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The costs and benefits of noncompete agreements

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THE COSTS AND BENEFITS OF NONCOMPETE AGREEMENTS

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ABSTRACT

Noncompete agreements are elements of workers' contracts that limit the worker's job mobility in the event of a job separation. In this dissertation, I address two major questions: first, why are noncompete agreements used, especially among workers earning low wages? Second, what are the ramifications of use of noncompete agreements, both for the firms using them and for the markets in which those firms exist? In the first chapter, co-authored with Matthew Johnson, I show that low wage workers sign noncompete agreements when their wages are constrained. I use a novel sample of owners of hair salons to empirically demonstrate that, when wage constraints are more binding due to a greater minimum wage or a greater labor supply, noncompete agreements are used more frequently. I show that use in this context may not maximize the firm's joint surplus, suggesting that policy interventions may be welfare-enhancing. In the second chapter, I generalize the theory of the first chapter, allowing for intertemporal changes in labor markets. I posit the existence of noncompete agreement cycles, which may explain recent trends in use among low wage employees. In a noncompete agreement cycle, workers who separate must exit the labor market. Low labor supply decreases use of noncompete agreements, allowing

labor supply to increase and leading to use of noncompete agreements once again. I examine the costs and benefits of a policy prohibiting NCAs, analyzing such a policy's sensitivity to various parameters. In the final chapter, I consider the effects of noncompete agreements on the effort exertion of workers. If a worker is able to exert effort in order to increase the value of an asset, that worker may wish to spin off a new firm to leverage its value. The worker's current employer faces a tradeoff: a noncompete agreement induces the employee to stay but decreases the employee's incentive to exert effort. I show that, when the value of a spinoff is unknown ex ante, noncompete agreements may cause large ex post efficiency losses by limiting creation of highly profitable spinoffs.

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Chapter 1

Restricting Mobility to Extract Surplus: Why Low-Wage Workers are Signing Noncompete Agreements[1]

1.1 Introduction

When a new worker receives his or her employment contract, it may include a noncompete agreement (hereafter, NCA), which contractually limits the worker's ability to enter into a professional position in competition with his or her employer in the event of a job separation. Economic theory of the hold-up problem (Grossman and Hart, 1986) suggests NCAs can potentially enhance efficiency by aligning incentives to invest in various assets, such as general human capital training, trade secrets, or client lists. At the same time, NCAs may also impose significant costs on workers by limiting their ability to pursue outside employment opportunities.

Recent evidence suggests our understanding of the reasons behind–and implications of–NCA use remains incomplete. For one, while NCAs are most prevalent in higher-skill, knowledge intensive industries and occupations, they are also frequently used in many traditionally lower-paying occupations (Starr et al., 2015), even among fast food workers,[2] leading some to question what benefit NCAs could be bringing

[1] This chapter was written jointly with Matthew S. Johnson (Duke University, Sanford School of Public Policy).

[2] Irwin, Neil. "When the Guy Making Your Sandwich Has a Noncompete Clause," *The New York Times*, October 14, 2014

to these employment relationships. Furthermore, use of,[3] and litigation over,[4] NCAs have been growing in recent years which, absent corresponding changes in the importance of training, trade secrets, client lists, or other facets of production technology, is difficult to rationalize with the theory of the hold-up problem alone. These developments have captured policymakers' attention: in Congress, the MOVE[5] (Mobility and Opportunity for Vulnerable Employees) and LADDER[6] (Limiting the Ability to Demand Detrimental Employment Restrictions) Acts, introduced on June 4, 2015, and June 24, 2015, respectively, would prohibit NCAs for workers earning less than $15 per hour, and bills with similar intents have been introduced by several state legislatures.[7] Both the U.S. Treasury[8] and the White House[9] released reports in 2016 pertaining to NCAs among low wage workers, and most recently, President Obama issued a State Call to Action on NCAs.[10] Despite this policy interest, little is known about the efficiency of NCAs in this context, let alone the rationale for their use in the first place.

In this paper, we show that NCAs arise when employers and employees are limited in their ability to transfer utility via the wage. When the market-clearing wage is constrained, NCAs may be used as a tool to transfer additional surplus to the employer, even if NCAs do not maximize an employer and employee's joint surplus.

[3]Greenhouse, Steven. "Noncompete Clauses Increasingly Pop Up in Array of Jobs," *The New York Times*, June 8, 2014

[4]Simon, Ruth, and Angus Loten. "When a New Job Leads to a Lawsuit–Litigation Over Noncompete Clauses is Rising; does Entrepreneurship Suffer?" Wall Street Journal, Aug 15 2013

[5]Senate bill S. 1504. Text available at https://www.govtrack.us/congress/bills/114/s1504/text

[6]House of Representatives bill H.R.2873. Text available at https://www.congress.gov/bill/114th-congress/house-bill/2873/text

[7]Some examples include Washington (HB 1926; introduced February 2, 2015), Utah (HB 251; introduced February 1, 2016), Massachusetts (H.4434; substituted for H.4323 June 27, 2016), and Illinois (Illinois Freedom to Work Act; goes into effect January 1, 2017)

[8]Treasury Report: https://www.treasury.gov/resource-center/economic-policy/Documents/UST%20Non-competes%20Report.pdf

[9]https://obamawhitehouse.archives.gov/sites/default/files/non-competes_report_final2.pdf

[10]Call to Action on NCAs: https://www.whitehouse.gov/sites/default/files/competition/noncompetes-calltoaction-final.pdf

In fact, such constraints on wages will *only* affect NCA use if NCAs are not surplus-maximizing for at least some firms. Thus, we provide a simple method which generates a sufficient condition to determine when NCAs do not maximize surplus: if a change in the bindingness of a wage constraint affects NCA use, NCAs cause a joint surplus loss (relative to a contract without an NCA) for at least a subset of the population at study. We implement this test using data from a survey we conducted of employers in the hair salon industry.

We start with a simple, perfectly competitive model of the labor market in which NCAs provide a benefit to the employer and impose a cost on the employee. If utility is fully transferable between the employer and employee via the wage, NCAs will be used only when the firm's net benefit of NCA use is positive: when NCAs maximize joint surplus. However, when utility transferability via the wage is limited, the terms of trade in the labor market may dictate that NCAs are used as a tool to transfer surplus from the employee to the employer, even if NCAs do not maximize firms' surplus. NCA use will therefore increase when the terms of trade become more favorable to the employer or when transferability of utility decreases.

To test the empirical predictions of our model, we surveyed owners of independent hair salons in April 2015 via the Professional Beauty Association, a trade association for the industry. The benefits of NCAs are clear in this setting, due to the importance of client attraction and retention in production, and the prevalence of on-the-job training. At the same time, due to state-level occupational licensing laws that make mobility costly, the costs of NCAs to workers are also potentially high. We find NCAs are widely used: 30% of our sample had their most recently hired stylist sign an NCA, and 39% have had at least one stylist sign an NCA in the past.

Taking the model to the data, we find strong empirical support that limitations on transferability of utility via the wage affect NCA use. First, we test the prediction that

NCA use is higher when the terms of trade in the labor market are more favorable for the employer. We find that outward shifts in labor supply (proxied by the number of applicants an owner received for her most recent vacancy), and increases to the local unemployment rate–both of which will be associated with a lower market-clearing wage–are associated with higher NCA use. We estimate that one additional applicant for a vacancy leads to a 4% increase in the probability the hired worker signed an NCA. This result is robust to the inclusion of controls (including prior NCA use), and the qualitative result holds for both within- and between-owner variation in the number of applicants received. We also find that salons in counties that experienced higher increases in the unemployment rate between 2006 and 2012 (roughly the period spanning the Great Recession) were more likely to have their most recently hired worker sign an NCA, even controlling for whether they used NCAs prior to 2006.

Second, we find that increases in the minimum wage, which limit transferability of utility, also have a strong effect on NCA use. Owners in states with a higher minimum wage for tipped employees are more likely to use NCAs. Because cross-sectional variation in the minimum wage might be driven by other, unobservable differences across states, we separately estimate the effect of the minimum wage on NCA use for salons that hire workers as employees versus those that hire as independent contractors. The latter group is not covered by the Fair Labor Standards Act, and thus acts as a "placebo group" for the minimum wage. The effect only holds for the employment-based salons in our sample, and is small and statistically insignificant for contractor-based salons. Among employment-based salons, a one-dollar increase in the minimum wage is associated with an 8 percentage point increase in the probability that an owner has used an NCA in an employment contract.

Combined with the implications of our model, these results imply that NCAs do not maximize surplus for at least some firms in our sample. However, NCAs may still be surplus-maximizing contracts for some firms in our sample. For example, if the benefits of NCAs are heterogeneous across employers, NCAs may maximize surplus for those firms with the highest benefit. For policy purposes, it is important to know if NCAs cause surplus losses across the board, or only for a subset of firms.

