete contracts and characterizes the optimal regulation. The quantitative evaluation based on the managerial labor market shows that there can be sizable gains from restricting these contracts. The insights obtained here have broader relevance for the macroeconomy, despite the necessary cautions for extrapolating the results to other labor market segments. For high-skilled labor, the same economic forces of similar magnitudes are likely to operate.

There are other potential channels that the analysis here has abstracted away. One channel is risk-sharing between firms and workers, which is shut down, given the risk-neutral assumption in the model. Noncompete contracts can improve risk-sharing by restricting workers' outside opportunities. Another channel is the agglomeration effects of industry clusters. Noncompete contracts prevent the formation of industry clusters by limiting technology spillover and discouraging entrepreneurship.[25] Incorporating these additional channels in future work would be useful. While the risk-sharing channel could attenuate my conclusion here, the agglomeration channel may further reinforce it.

A Proofs

A.1 Proof of Lemma 1

The bilateral efficiency result is obtained by incorporating the PK constraint (1) in the firm's objective (2) and (3). The HJB equations (7) and (8) are formally derived in Appendix B.3.

A.2 Proof of Lemma 2 and Proposition 1

I first solve the choice of buyout menu. The steps are similar to solving a second-degree price discrimination problem. According to the envelope condition for the IC constraint (4) and a binding IR constraint (5) at the poaching threshold, the buyout payment satisfies

$$\tau\left(\tilde{\pi}(\theta|z,\kappa)|z,\kappa\right) = e^{-r\tilde{\pi}(\theta|z,\kappa)}J^n(z\theta,\kappa) - \int_{\bar{\theta}^n}^{\theta} e^{-r\tilde{\pi}\left(\tilde{\theta}|z,\kappa\right)}J_z^n\left(z\tilde{\theta},\kappa\right)d\tilde{\theta} - J^n(z,\kappa). \tag{29}$$

[25] Many studies point to job-hopping and spinouts as instrumental in the formation of industry clusters, to which mobility restrictions bring adverse effects (e.g., Fallick, Fleischman, and Rebitzer, 2006; Franco and Filson, 2006; Franco and Mitchell, 2008; Samila and Sorenson, 2011; Rauch, 2016; Baslandze, 2017).

The problem of maximizing expected buyout payments becomes

$$\begin{aligned}
&\max_{\mathcal{M}} \int_{\bar{\theta}^n}^{\infty} \left[e^{-r\tilde{\pi}(\theta|z,\kappa)} J^n(z\theta,\kappa) - \int_{\bar{\theta}^n}^{\theta} e^{-r\tilde{\pi}\left(\tilde{\theta}|z,\kappa\right)} J_z^n\left(z\tilde{\theta},\kappa\right) d\tilde{\theta} - J^n(z,\kappa) \right] F(\theta) \\
= &\max_{\mathcal{M}} \int_{\bar{\theta}^n}^{\infty} \left[e^{-r\tilde{\pi}(\theta|z,\kappa)} \left(J^n(z\theta,\kappa) - \frac{1 - F(\theta)}{f(\theta)} J_z^n(z\theta,\kappa) \right) - J^n(z,\kappa) \right] F(\theta).
\end{aligned}$$

The first-order conditions with respect to $\tilde{\pi}(\theta|z,\kappa)$ and $\bar{\theta}^n$ are, respectively,

$$J^n(z\theta,\kappa) - \frac{1 - F(\theta)}{f(\theta)} J_z^n(z\theta,\kappa) \geq 0 \text{ with `` = '' if } \tilde{\pi}(\theta|z,\kappa) > 0,\ \forall\theta \geq \bar{\theta}^n \tag{30}$$

$$e^{-r\tilde{\pi}\left(\bar{\theta}^n|z,\kappa\right)} \left(J^n\left(z\bar{\theta}^n,\kappa\right) - \frac{1 - F\left(\bar{\theta}^n\right)}{f\left(\bar{\theta}^n\right)} J_z^n\left(z\bar{\theta}^n,\kappa\right) \right) - J^n(z,\kappa) = 0. \tag{31}$$