To investigate the extent of variation in the benefit of NCAs in our sample, we first corroborate existing evidence that one benefit of NCAs is to enhance incentives for employers to invest in production assets, and we then utilize a measure of employers' ability to invest in production assets originating in the corporate finance literature: access to a line of credit with a bank (Sufi, 2009). We find strong evidence consistent with NCAs being surplus-maximizing for employers with high capacity for investment, but not for those with low capacity. Employers with high capacity use NCAs at a high rate, regardless of whether the market-clearing wage is likely constrained. On the other hand, employers without a line of credit are highly unlikely to use NCAs in an unconstrained environment (proxied by a low minimum wage, low level of labor supply, or low local unemployment rate), but this likelihood increases as the wage becomes constrained (via either a high minimum wage, a high level of labor supply, or a high local unemployment rate).

Overall, our results highlight a potential explanation for the growth of NCAs among lower-wage occupations and industries in recent years. Between 2007 and 2009, the federal minimum wage rose from \$5.15 per hour to \$7.25 per hour, and several states have increased their minimum wage in more recent years.[11] Furthermore, in the wake of the Great Recession, there is a consensus that the labor market has deteriorated dramatically, especially for low-wage workers. Our results imply employers may have leveraged this weak labor market to use NCAs as a tool to extract additional surplus from workers over this period, even if workers incurred a high cost

[11] Historical changes to state-level minimum wages are available from the Wage and Hour Division of the Department of Labor (https://www.dol.gov/whd/state/stateMinWageHis.htm, accessed December 2016).

as a result.

At the same time, even within a narrowly defined industry, we find NCAs do not maximize surplus for some firms, but do for others. This finding stresses the need for future research to further investigate the benefits NCAs provide to firms, which can aid policymakers by pinpointing where NCAs are most likely to be surplus-diminishing, and thus should potentially be banned, as is currently being considered in multiple U.S. states.

This paper contributes to multiple literatures. First, a growing literature has investigated the rationale for NCAs and the effects of their use. Using variation in the enforceability of NCAs across states, an increase in NCA enforceability has been found to increase firm-sponsored training (Starr, 2015), increase firm shareholder value (Younge and Marx, 2015), and decrease employee mobility (Marx et al., 2009; Fallick et al., 2006). Two papers prior to ours use individual-level data on NCA use: employees who sign NCAs have longer tenure and higher monetary returns to tenure among a sample of physicians (Lavetti et al., 2016), and among a nationally representative survey (Starr et al., 2015). Two papers theoretically explore the effects of liquidity constraints that hinder an employee's ability to buy out of noncompete agreements (Rauch and Watson, 2015; Rauch, 2015), finding that such liquidity constraints make NCAs lead to inefficiently low levels of entrepreneurship. Finally, in Chapter 2, I explore the theoretical dynamics of labor markets with limited utility transferability and NCAs, finding that cycles of NCA use may exist when labor market entry is limited. We add to the literature by empirically demonstrating how forces external to the firm influence the decision to use NCAs in the first place, and by providing a method to identify the presence of NCAs that do not maximize a firm's joint surplus. We also conduct the first survey on NCA use with *employer* information, allowing us to explore determinants and effects of NCA use not available through worker surveys or variation in enforceability.

This paper also contributes to a literature that addresses the ways in which nontransferability of utility affects a firm's internal decisions. A small literature has empirically investigated the role of the minimum wage on provision of nonwage compensation, such as on-the-job training (Acemoglu and Pischke, 2003) and fringe benefits (Simon and Kaestner, 2004). Theoretically, it has been shown that a minimum wage may reduce inefficient monitoring (Acemoglu and Newman, 2002). We add to this literature by analyzing how the bindingness of the minimum wage affects the prevalence of NCAs, which are not only an important aspect of nonwage compensation but also an organizational feature of the firm. A related branch of the literature has theoretically investigated how market factors and factors external to the firm affect the internal organizational structure of firms (such as integration and control allocation) in the face of nontransferable utility (Aghion and Bolton, 1987; Udry, 1996; Legros and Newman, 2008, 2012). We add to this literature by investigating the ways in which external *labor* market characteristics affect internal organizational decisions of the firm.

Section 1.2 describes the model and its testable implications. Section 1.3 describes the survey and the resulting dataset. Section 1.4 presents our empirical results, and Section 1.5 concludes.

1.2 Model

Our model seeks to address the relationship between labor market conditions, limitations on the transferability of utility, and NCAs. Broadly speaking, our model yields the insight that, even when NCAs are not surplus-maximizing for an employer/employee pair, they may be used as a means to transfer surplus to employers when an employee's wage may not be decreased to the market-clearing level. This scenario will be more likely when terms of trade favor employers (which may occur when labor is plentiful). We consider the effects of a minimum wage, which may simultaneously affect transferability of utility (by constraining the market clearing wage) and the terms of trade (by increasing an employee's outside option). Finally, we provide a method to generate a sufficient condition for whether NCAs cause a surplus loss, based on the insight that limitations on the transferability of utility via the wage from an employee to an employer will not affect surplus-maximizing NCA use, but may affect NCA use otherwise.

1.2.1 Description of the Model

The model has uncountably many of two types of agents: employers (R) and employees (E), with associated measures μ_R and μ_E. R and E form "firms" in frictionless labor markets. A firm is comprised of at most one R and one E. When firms are formed, they engage in production of a consumer good, which sells for an exogenously determined price, P. A firm containing employer i (called firm i) produces an exogenously determined quantity, $\gamma(i)$, of the consumer good, which results in value of production equal to $\gamma(i)P$. The population distribution of γ is Γ, which has compact support $[\underline{\gamma}, \bar{\gamma}]$ and no mass points. Employers are denoted R_i, where the index i is ordered such that $\gamma(i)$ is decreasing in i. Employers have an outside option with value equal to π_R. Employee productivity is assumed to be homogeneous, and employees have an outside option with value equal to π_E. Singleton agents, whether they are of type R or E, do not produce the consumer good, and receive only their outside option.

Contracts written by an R and an E consist of two elements: a wage payment (w) and, possibly, an NCA (A). The wage may be constrained by a monetary transferability limitation, l, which requires that $w \geq l$. The constraint $w \geq l$ may reflect the inability of an employer to lower wages due to the need for incentive provision

(Shapiro and Stiglitz, 1984; Arnott et al., 1988), an employee's borrowing constraints, fairness concerns (Akerlof and Yellen, 1990), turnover reduction (Campbell III and Kamlani, 1997), employee cooperation (Fehr and Falk, 1999), or a regulated minimum wage.

If a firm writes a contract with an NCA ($A = 1$), a positive benefit of B accrues to R and a positive cost of C is paid by E.[12] B may represent many different elements: the ability of the employer to make investments in the employee without facing a hold-up problem, retention of the firm's client list if the employee quits, or protection of trade secrets, among others. C may represent the foregone future employment opportunities of the employee. It may also include the inability of an employee to leverage a client list or other assets to garner future wage increases, the cost of skewed incentives due to the NCA (see, for example, Chapter 3), or the delay in compensation necessary to align the employee's incentives with the employer's incentives (e.g., if the employer must defer compensation to guarantee that the employee produces "persistent clients", as discussed in Grossman and Hart (1986)). Notably, many of these costs are independent of the labor market characteristics which will be used empirically in this paper. The limited menu of available contracts follows the incomplete contracting literature pioneered by Grossman and Hart (1986), and is reflective of the judicial environment surrounding contracts similar to NCAs, as well as the cost of writing complex contracts.

R and E are risk neutral. Let $V_i(w, A)$ be the utility function of R_i if she is a

[12]For simplicity, we present B and C as the gross benefit and cost of an NCA. The qualitative implications of the model are unchanged if one assumes that B and C are the net benefit and cost of an NCA, relative to a hypothetical first-best contract. For example, optimal incentive provision may dictate that the first-best contract has the employee "buy his job" and become the residual claimant on the firm's income. If the employee is unable to buy his job due to cash constraints, an NCA may induce second-best incentive provision by increasing the penalty an employee faces if he is fired. In this case, the gross benefit of the NCA is the value of the incentives provided relative to an employment contract in which the employee did not buy his job and has no NCA, and the net benefit of the NCA is the value of the NCA relative to the first-best contract in which the employee is able to buy his job.

member of a firm. $V_i(w, A)$ includes the value of production, the wage payment, and the benefit gained from use of an NCA:

$$V_i(w, A) = \gamma(i)P - w + AB$$

Any R who is not a member of a firm receives their outside option, π_R.

The utility function of an E if he is a member of a firm includes the wage payment and the cost, C, incurred by an E if his contract includes an NCA:

$$W(w, A) = w - AC$$

Any E who is not a member of a firm receives his outside option, π_E.

An equilibrium is a set of firms and a contract for each firm, $\{w, A\}$, such that all matches are stable (i.e., there does not exist an R and an E who may form a new firm with a contract that yields strictly greater utility to one member of the pair and weakly greater utility to the other member of the pair) and contracts are optimal (i.e., there does not exist a deviation contract for a firm that yields strictly greater utility to one member of the pair and weakly greater utility to the other member of the pair).

In the following sections, we first construct labor demand and labor supply curves by analyzing a firm's optimal contracting problem. Using those results, we characterize equilibrium contracts. Finally, we generate testable implications based on comparative statics of the model.

1.2.2 The Firm's Problem

The wage that an employer is willing to pay an employee depends on whether or not the contract includes an NCA. The willingness to pay of employer R_i under an optimal contract may be found by maximizing E's utility over all possible contracts, subject to satisfying the limited transferability constraint LTC and both agents' participation constraints, PCR and PCE:

$$\max_{w\in\mathbb{R},A\in\{0,1\}} w - AC$$

$$w \geq l \tag{LTC}$$

$$\gamma(i)P - w + AB \geq \pi_R \tag{PCR}$$

$$w - AC \geq \pi_E \tag{PCE}$$

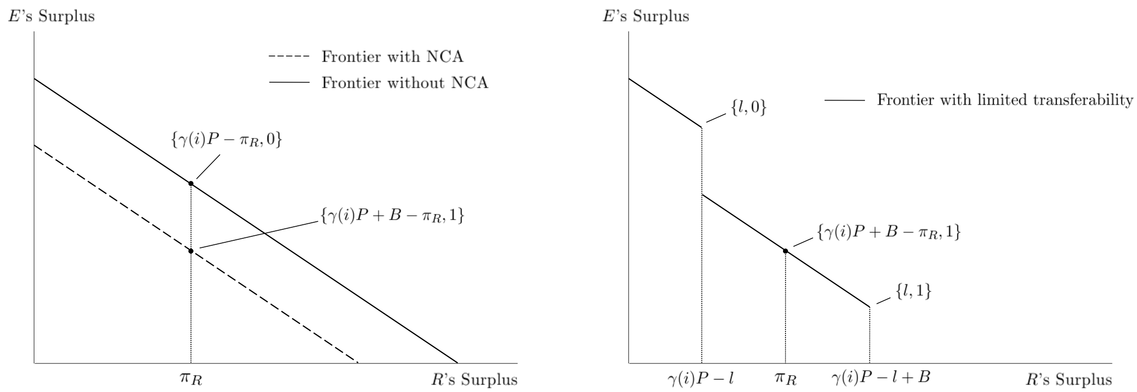
Consider first a simplified problem which ignores the limited transferability constraint, (LTC). Assuming that (PCR) binds but (PCE) does not, substituting (PCR) into the maximand yields the reduced problem:

$$\max_{A\in\{0,1\}} \gamma(i)P + A(B - C) - \pi_R$$

The solution to this problem is $A = 0$ whenever $B < C$, and $A = 1$ whenever $B > C$. In other words, when utility is fully transferable via the wage (i.e., LTC does not bind), NCAs that maximize the firm's surplus are optimal, and NCAs that do not maximize the firm's surplus are not. The wage allocates the value of production and the benefit of an NCA to E, net of R_i's outside option: $w = \gamma(i)P + AB - \pi_R$. [13] The simplified problem (ignoring (LTC)) when $B < C$ is illustrated in Panel (a) of Figure 1·1. The optimal contract that satisfies (PCR), $\{\gamma(i)P - \pi_R, 0\}$, lies on the frontier without an NCA, since $B < C$.

Now, consider the full problem with limited transferability, so that the wage cannot be lower than l. If $l > \gamma(i)P - \pi_R$, the transferability constraint and R_i's participation constraint may be satisfied simultaneously only if $A = 1$, even when NCAs do not maximize the firm's surplus ($B < C$).

[13] Note that the assumption that (PCE) does not bind is equivalent to $\gamma(i)P + A(B - C) > \pi_E + \pi_R$: if PCE binds, there is no contract that R_i and E both prefer to simply receiving their outside options, and the maximization problem has no solution.



(a) With unlimited transferability of utility, R_i's participation constraint may be satisfied on the surplus-maximizing frontier. Here, $B < C$, so surplus-maximizing contracts do not include NCAs.

(b) With a transferability limitation, the Pareto frontier includes contracts with NCAs. A firm may need to use an NCA in order to satisfy R_i's participation constraint.

Figure 1·1: Pareto frontiers with and without utility transferability limitations.

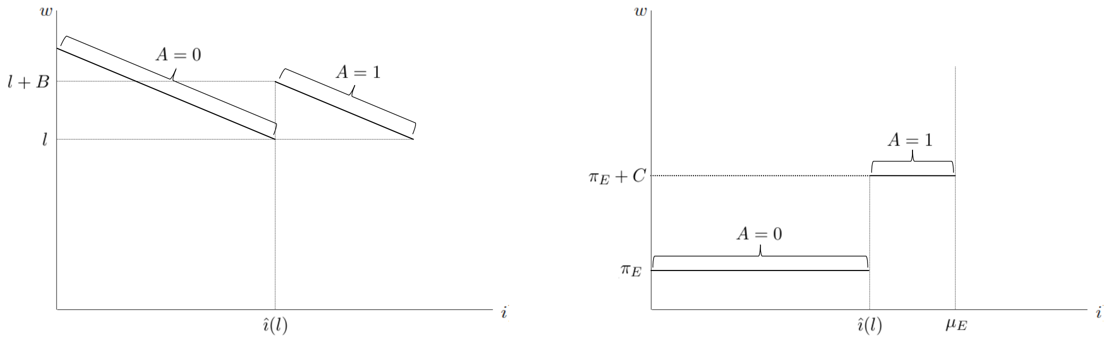
The solution to this problem is:

$$\{\gamma(i)P - \pi_R, 0\} \qquad \text{if } B < C \text{ and } l \leq \gamma(i)P - \pi_R \tag{1.1}$$

$$\{\gamma(i)P + B - \pi_R, 1\} \qquad \text{if } B > C \text{ or } l > \gamma(i)P - \pi_R. \tag{1.2}$$

This problem is illustrated in Panel (b) of Figure 1·1. The most favorable contract for R_i with $A = 0$, $\{l, 0\}$, does not satisfy R_i's participation constraint. Thus, the optimal contract that satisfies (PCR) is $\{\gamma(i)P + B - \pi_R, 1\}$. This contract does not maximize the firm's joint surplus: the total surplus generated under this contract falls short of that generated under the unconstrained optimal contract.

Given values for B, C, and l, Expressions 1.1 and 1.2 represent the inverse labor demand curve. When $B > C$, all contracts have $A = 1$, and the inverse demand curve (hereafter denoted by $D(i)$) is $D(i) = \gamma(i)P + B - \pi_R$. When $B < C$, the inverse labor demand curve has a discontinuity at $\hat{\imath}(l)$, given by $\gamma(\hat{\imath}(l))P - \pi_R = l$ (the R that is indifferent between the contract $\{l, 0\}$ and receiving her outside option), which



(a) The labor demand curve. The increase in willingness to pay at $\hat{\imath}(l)$ represents the benefit, B, associated with NCA use.

(b) The labor supply curve. The increase in willingness to accept at $\hat{\imath}(l)$ represents the cost, C, associated with NCA use.

Figure 1·2: Labor demand and labor supply when $B < C$.

exists whenever $\underline{\gamma} - \pi_R < l$. For $i \leq \hat{\imath}(l)$, inverse labor demand is $D(i) = \gamma(i)P - \pi_R$ with $A = 0$. For $i > \hat{\imath}(l)$, inverse labor demand is $D(i) = \gamma(i)P + B - \pi_R$ with $A = 1$.

Panel (a) of Figure 1·2 shows the labor demand curve when $B < C$, taking into account the limitation on monetary transferability of utility. The increase in willingness to pay at the discontinuity represents the value of an NCA to the employer, B.

Labor supply is constructed in an analagous fashion. The relevant maximization problem is:

$$\max_{w \in \mathbb{R}, A \in \{0,1\}} \gamma(i)P - w + AB$$

$$w \geq l \tag{LTC}$$

$$\gamma(i)P - w + AB \geq \pi_R \tag{PCR}$$

$$w - AC \geq \pi_E \tag{PCE}$$

Whenever (PCR) does not bind but (PCE) does, the solution to this problem is:

$$\{\pi_E, 0\} \text{ if } B < C \text{ and } l \leq \gamma(i)P - \pi_R \tag{1.3}$$

$$\{\pi_E + C, 1\} \text{ if } B > C \text{ or } l > \gamma(i)P - \pi_R \tag{1.4}$$

The inverse labor supply curve, hereafter denoted by $S(i)$, is given by expressions 1.3 and 1.4. It is a horizontal line when $B > C$ at $S(i) = \pi_E + C$. When $B < C$, $S(i)$ has a discontinuity at $\hat{\imath}(l)$, jumping from $S(i) = \pi_E$ to $S(i) = \pi_E + C$.