Equation (31) implies that $J^n(z\theta,\kappa) - \frac{1-F(\theta)}{f(\theta)} J_z^n(z\theta,\kappa) > 0$ always holds for any $\theta > \bar{\theta}^n$. Therefore, in equation (30), the entrant chooses to reduce the noncompete duration to zero:

$$\tilde{\pi}(\theta|z,\kappa) = 0,\ \forall\theta \geq \bar{\theta}^n. \tag{32}$$

Substituting the buyout level in equation (32) into equation (29), the payment is bunched to a single price, regardless of the match quality θ:

$$\tau(0|z,\kappa) = J^n\left(z\bar{\theta}^n,\kappa\right) - J^n(z,\kappa).$$

Next, I solve for the poaching threshold. Substituting (32) into equation (31), I obtain

$$L\left(\bar{\theta}^n|z,\kappa\right) \coloneqq J^n\left(z\bar{\theta}^n,\kappa\right) - \frac{1 - F\left(\bar{\theta}^n\right)}{f\left(\bar{\theta}^n\right)} J_z^n\left(z\bar{\theta}^n,\kappa\right) - J^n(z,\kappa) = 0. \tag{33}$$

I guess and verify that the joint value functions are linear in z, i.e., $J^c(z) = j^c z$ and $J^n(z,\kappa) = j^n(\kappa)z$. The poaching threshold equation (33) reduces to

$$L\left(\bar{\theta}^n\right) \coloneqq \bar{\theta}^n - \frac{1 - F\left(\bar{\theta}^n\right)}{f\left(\bar{\theta}^n\right)} - 1 = 0.$$

The guess implies that, first, the poaching thresholds $\bar{\theta}^c$ and $\bar{\theta}^n$ are independent of productivity z. Second, the buyout payment is proportional to productivity, $\tau(\tilde{\pi}|z,\kappa) = j^n(\kappa)z\left(\bar{\theta}^n - 1\right)$. Finally, the investment decisions $\mu^c = (c')^{-1}(j^c)$ and $\mu^n(\kappa) = (c')^{-1}(j^n(\kappa))$ are also independent of z. Combining the three results above and replacing them in the HJB equations (7) and (8), I obtain the expressions for j^c and $j^n(\kappa)$ in equation (17). Note that $L(1) < 0$ and $L(\infty) > 0$. Under the following regularity condition, $L(\bar{\theta}^n)$ is strictly increasing in θ, and there exists a unique solution to equation (19).

$$\frac{\partial L(\bar{\theta}^n)}{\partial \bar{\theta}^n} = 2 + \frac{1 - F(\bar{\theta}^n)}{f(\bar{\theta}^n)} \frac{f'(\bar{\theta}^n)}{f(\bar{\theta}^n)} > 0 \rightarrow \frac{f(\bar{\theta}^n)}{1 - F(\bar{\theta}^n)} > -\frac{1}{2} \frac{f'(\bar{\theta}^n)}{f(\bar{\theta}^n)}. \tag{34}$$

To solve the noncompete duration, I move backward to the wage-bidding stage. Consider the entrant that just wins the bid: $e^{-r\pi} j^n(\kappa) z \bar{\theta}^n = j^n(\kappa) z$, which implies that $\pi = \frac{1}{r} \log(\bar{\theta}^n)$.

Finally, the cutoff cost type $\bar{\kappa}$ is characterized by $j^n(\bar{\kappa}) = j^c$. At the cutoff, the investment response is zero, since $\mu^n(\bar{\kappa}) = (c')^{-1}(j^n(\bar{\kappa})) = (c')^{-1}(j^c) = \mu^c$. The cutoff condition becomes

$$\frac{1 - c(\mu^c)}{r - \mu^c} = \frac{1 - c(\mu^c) - \bar{\kappa}}{r - \mu^c - \lambda p (\bar{\theta}^n - 1)(1 - F(\bar{\theta}^n))},$$

which leads to the cutoff expression in equation (18).