1.2.3 Characterization of Equilibrium

When $B > C$, all firms will use NCAs, since they are the optimal contract for any firm, no matter the values of other parameters. Recall that μ_E and μ_R denote the measures of E and R in the labor market. The unconstrained market-clearing wage, which we denote by $w^{B>C}$, is determined by the intersection of supply and demand:

$$w^{B>C} = \begin{cases} \gamma(\mu_E)P + B - \pi_R & \text{if } \mu_E < \mu_R \text{ and } D(\mu_E) > S(\mu_E) \\ \pi_E + C & \text{otherwise} \end{cases}$$

If the market-clearing wage is constrained ($w^{B>C} < l$), then the market contract is $\{l, 1\}$, and there will be a surplus of labor.

When $B < C$, the contract of the marginal firm in the labor market (hereafter denoted firm $\bar{\imath}$) will have $A = 1$ if $\bar{\imath} > \hat{\imath}(l)$: that is, if $R_{\bar{\imath}}$'s willingness to pay lies on the portion of the labor demand curve for which the firm's optimal contract includes an NCA. Indeed, all R_i whose willingness to pay lies on the NCA portion of the labor demand curve (i.e., $\hat{\imath}(l) < i \leq \bar{\imath}$) will use NCAs: they prefer their outside option to the contract $\{l, 0\}$, which is the most favorable allowable contract with $A = 0$. Denote the market wage in such contracts by w_1^*, which is set by firm $\bar{\imath}$.

Firms whose productivity is high enough that they would be willing to pay a wage equal to l with no NCA are not precluded from writing contracts without NCAs.

However, the contract used by the marginal firm sets the market: that contract, $\{w_1^*, 1\}$, yields greater utility to any R than even the most favorable contract for an R with $A = 0$ (the contract $\{l, 0\}$). Otherwise, $\{l, 0\}$ would also be optimal for firms with $i > \hat{\imath}(l)$.

The above logic is summarized in Proposition 1.2.1. We first simplify the analysis with the following assumptions:

Assumption 1. $\underline{\gamma}P < l + \pi_R$ *(i.e., $\hat{\imath}(l)$ exists)*

Assumption 2. $\gamma(\hat{\imath}(l))P + B - \pi_R > \pi_E + C$

The purpose of Assumptions 1 and 2 is to avoid trivial outcomes in which all firms' productivity is so high, or the cost of NCA use is so great, that no firms may optimally form which use NCAs. Assumption 1 says that there are some R_i for whom a contract with $A = 1$ would be optimal. Assumption 2 says that, at least for the firm that is indifferent between using $A = 0$ and $A = 1$, firm formation with an NCA yields surplus greater than each agent receiving their outside option[14].

Proposition 1.2.1. *Under Assumptions 1 and 2, whenever $B < C$, all firms' equilibrium contracts have $A = 0$ when there are few E, and $A = 1$ when there are many E.*

All proofs are contained in Appendix A.4.

Intuitively, Proposition 1.2.1 states that, when transferability is limited and there are many E in the market, the marginal R is unwilling to hire an E without an NCA. That firm sets the market, causing NCAs that do not maximize joint surplus to be the optimal contract for all firms. Put another way, limitations on transferability

[14] Assumption 2 also guarantees that, whenever $B < C$, $D(i) > S(i)\ \forall i < \hat{\imath}(l)$: firm formation yields greater surplus than nonformation for all firms for whom NCAs are not optimal when NCAs are not surplus-maximizing. This follows from simple algebra:

$$D(i) = \gamma(i)P - \pi_R > \gamma(\hat{\imath}(l))P - \pi_R > \pi_E + C - B > \pi_E = S(i),$$

where the first inequality follows from the decreasing nature of $\gamma(\cdot)$, the middle immediately follows from Assumption 2, and the last inequality holds when $B < C$.

make NCAs "cheaper" for Rs: the cost of an NCA to an R is the difference in the wages she must pay for a contract with versus without an NCA. This difference is less when the transferability limitation increases the wage paid without an NCA.

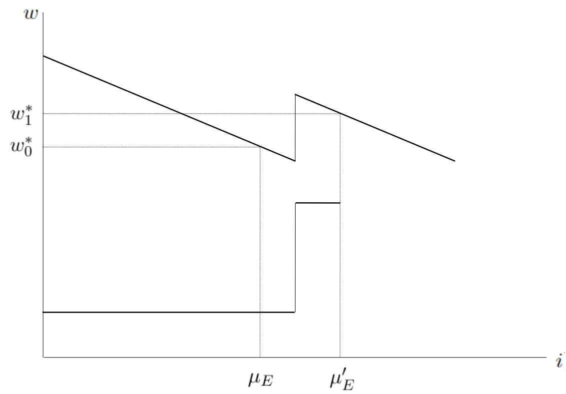
When $\mu_E < \mu_R$, we may alternatively interpret the condition which generates equilibria with $A = 1$ (i.e., that $\mu_E > \hat{\imath}(l)$) as $\gamma(\mu_E)P - \pi_R < l$.[15] This condition states that the willingness to pay of R_{μ_E} is constrained by l. These two interpretations correspond directly to the two basic comparative statics described in the next section: the effects of changes in the terms of trade and changes in utility transferability.

1.2.4 Comparative Statics: Terms of Trade, Utility Transferability, and the Minimum Wage

Two immediate predictions arise from Proposition 1.2.1. First, increases in labor supply (μ_E) may increase the use of NCAs for a given l. When NCAs do not maximize firms' surplus ($B < C$), they will be used *only* when $\mu_E > \hat{\imath}(l)$. Holding all other parameters fixed, this inequality is satisfied more easily the larger the value of μ_E. This is illustrated in Figure 1·3. An outward shift in labor supply causes the marginal firm to be one for which NCAs are optimal, resulting in an equilibrium with NCAs. This result stands in contrast to the environment in which NCAs maximize firms' surplus ($B > C$). In that case, shifts in labor supply do not affect NCA use.

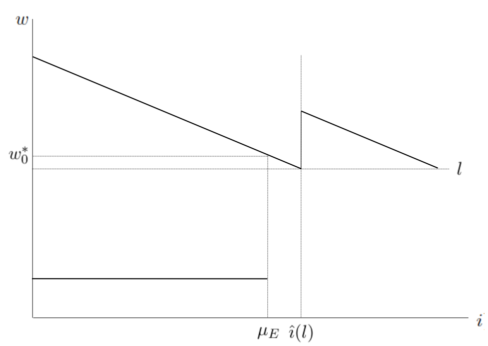
Whether contracts have $A = 1$ in equilibrium is also a function of l, which is clear from the condition $\gamma(\mu_E)P - \pi_R < l$. Holding all else equal, a more binding utility transferability constraint (greater l) may increase the use of NCAs. This result is illustrated in Figure 1·4. An increased transferability limitation causes the marginal firm to be one for which NCAs are optimal, resulting in an equilibrium with NCAs which do not maximize firms' surplus. Note that, when NCAs do maximize firms' surplus ($B > C$), changes in the transferability of utility do not affect NCA use.

[15] This equivalence is straightforward: since $\mu_E > \hat{\imath}(l)$ and $\gamma(\cdot)$ is decreasing, $\gamma(\mu_E)P - \pi_R <$

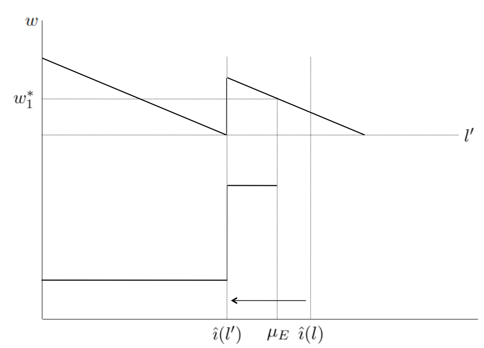


(a) A shift in labor supply from μ_E to μ'_E causes the marginal firm to be one for which NCAs are optimal. The optimal contract changes from $\{w_0^*, 0\}$ to $\{w_1^*, 1\}$.

Figure 1·3: The effect of a change in labor supply.



(a) When l is low, the marginal firm is one for whom a contract with no NCA is optimal. The market contract is $\{w_0^*, 0\}$.



(b) When l increases to l', the marginal firm becomes one for whom a contract with an NCA is optimal. The market contract is $\{w_1^*, 1\}$.

Figure 1·4: The effect of a change in l.

These observations are summarized in the following:

Prediction 1. *Increases in μ_E (outward shifts in labor supply) lead to increases in NCA use when $B < C$. When $B > C$, increases in μ_E have no effect on NCA use.*

Prediction 2. *Increases in l (the monetary transferability constraint) lead to increases in NCA use when $B < C$. When $B > C$, increases in l have no effect on NCA use.*

Corollary 1.2.2. *When decreases in monetary transferability of utility or increases in labor supply lead to increases in NCA use, NCAs do not maximize the firm's total surplus ($B < C$).*

One outright constraint on monetary utility transferability is a minimum wage. An increase in the minimum wage will increase NCA use insofar as it decreases transferability of utility via the wage, as explained in Prediction 2. However, the minimum wage may also affect the terms of trade in the market by influencing an E's outside option, π_E. On the one hand, a greater minimum wage may provide more desirable alternative employment opportunities (increasing π_E); on the other hand, it could decrease the probability that an individual is able to find a job (decreasing π_E). As changes in π_E act similarly to changes in μ_E, an increase in the minimum wage that has the effect of raising an employee's outside option will decrease NCA use via the outside option channel. Therefore, for any increase in the minimum wage, the overall effect on NCA use will depend on the relative magnitudes of its effect on the transferability and outside option channels. Whenever the impact on transferability dominates the net impact on an employee's outside option, NCA use will increase. Indeed, if a one dollar increase in the minimum wage directly corresponds to a one dollar increase in the transferability constraint, then as long as an employee's outside option does not increase by *more* than one dollar, NCA use will not decrease, and may increase. For further discussion of the theoretical effect of the minimum wage on NCA use, see Appendix A.3.

$\gamma(\hat{\imath}(l))P - \pi_R = l$.

1.3 Data and Measures

The primary data source for this paper is a survey we conducted of owners of independent hair salons in the U.S. in April 2015. We conducted the survey by email via the Professional Beauty Association (PBA)[16], a trade organization of salon professionals. The survey asked salon owners about various business, employment, compensation, and hiring practices, their experience using NCAs, as well as various geographic and demographic details. We also surveyed individual hair stylists separately, but do not discuss those results in this paper. Individuals who completed the survey were entered into a raffle for one of ten $50 Amazon gift cards.

The PBA emailed its entire email list, with separate links for owners and for stylists. The email list included 26,827 individuals, and PBA estimates 20% of these were salon owners. We received 218 completed surveys, resulting in a response rate of roughly 4% among those receiving an email. However, many of these email addresses may have been inactive, or otherwise unaware of PBA mailings: only 3,523 individuals opened the email. If the ratio of salon owners among those opening the email was identical to the ratio on the email list as a whole, our response rate among those opening the email would be 218/(3,523*0.20) = 31%. Thus, our "true" response rate lies between 4% and 31%. While our response rate is uncertain, we do not anticipate it causes selection that biases our results for a few reasons. First, the survey was advertised as part of a research study to learn about the use of certain types of business and hiring practices in the salon industry, and the email did not mention anything about NCAs explicitly. Second, the response rate was in line with, if not slightly higher than, prior surveys PBA had sent out to its members on a variety of topics.[17]

The model in Section 1.2 made empirical predictions regarding the use of NCAs,

[16] http://www.probeauty.org

[17] Private email correspondence by authors with Chelsea MacFarland at PBA on 11/19/2015.

shifts in labor supply, and the minimum wage. Here we describe our measures for each of these items.

To measure labor supply, we asked owners for the number of applicants they received for their most recent vacancy, and whether this number was more, about the same, or less than they had received for a typical vacancy in the past.

To measure the minimum wage, we use the schedule of each state's minimum wage in 2014 from the Bureau of Labor Statistics. Because hair stylists are tipped employees, we use each state's minimum hourly cash wage for tipped employees. We merged this schedule into our survey dataset using each salon's state.

An additional measure used in our analysis is the local unemployment rate. We use the annual county-level unemployment rate from the Bureau of Labor Statistics Local Area Unemployment Statistics. We merge this dataset into our survey dataset using each salon's county.[18]

To measure use of NCAs, we asked employers whether their most recently hired stylist signed an NCA and, if not, whether they have ever had a stylist sign an NCA in the past. For empirical tests of how shifts in labor supply and the unemployment rate affect NCA use, we measure NCA use with a dummy equal to one if an owner used an NCA for its most recently hired stylist, as we do not have a measure of labor supply for previously hired stylists. For tests of how the minimum wage affects NCA use, we measure NCA use with a dummy equal to one if an owner has ever used an NCA, either for its most recently hired stylist or in the past.

We merged in other datasets primarily to include relevant controls in our empirical specification. We use data from Bishara (2010) to measure each state's enforceability of NCAs as of 2009. The measures were created by analyzing case law in each state and comparing laws based on seven dimensions. Each state is assigned a score from 0-10

[18] We identified each salon's county from the zip code the owner reported, using a zip code-county crosswalk.

on each of these dimensions, with a higher score indicating stricter enforcement, and given a composite score based on a weighted sum of the seven scores.[19] We normalize each state's aggregate score by dividing by the highest (i.e., most enforceable) score across all 50 states and the District of Columbia, so that the normalized score ranges from zero to one. We also use each salon's county to merge in the number of salons in each respondent's county in 2012, which comes from the County Business Patterns database from the Census Bureau.[20]

Some of our survey questions had small rates of non-response. To deal with non-responses, we imputed missing values by regressing each variable on the state's Bishara score, state's minimum wage, a dummy for employment-based salons, and the number of salons in the respondent's county, and we generated predicted values for missing responses. We only performed this imputation for potential covariates to our regression models, and not for our primary regressors of interest (e.g., *Number of Applicants*).

Summary statistics are given in Table A.1. Thirty percent of our sample had their most recently hired stylist sign an NCA, and 39% has ever used one. As a point of comparison with prior studies, Lavetti et al. (2016) find 45% of a sample of physicians were currently working under an NCA, Marx (2011) finds 47% of a sample of engineers had ever signed one, and Starr et al. (2015) found that 18% of a representative sample of U.S. workers were currently working under, and 38% had ever signed, an NCA. The average salon in our sample has 7.1 stylists working and an annual revenue of $379,000. Another important variable is whether the salon is employment- or contractor-based: 48% of our owners own employment-based salons, meaning the stylists working are employees (and thus covered by the Fair Labor Standards Act); the remaining 52% are contractor-based salons, meaning the stylists

[19] See Bishara (2010) for a more thorough description of the data.

[20] Beauty salons are identified in the County Business Patterns by the NAICS industry code "812112".

that work there are independent contractors. Stylists in such salons typically rent space from the owner and do not earn wages. Income for contractors comes directly from the services they provide.

A tabulation of the states in our sample is given in Table A.7

1.4 Empirical Results

In this section, we first set out to test predictions 1 and 2 regarding how labor market conditions affect NCA use. By Corollary 1.2.2, these results act as a method to identify the presence of NCAs which do not maximize firms' surplus in our sample.

We then examine whether NCAs are not surplus-maximizing for our whole sample, or for only a subset of firms. In Section 1.4.4 we investigate a potential benefit of NCAs: alleviation of investment hold-up problems. Finally, in Section 1.4.5, we demonstrate that the effect of labor market conditions on NCA use is moderated by a measure of the importance of this benefit.

1.4.1 Labor Supply and NCA Use

The first prediction of our model is that, if NCAs which do not maximize joint surplus exist, outward shifts in labor supply increase the use of NCAs. Table A.2 tests this prediction.

Columns 1 and 2 investigate the cross-sectional relationship between NCA use and one measure of labor supply: the number of applicants the owner received for her most recent position. We run a linear probability model with the dependent variable equal to 1 if the most recently hired stylist signed an NCA, and we report the coefficient on the variable equal to the number of applicants the employer received for the position ($\#Applicants$). Each specification controls for the state's Bishara enforceability score. Column 2 adds a vector of additional covariates correlated with NCA use: the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists current working in the salon, and the number of salons in a respondent's county.[21]

Column 1 shows that one additional applicant for a position is associated with a 1.2 percentage point increase ($p < .01$) in the probability the hired stylist signed an NCA.[22] The coefficient on the *Bishara* score shows going from the state with the lowest to highest NCA enforceability is associated with a 30 percentage point increase in NCA use, a point estimate very similar to that found in Lavetti et al. (2016). The coefficient on *# Applicants* shrinks by a small amount to .97 percentage points, but remains highly statistically significant, when we add controls in Column 2.