A.3 Proof of Proposition 2

To derive equation (23), I first take the log difference of the first-order condition (21):

$$\log(c'(\mu^n(\kappa))) - \log(c'(\mu^c)) = \log(j^n(\kappa)) - \log(j^c) \approx \frac{\lambda p (\bar{\theta}^n - 1)(1 - F(\bar{\theta}^n)) - \frac{1}{j^c} \kappa}{r - \mu^c}.$$

Substituting in $\log(c'(\mu^n(\kappa))) - \log(c'(\mu^c)) \approx (\mu^n(\kappa) - \mu^c) \frac{c''(\mu^c)}{c'(\mu^c)}$, I obtain equation (23).

A.4 Proof of Proposition 3

Similar to the linearity result in Lemma 2, the social value functions are also linear. The proof is straightforward using a guess-and-verify method.

Lemma 4 (Linearity)**.** *The social value functions are linear in z:*

$$S^c(z) = s^c z + \frac{\delta}{\rho + \delta} S_0 \quad \textit{and} \quad S^n(z, \kappa) = s^n(\kappa) z + \frac{\delta}{\rho + \delta} S_0,$$

where $S_0 = \iint S(z, \kappa) dH(z) d\Phi(\kappa)$ and s^c and $s^n(\kappa)$ satisfy:

$$s^c = \frac{1 - c(\mu^c)}{r - \mu^c - \lambda \int_{\bar{\theta}^c}^{\infty} (\theta - 1) dF(\theta)} \tag{35}$$

$$s^n(\kappa) = \frac{1 - c(\mu^n(\kappa)) - \kappa}{r - \mu^n(\kappa) - \lambda \left[p \int_{\bar{\theta}^n(\kappa)}^{\infty} (\theta - 1) dF(\theta) + (1 - p) \int_{\bar{\theta}^c}^{\infty} (\theta - 1) dF(\theta) \right]}. \tag{36}$$

In the extensive margin, the planner chooses to include a noncompete clause if and only if $s^n(\kappa) \geq s^c$. The social-optimal cutoff $\bar{\kappa}^*$ is characterized by $s^n(\bar{\kappa}^*) = s^c$. Consider any noncompete duration $\pi > 0$. At the private-optimal cutoff $\bar{\kappa}$, $j^n(\bar{\kappa}) = j^c$ and the investment response is zero $\mu^n(\bar{\kappa}) = \mu^c$. Therefore, as long as $p > 0$, $s^n(\bar{\kappa}) < s^c$. It must be that $\bar{\kappa}^* < \kappa$.

In the intensive margin, maximizing the social value $s^n(\kappa)$ boils down to choosing $\bar{\theta}^n$ accounting for how it affects μ^n according to $c'(\mu^n) = j^n(\kappa)$. The optimality condition $\partial s^n(\kappa)/\partial\bar{\theta}^n = 0$ states that the marginal social gains from additional investment equals the marginal social cost from reduced reallocation:

$$(s^n(\kappa) - c'(\mu^n))\frac{\partial \mu^n}{\partial \bar{\theta}^n} = s^n(\kappa)\lambda p\big(\bar{\theta}^n - 1\big) f\big(\bar{\theta}^n\big).$$

Substituting in $c'(\mu^n) = j^n(\kappa)$ in the equation above:

$$\frac{\lambda\big[p\int_{\bar{\theta}^n}^{\infty}\big(\theta - \bar{\theta}^n\big)dF(\theta) + (1-p)\int_1^{\infty}(\theta - 1)dF(\theta)\big]}{r - \mu^n - \lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big)}\frac{\partial \mu^n}{\partial \bar{\theta}^n} = \lambda p\big(\bar{\theta}^n - 1\big) f\big(\bar{\theta}^n\big). \tag{37}$$

Differentiating $c'(\mu^n) = j^n(\kappa)$ with respect to $\bar{\theta}^n$:

$$\frac{\partial \mu^n}{\partial \bar{\theta}^n} = \varepsilon\frac{\mu^n - \frac{1}{2}\sigma^2}{r - \mu^n - \lambda p\big(\bar{\theta}^n - 1\big)\big(1 - F\big(\bar{\theta}^n\big)\big)}\lambda p\big[1 - F\big(\bar{\theta}^n\big) - \big(\bar{\theta}^n - 1\big) f\big(\bar{\theta}^n\big)\big]. \tag{38}$$