Still, these controls may not capture an unobserved variable that jointly determines NCA use and the number of applicants an owner gets. If this unobserved variable is correlated with overall NCA use, not just with most recent hire, we can capture it by controlling for NCA use prior to the most recent hire. Thus, Column 3 includes a dummy indicating whether an owner ever used NCAs prior to its most recent hire. As would be expected, its coefficient is large (.59) and highly significant ($p < .01$). Even controlling for prior NCA use, the coefficient on *# Applicants* remains highly significant and decreases in magnitude only slightly (.0082). To put this magnitude in perspective, the standard deviation of *#Applicants* in our sample is 9.4, suggesting a one standard deviation increase in number of applicants received for a

[21]Because we had many covariates we thought might be relevant to our analysis, we ran the risk of over-fitting the data by including all of them. Instead, we selected this set of covariates using an approach involving LASSO outlined in Belloni et al. (2014). LASSO penalizes having too many parameters in the model, and uses cross-validation to determine the subset of regressors that yields the best out-of-sample predictions of the dependent variable. We run two LASSO regressions: the first with the dependent variable equal to 1 if the most recently hired stylist signed an NCA, and the second with the dependent variable equal to the number of applicants received for the most recent position, and we keep the union of regressors that are selected in both LASSOs. We also include the number of salons in the owner's county as a covariate, which was not selected in this LASSO procedure, but which we include to ensure that *# Applicants* can be interpreted as labor supply, rather than reflecting the size of the beauty industry in the local labor market.

[22]We obtain results with essentially identical statistical significance using a logit or probit specification.

position is associated with a roughly 7.7 percentage point increase in the probability the stylist that is hired signs an NCA, which is 25% of the sample mean.

Even though the specification in Column 3 arguably controls for the most likely sources of potential omitted variable bias affecting the coefficient on *# Applicants*, it is still possible the correlation between NCA use and applicants could be driven by an unobserved variable. Thus, Table A.8 investigates the effects of a *change* in the number of applicants an owner gets for a position on the *change* in its use of NCAs. The dependent variable is now the difference between *Last Applicant NCA* (a dummy indicating whether an owner had its most recently hired stylist sign an NCA), and a dummy indicating whether the owner reported ever using NCAs prior to its most recent hire. A value of 1 indicates an owner switched from not using to using NCAs, and vice versa for a value of -1. A value of 0 indicates NCA use remained constant. Our regressors of interest are two dummies if the salon owner reported that the number of applicants received for its most recent vacancy was "Fewer than usual" or "More than usual," respectively (the omitted category is "About the Same"). Our prediction is that owners receiving more applicants than usual (i.e., an outward shift in labor supply) are more likely to switch into NCA use, and vice versa for owners receiving fewer applicants than usual.

Column 1 of Table A.8 reports results controlling only for the Bishara index. Owners that received more applicants than usual for their most recent vacancy were 12 percentage points more likely to switch into using NCAs for their most recent hire, though the result is not statistically significant (p = .20). The inclusion of additional controls in Column 2 does little to change the estimates. Overall, while these estimates are not statistically significant, they provide support that changes in our measure of labor supply also lead to within-owner changes in the use of NCAs.

1.4.2 The Unemployment Rate and NCA Use

In this section, we test how the local unemployment rate–which models other than our baseline frictionless supply and demand model predict is correlated with the terms of trade in the labor market (and therefore, the unconstrained equilibrium wage)–affects NCA use.

In the frictionless labor market presented in Section 1.2, unemployment only occurs as a result of monetary transferability constraints. However, different models of the labor market generate a direct relationship between the unemployment rate and the wage. For example, in the canonical search model of the labor market introduced by Mortensen and Pissarides (1994), exogenous positive shocks to the separation rate, the cost of capital, the cost of hiring a worker, or exogenous negative shocks to production technology lead to an increase in the equilibrium unemployment rate and a decrease in the equilibrium wage, yielding a negative relationship between the unemployment rate and the wage. In contrast, exogenous increases in worker bargaining power or unemployment benefits lead to an increase in both the unemployment rate and the wage. As a second example, an "implicit contracts" model of the labor market (Beaudry and DiNardo, 1991) yields a *causal* negative relationship between the unemployment rate and wages, regardless of the reason for variation in the unemployment rate, due to the effect of the unemployment rate on a worker's reservation wage. Therefore, as long as variation in the unemployment rate is not driven by shocks to worker bargaining power or changes to unemployment benefits, both of these models predict a negative relationship between the unemployment rate and the unconstrained equilibrium wage.

However, if the wage is bound by a transferability constraint, our model predicts that increases in the unemployment rate, in such cases, may instead be associated with increases in NCA use among firms for which NCAs do not maximize firms' surplus. Therefore, we can use variation in the unemployment rate as an additional test of the prediction that NCA use is induced by constraints on the wage, as long as variation in the unemployment rate is not attributed to worker bargaining power or unemployment benefits *a la* Mortensen and Pissarides (1994).

To implement the test, we calculate the change in the county-level unemployment rate between 2006 and 2012 corresponding to the county in which a salon is located. The period over which this change is calculated roughly spans the Great Recession, a period in which the national unemployment rate increased from 4.7% to 8.3%. There is overwhelming evidence that the overall increase in the unemployment rate over this period, as well as regional variation in the change, were due to factors other than increases in worker bargaining power or unemployment benefits. County-level variation in the increase in non-employment over the Great Recession was driven by factors such as variation in the deterioration in housing net worth (Mian and Sufi, 2014), which points to a demand-level channel akin to a negative shock to production technology. Additionally, the cost of capital for small business increased in the Great Recession (Greenstone et al., 2014). Both of these explanations point to factors that would lead to a negative relationship between the unemployment rate and the wage in a search model of the labor market. We estimate how the change in a county's unemployment rate over 2006-2012 led to a change in the likelihood an owner used NCAs over this same period.

Results are shown in Table A.3. The dependent variable is *Last Applicant NCA*. All regressions include the full set of controls used in Column 2 of Table A.2,[23] and standard errors are clustered by county. Column 1 displays the coefficient on the *level* of the unemployment rate in 2012. The coefficient is positive but small and

[23]For simplicity, we use the same set of controls from the variable selection procedure specific to the regressions involving # *Applicants*. If we instead use the approach in Belloni et al. (2014) to separately choose controls for every regression, we obtain essentially identical results to those we report.

nowhere near statistically significant. However, cross sectional variation in the local unemployment rate is very likely driven by many unobserved factors that also might affect employment contracts. Thus, Column 2 instead uses the *change* in the county's unemployment rate between 2006 and 2012, and the coefficient suggests a 1 percentage point increase in the change in the local unemployment rate is associated with a 0.041 percentage point increase in the probability that an owner's most recently hired stylist signed an NCA ($p = .066$). However, our goal is to test how the change in the unemployment rate led to a *change* in NCA use. Thus, column 3 restricts the sample to owners who reported being in the beauty industry since at least 2006, and includes a dummy equal to 1 if she reported using NCAs in 2006 or earlier. The point estimate and statistical significance on the change in the unemployment rate are essentially unchanged.

Overall, these results provide further evidence that NCA use increases when the market-clearing wage is more likely to be bound by monetary utility transferability constraints.

1.4.3 The Minimum Wage and NCA Use

The second prediction of our model is that–if the cost of an NCA to an employee is lower than the benefit accruing to his employer–NCA use will be higher when monetary utility transferability is more limited. If the minimum wage is a binding transferability constraint, then as long as a one dollar increase in the minimum wage does not induce an increase in an employee's outside option that is *greater* than one dollar, we expect that NCA use will be higher when the minimum wage is higher.

Table A.4 investigates this relationship. The coefficient of interest is that on the *Minimum Cash Wage*, the 2014 state minimum wage excluding tips for tipped employees. The dependent variable is now equal to 1 if the employer has ever used an NCA, either for its most recently hired stylist or in the past (*Ever Used NCA*).

Note we use this as our dependent variable, rather than *Last Applicant NCA*, which we use in our regressions of NCA use on labor supply and the unemployment rate. Whereas our measure of labor supply (*# Applicants*) pertained only to an employer's most recently hired stylist, the minimum wage affects all hiring decisions, not just the most recent one. *Ever Used NCA* is a more stable measure of NCA use than *Last Applicant NCA*, which is more idiosyncratic and potentially subject to more classical measurement error. Furthermore, because most states' minimum wages for tipped employees have remained largely unchanged over the last several years, our prediction regarding the minimum wage is more closely tied to this broader measure of NCA use. The results we report in this section are all qualitatively very similar when we use *Last Applicant NCA* rather than *Ever Used NCA*. See Table A.9 for results using *Last Applicant NCA*.[24]

Column 1 reports the coefficient on *Minimum Cash Wage*, controlling only for the state's Bishara enforcement score. The coefficient is positive and significant at the 5 percent level. Column 2 includes the additional controls used in the previous sections, and the coefficient on *Minimum Cash Wage* increases in magnitude and is highly significant ($p < .01$).[25]

Cross-sectional variation in the minimum wage might be driven by other unobservable differences across states, biasing the coefficient on *Minimum Cash Wage*. However, minimum wage laws are only applicable to employment-based salons; independent contractors are not covered by the Fair Labor Standards Act. Thus, to the

[24]All else equal, *Ever Used NCA* is more likely to be equal to one for older firms and firms with more employees. However, all of our results using *Ever Used NCA* as a dependent variable are unchanged if we control for the number of years the salon has been open and the number of stylists working at the salon.