Combining (38) and (37), I obtain equation (28). At the private-optimal $\bar{\theta}^n$ characterized in (19), the marginal social gains from investment is zero $\partial\mu^n/\partial\bar{\theta}^n = 0$, but the marginal social cost from lost reallocation is positive. At $\bar{\theta}^n = 1$, the marginal cost from lost reallocation is zero, but the investment gain is positive $\partial\mu^n/\partial\bar{\theta}^n > 0$. Therefore, $1 < \bar{\theta}^{n*} < \bar{\theta}^n$.

References

ACEMOGLU, D. (1997): "Training and Innovation in an Imperfect Labour Market," *The Review of Economic Studies*, 64, 445–464.

ACEMOGLU, D. AND J. S. PISCHKE (1999): "The Structure of Wages and Investment in General Training," *Journal of Political Economy*, 107, 539–572.

AGHION, P. AND P. BOLTON (1987): "Contracts as a Barrier to Entry," *American Economic Review*, 77, 388–401.

ANDERSON, E. T. AND J. D. DANA (2009): "When Is Price Discrimination Profitable?" *Management Science*, 55, 980–989.

Atkeson, A. and A. T. Burstein (2010): "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 118, 433–484.

Baslandze, S. (2017): "Entrepreneurship through Spinouts, Innovation and Growth," Discussion paper.

Becker, G. S. (1962): "Investment in Human Capital: A Theoretical Analysis," *Journal of Political Economy*, 70, 9–49.

Bishara, N. D. (2011): "Fifty Ways to Leave Your Employer: Relative Enforcement of Covenants Not to Compete, Trends, and Implications for Employee Mobility Policy," *University of Pennsylvania Journal of Business Law*, 13, 751–795.

Cahuc, P., F. Postel-Vinay, and J.-M. Robin (2006): "Wage Bargaining with On-the-Job Search: Theory and Evidence," *Econometrica*, 74, 323–364.

Clementi, G. L., T. F. Cooley, and C. Wang (2006): "Stock Grants as a Commitment Device," *Journal of Economic Dynamics and Control*, 30, 2191 – 2216.

Cooley, T., R. Marimon, and V. Quadrini (2020): "Commitment in Organizations and the Competition for Talent," *Review of Economic Studies*, 87, 2165–2204.

Davis, S. J. and J. Haltiwanger (2014): "Labor Market Fluidity and Economic Performance," Working Paper 20479, National Bureau of Economic Research.

Deneckere, R. J. and R. P. McAfee (1996): "Damaged Goods," *Journal of Economics and Management Strategy*, 5, 149–174.

Diamond, P. A. and E. Maskin (1979): "An Equilibrium Analysis of Search and Breach of Contract, I: Steady States," *The Bell Journal of Economics*, 10, 282–316.

Fallick, B., C. A. Fleischman, and J. B. Rebitzer (2006): "Job-Hopping in Silicon Valley: Some Evidence Concerning the Microfoundations of a High-Technology Cluster," *The Review of Economics and Statistics*, 88, 472–481.

Franco, A. M. and D. Filson (2006): "Spin-Outs: Knowledge Diffusion Through Employee Mobility," *The RAND Journal of Economics*, 37, 841–860.

Franco, A. M. and M. F. Mitchell (2008): "Covenants Not to Compete, Labor Mobility, and Industry Dynamics," *Journal of Economics & Management Strategy*, 17, 581–606.

Frydman, C. (2019): "Rising Through the Ranks. The Evolution of the Market for Corporate Executives, 1936-2003," *Management Science*.

Garmaise, M. J. (2009): "Ties that Truly Bind: Noncompetition Agreements, Executive Compensation, and Firm Investment," *Journal of Law, Economics, and Organization.*

Gautier, P. A., C. N. Teulings, and A. Van Vuuren (2010): "On-the-Job Search, Mismatch and Efficiency," *The Review of Economic Studies*, 77, 245–272.

Heggedal, T.-R., E. R. Moen, and E. Preugschat (2017): "Productivity Spillovers through Labor Mobility in Search Equilibrium," *Journal of Economic Theory*, 169, 551 – 602.

Hopenhayn, H. and R. Rogerson (1993): "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy*, 101, 915–938.

Hosios, A. J. (1990): "On the Efficiency of Matching and Related Models of Search and Unemployment," *The Review of Economic Studies*, 57, 279–298.

Jeffers, J. S. (2018): "The Impact of Restricting Labor Mobility on Corporate Investment and Entrepreneurship," Discussion paper, University of Chicago.

Lavetti, K., C. Simon, and W. D. White (2019): "The Impacts of Restricting Mobility of Skilled Service Workers: Evidence from Physicians," *Journal of Human Resources.*

Lentz, R. and N. Roys (2015): "Training and Search On the Job," Working Paper 21702, National Bureau of Economic Research.

Lucas, R. E. and B. Moll (2014): "Knowledge Growth and the Allocation of Time," *Journal of Political Economy*, 122, 1–51.

Luttmer, E. G. J. (2007): "Selection, Growth, and the Size Distribution of Firms," *The Quarterly Journal of Economics*, 122, 1103–1144.

Marimon, R. and V. Quadrini (2011): "Competition, human capital and income inequality with limited commitment," *Journal of Economic Theory*, 146, 976 – 1008.

Marx, M., D. Strumsky, and L. Fleming (2009): "Mobility, Skills, and the Michigan Non-Compete Experiment," *Management Science*, 55, 875–889.

Moen, E. R. and A. Rosen (2004): "Does Poaching Distort Training?" *The Review of Economic Studies*, 71, 1143–1162.

Nordhaus, W. D. (1967): "The Optimal Life of a Patent," Cowles Foundation Discussion Papers 241, Cowles Foundation for Research in Economics, Yale University.

Pakes, A. and S. Nitzan (1983): "Optimum Contracts for Research Personnel, Research Employment, and the Establishment of "Rival" Enterprises," *Journal of Labor Economics*, 1, 345–365.

Perla, J. and C. Tonetti (2014): "Equilibrium Imitation and Growth," *Journal of Political Economy*, 122, 52–76.

Peters, R. H. and L. A. Taylor (2017): "Intangible Capital and the Investment-Q Relation," *Journal of Financial Economics*, 123, 251 – 272.

Postel-Vinay, F. and J.-M. Robin (2002): "Equilibrium Wage Dispersion with Worker and Employer Heterogeneity," *Econometrica*, 70, 2295–2350.

Postel-Vinay, F. and H. Turon (2010): "On-the-Job Search, Productivity Shocks, and the Individual Earnings Process," *International Economic Review*, 51, 599–629.

Prescott, J., N. Bishara, and E. P. Starr (2016): "Understanding Noncompetition Agreements: The 2014 Noncompete Survey Project," *Michigan State Law Review*, 2, 369–464.

Rauch, J. E. (2016): "Dynastic Entrepreneurship, Entry, and Non-compete Enforcement," *European Economic Review*, 86, 188–201.

Romer, P. M. (1990): "Endogenous Technological Change," *Journal of Political Economy*, 98, S71–S102.

Samila, S. and O. Sorenson (2011): "Noncompete Covenants: Incentives to Innovate or Impediments to Growth," *Management Science*, 57, 425–438.

Starr, E. (2019): "Consider This: Training, Wages, and the Enforceability of Covenants Not to Compete," *ILR Review*, 72, 783–817.

Starr, E., N. Balasubramanian, and M. Sakakibara (2017): "Screening Spinouts? How Noncompete Enforceability Affects the Creation, Growth, and Survival of New Firms," *Management Science*, 64, 495–981.

The U.S. Department of Treasury (2016): "Non-Compete Contracts: Economic Effects and Policy Implications," https://www.treasury.gov/resource-center/economic-policy/Documents/UST%20Non-competes%20Report.pdf.

The White House (2016): "Non-Compete Agreements: Analysis of the Usage, Potential Issues, and State Responses," https://obamawhitehouse.archives.gov/sites/default/files/non-competes_report_final2.pdf.