[25]The inclusion of controls increases the coefficient on *Minimum Cash Wage* primarily due to the dummy indicating whether a salon is employment-based. That the inclusion of the employment-based dummy increases the coefficient on *Minimum Cash Wage* so much suggests these two variables are negatively correlated, which a simple correlation shows to be the case in our data (correlation coefficient=-.20).

extent the minimum wage may bind the market-clearing wage, it could only do so for employment-based salons, and we can treat contractor-based salons as a "placebo group." If we found the minimum wage affected NCA use for contractor-based salons, we would worry the observed effect of the minimum wage is plagued by omitted variable bias.

Column 3 includes an interaction term of the Minimum Wage with *Emp-based Salons* (the main effect of *Emp-based Salons* is not shown).[26] Thus, the main effect of *Minimum Cash Wage* indicates the effect of the minimum wage for contractor-based salons, and the interaction term indicates its effect for employment-based salons. Reassuringly, the main effect is small and statistically insignificant (0.032, $p = 0.14$), whereas the interaction term is nearly twice as large and significant at the 5 percent level (0.057, $p = .03$).

These results strongly support our prediction that the minimum wage affects NCA use, and they also provide evidence that the observed effect of the minimum wage on NCA use is not driven by omitted variable bias or sampling error.

Our model yields a slightly more subtle prediction regarding an interaction effect between the minimum wage and the number of applicants: the higher the minimum wage, the more likely an outward shift in labor supply results in an equilibrium wage w_0^* that falls below l. Similarly, the more that labor supply is shifted out (i.e., the higher the number of applicants an owner receives), the more likely an increase in the minimum wage ends up above w_0^*. Table A.10 tests this prediction. The dependent variable is a dummy indicating whether the most recently hired stylist signed an NCA. Columns 1 and 2 restrict the sample to employment-based salons. Column 1 includes both *# Applicants* and the *Minimum Cash Wage*, and Column 2 also includes their interaction effect. As can be seen in Column 2, the inclusion

[26]This regression is a fully interacted model, meaning that *Emp-based Salon* is also interacted with the Bishara score and each of the additional controls.

of the interaction drives the main effects to shrink in magnitude and lose statistical significance. The interaction term itself is positive, as predicted by our model, but not statistically significant ($p = 0.20$). On the other hand, when we restrict the sample to non-employment based salons (for which there should be no interaction effect of the minimum wage and labor supply), reassuringly we find an interaction term that is essentially zero and nowhere near statistically significant (Column 4).

1.4.4 Analyzing the Potential Benefits of NCAs: Enhancing Investment

The empirical findings in Sections 1.4.1, 1.4.3 and 1.4.2 suggest that the characteristics of the labor market–both outright constraints on wages and shifts in the market-clearing wage–affect NCA use in our sample of independent hair salons. Taken together with Corollary 1.2.2, these results suggest NCAs do not maximize surplus ($B < C$) for at least some of the firms in our sample: if NCAs were surplus maximizing for all firms, their use would be unaffected by the minimum wage, and its relation to the market-clearing wage.

However, our results do not necessarily imply NCAs do not maximize joint surplus for *every* firm in our sample. If we relax the assumption that the benefit employers derive from NCAs (B) is constant across all employers, it is possible B is high enough for some employers to make NCAs surplus-maximizing contracts. To investigate the extent to which this is the case, in this section we seek to unpack one potential benefit of NCAs to employers: in particular, that they enhance incentives for employers to invest in nonphysical assets. In the section that follows, we test whether the value of this benefit to an employer moderates the effect of labor market conditions on NCA use.

One commonly cited potential benefit of NCAs is that, by effectively assigning control rights to nonphysical assets to the employer, they mitigate hold-up problems that distort incentives to invest in those assets (Lavetti et al., 2016). For example, states with higher NCA enforceability have been shown to have higher rates of firm-sponsored training (Starr, 2015), and employees signing NCAs are more likely to receive such training (Starr et al., 2015). If such assets are valuable to production, the benefits of NCAs could indeed be quite large.

To investigate the importance of this benefit of NCAs in our sample, in our survey we asked salon owners about their investment in two types of assets essential to production for hair salons: client attraction and on-the-job training. Regarding client attraction, we asked owners whether they did any of the following to attract or retain clients: have a website, have a social media account, give offers on daily deal sites (e.g., Groupon), maintain a client email list with regular promotions, and/or engage in some other type of marketing. Regarding training, we asked whether the owner's salon provided on-the-job training for newly hired stylists. We run a series of regressions with the dependent variable equal to one if the owner indicated engaging in each corresponding type of investment. Our independent variable of interest is the *Ever Used NCA* dummy, and we include the Bishara score and our full set of controls from previous regressions. Because the decisions to make these investments and use NCAs are made jointly, these regressions should be interpreted as correlations rather than causal.

The results are shown in Table A.5. Columns 1-5 display results for each of the five outcomes related to client attraction. The coefficient on *Ever Used NCA* is positive for all but one form of client attraction (social media), and is statistically significant for *Deal Sites* and nearly so for *Email List* (p=0.102). These latter two forms of client attraction are the two that specifically offer discounts and promotions, and are likely the most costly, and thus are most likely the forms most affected by the hold-up problem.

Column 6 gives the results for on-the-job training. The coefficient of 0.11 ($p = .01$)

on *Ever Used NCA* suggests salons that use NCAs are 14% more likely to provide training to new workers relative to the sample mean (.11/.798 = .14).[27]

These results, while not necessarily causal, support the idea that NCAs can indeed offer significant benefits by improving employers' incentives to invest in transferable assets valuable to production. Next, we test whether the extent to which this benefit is likely to be valuable for an employer moderates the relationship between labor market conditions and NCA use.

1.4.5 Moderating Role of Employer Liquidity Constraints on NCA Use

The empirical results from the previous section support the premise that one primary benefit of NCAs to employers is to alleviate hold-up problems that distort investment. If the value of this benefit is heterogeneous across employers, it is possible that NCAs maximize surplus for those firms in our sample who value this benefit the most, even though our findings in Sections 1.4.1, 1.4.3 and 1.4.2 provide evidence they do not maximize firms' surplus for at least a portion of our sample. In this section, we identify a measure that we argue is a proxy for the magnitude of the benefit of an NCA for an employer, and then we test if this measure moderates the effect of the labor market on NCA use.

A potentially important source of heterogeneity in the magnitude of B is employers' capacity to make investments in transferable assets. An insight from the corporate finance literature is that financing constraints limit an employer's ability to make valuable investments (Fazzari et al., 1988; De Mel et al., 2008). If such constraints are present, they may result in less potential investment to be "held-up," limiting the benefits of NCAs.

[27] The magnitude of our result on training is strikingly similar to Starr et al. (2015): we find salons using NCAs are 11 percentage points more likely to offer training, relative to a sample mean of 0.8. (Starr et al., 2015) find workers that have signed an NCA are 7.5 percentage points more likely to receive training, or 15% of the sample mean of 50%.

To measure the extent to which an employer is financially constrained from making investments, we asked employers “Do you have a line of credit or other ongoing banking relationship you use to finance cash outlays?” Access to lines of credit have been shown to be a statistically powerful measure of financial constraints (Sufi, 2009). Such lines of credit alleviate capital market frictions, ensuring funds are available to firms for valuable investments. If owners with access to a line of credit have higher capacity for investment, they also likely have more to gain from using NCAs. Indeed, in Table A.11, we find employers in our sample with access to lines of credit have statistically significantly higher rates of investment in all forms of client attraction and worker training. This relationship, while not necessarily causal, is consistent with lines of credit alleviating constraints that limit ability to make such investments.

This evidence suggests that an employer’s access to a line of credit is a meaningful proxy for the magnitude of the benefit she reaps from using NCAs. If the benefit of NCAs to owners with a line of credit is high enough to cause an NCA to maximize surplus for a firm ($B > C$), NCAs will be used among such employers independent of whether or not the unconstrained market-clearing wage is bound by the minimum wage. Thus, if some employers have a line of credit (and therefore have $B > C$) and some employers have no line of credit (and therefore have $B < C$), all else equal, owners with a line of credit will a) be more likely to use NCAs, and b) their use will be less affected by shifts in labor supply and the minimum wage.

Two extreme examples provide intuition on these results. First, consider a labor market with no minimum wage. Each firm will write a surplus-maximizing contract: i.e., employers with $B > C$ will have NCAs in their contracts, and employers with $B < C$ will not. The wage will adjust so that workers are indifferent between working for an employer with and without a line of credit.[28] Now, suppose the minimum wage

[28]A clear empirical prediction of this model is that the wage of an employee with an NCA will be higher than the wage of an employee without an NCA. This prediction is supported by existing

is quite high. For an employer with $B > C$, the minimum wage will not affect her ability to pay a wage premium associated with NCA use (i.e., for any contract $\{w, 1\}$ for a firm with $B > C$, there does not exist a contract that is a profitable deviation for both E and R, regardless of the minimum wage). An employer with $B < C$ with the contract $\{w, 1\}$ also may not have a profitable deviation contract with $A = 0$ if l is large enough: even the most favorable contract for R with $A = 0$, $\{l, 0\}$, may be worse for R if $B > w - l$. Therefore, the minimum wage may induce employers with low benefit to use NCAs while not changing the contracts of employers with high benefit.

Table A.6 tests these predictions. Columns 1-3 report results examining how access to credit affects NCA use, and how it moderates the relationship between NCA use and labor supply. As in Section 1.4.1, the dependent variable is a dummy equal to 1 if the most recently hired stylist signed an NCA, since our measure of labor supply pertains to the most recently filled vacancy. In all regressions, we control for the same full set of controls as previous tables. Column 1 shows owners with a line of credit (*Line of Credit*) are 15 percentage points more likely to have had their most recently hired stylist sign an NCA (p=.024). One potential concern is that access to a line of credit may be picking up a measure of overall business acumen or management quality of the employer, and not just its ability to access credit for investment. One piece of evidence this is not a practical concern is the coefficient on *Line of Credit* changes very little if we do not include the full set of controls (results not shown). As a second piece of evidence, if better managed firms also get a higher number of applicants, then including our # *Applicants* measure should change the coefficient on *Line of Credit*. However, the coefficient on *Line of Credit* is essentially unchanged when we control for # *Applicants*. (Column 2).[29]

empirical work, such as Lavetti et al. (2016) and Starr et al. (2015), which both find that workers who have signed NCAs have higher earnings.

[29] Also note the coefficient on # *Applicants*, .01, is nearly identical to that obtained in the model in

Column 3 includes an interaction of *Line of Credit* with *# Applicants*. If the benefit of NCAs for those employers with a banking relationship is large enough such that $B > C$, then by Prediction 1, changes in labor supply should have no effect on their use. The results in Column 3 strongly support this prediction: the main effect of *# Applicants* (.017) and its interaction term with *Line of Credit* (-.016) completely cancel each other out, meaning that shifts in applicants have no effect on NCA use among employers with a banking relationship. On the other hand, the main effect on *# Applicants* shows that, among employers without a banking relationship, one additional applicant is associated with a 1.7 percentage point increase in the probability the hired worker signed an NCA ($p < .01$).

To visualize these results, Figure A·1 plots the average predicted probabilities that *Last Hire NCA* equals 1 if every employer in the sample does vs. does not have a line of credit, by different values of number of applicants received. These predicted values correspond to the model in Column 3 of Table A.6. The average predicted probability that employers with a line of credit in our sample used an NCA for their most recent hire is stable at roughly 0.37 no matter the number of applicants received. On the other hand, the predicted probabilities for employers without a line of credit vary significantly with the number of applicants. If the number of applicants received is 1 (the 10th percentile in our sample, where the market-clearing wage is least likely constrained by the minimum wage), the predicted probability is .12. If the number of applicants is 15 (the 90th percentile, where the market-clearing wage is most likely constrained by the minimum wage), the predicted probability jumps to .36.

Turning back to Table A.6, Columns 4-5 investigate how access to credit moderates the relationship between NCA use and the change in the local unemployment rate. In Column 4, the main effect of *Line of Credit* holds controlling for the change in the local

which we did not control for *Line of Credit* (Table A.2, Column 2), which provides further evidence that *# Applicants* is a measure of labor market conditions rather than driven by an unobserved employer-specific factor (at least one correlated with access to a line of credit).

unemployment rate between 2006-2012. In Column 5, the inclusion of an interaction between these two variables leads to results remarkably similar to Column 3: the main effect of the change in the unemployment rate and its interaction with *Line of Credit* completely cancel out, suggesting changes in the unemployment rate have no effect on NCA use among employers with a line of credit. On the other hand, among employers without a line of credit, a one percentage point increase in the unemployment rate over the 2006-2012 period is associated with an 8.3 percentage point increase in the probability the most recently hired worker signed an NCA ($p < .01$).

Columns 6-8 report results examining how access to credit moderates the relationship between NCA use and the minimum wage. Now, as in Section 1.4.3, the dependent variable is a dummy equal to one if the owner has ever used NCAs. Column 6 shows a coefficient on *Line of Credit* slightly smaller to Column 1 (when the dependent variable is a dummy if the most recently hired stylist signed one). The coefficient is unchanged controlling for the state's minimum wage (Column 7). Column 8 includes an interaction of *Line of Credit* with the minimum wage. The interaction term, significant at the 5% level ($p = .024$), suggests the effect of the minimum wage on the probability of NCA use is 60% smaller for the group of owners with a banking relationship compared to the group without one (.067-.038=-.029, compared to .067).

A final note about these results is they each consistently show that, when wages are unconstrained, only those firms for which we expect NCAs to be surplus-maximizing are likely to use them. The main effects of *Line of Credit* in Columns 3, 5 and 6 (0.27, 0.44 and 0.31, respectively, all $p < .01$) each provide an estimate of the difference in probabilities that owners with high B use NCAs in 3 different scenarios when the market-clearing wage is least likely to be constrained. This similarity in the main effect across these regressions provides further support that our model is capturing the determinants of NCA use in our sample: regardless of how we proxy for a scenario when the market-clearing wage is unconstrained, we get a very similar estimate of the difference in probabilities that employers with high vs low benefit from NCAs use them.

These results paint a nuanced portrait of NCA use and surplus maximization among the firms in our sample. We find strong evidence that constraints on wages in the labor market have a statistically significant and economically meaningful effect on NCA use. However, this relationship only exists for the employers in our sample likely to benefit the least from NCA use. On the other hand, among employers likely to benefit the most from NCAs, and thus for which NCAs are most likely to maximize joint surplus, NCAs are both more widely used, and are unaffected by constraints on wages. These results suggest NCAs may be surplus-maximizing for some firms in our sample, but not others.

1.5 Conclusion

Noncompete agreements are part of a large and growing share of employment relationships in the U.S., and questions about their rationale, effects and efficiency have made NCAs a controversial topic among policymakers. This paper shows NCAs may arise for reasons unrelated to their ability to maximize a firm's surplus–or even *despite* the fact that they do not maximize a firm's surplus. We develop a simple model with the implication that, when workers and employers are constrained in their ability to use monetary transfers to equilibrate labor markets, NCAs may arise as a non-pecuniary tool to transfer surplus from employees to employers. Such constraints can only affect NCA use if NCAs are not used in an unconstrained world, which they will not be if the employee's cost of an NCA exceeds the employer's benefit (i.e., when NCAs do not maximize firms' surplus). Our model generates a method that provides a sufficient condition for existence of NCAs which do not maximize firms' surplus: if the bindingness of transferability constraints affects NCA use (e.g., via changes in the minimum wage or labor supply), then NCAs which do not maximize firms' surplus exist.

Using a new survey of independent salon owners in the beauty industry, we find strong empirical evidence that constraints on monetary transfers (in the form of the minimum wage) and variation in forces that are associated with the market-clearing wage (labor supply and the unemployment rate) have statistically significant and economically meaningful effects on NCA use. These results support the conclusion that contracts that cause a surplus loss exist in this labor market, and provide some of the first evidence that changes to the external labor market affect internal non-monetary contracting decisions of firms.

We further explore the benefits associated with NCA use by identifying a subset of firms for which NCAs are likely to have a low private benefit: firms that, due to lack of access to a line of credit with a bank, are less able to make relevant investments, such as in client attraction or general human capital training. Due to the low benefit of NCAs for those firms, NCAs are likely not to maximize joint surplus for them. Consistent with that hypothesis, we find that NCA use at those firms is most affected by conditions in the labor market.

One limitation of the test we propose is that it only identifies NCAs which do not maximize joint surplus at the firm level. It does not necessarily follow that NCAs identified in this way do not maximize *social* surplus. For example, if NCAs cause a surplus loss for a firm, but a minimum wage makes it optimal for employers to use NCAs, our model predicts the equilibrium quantity of labor employed will be higher than it would if NCAs were unavailable. However, there are other reasons to believe NCAs will not maximize social surplus if they do not maximize firms' surplus. For example, they may depress levels of entrepreneurship (Rauch and Watson, 2015;

Samila and Sorenson, 2011) or decrease labor market churn (Marx et al., 2009) which may limit efficient matching.

From a policy standpoint, our findings offer support for bills, such as the MOVE Act, which would render NCAs signed by low-wage workers unenforceable. Our model predicts a tradeoff from such policies. Employment may decrease if NCAs are not available to equilibrate labor markets. However, firms that are productive enough to hire workers with no NCA will use surplus maximizing contracts. If the employment effects of a minimum wage are small or an NCA's cost to an employee is much greater than the benefit to an employer, the overall effect of legal nonenforcement would be positive, even ignoring any negative externalities. If the employment effects are large or the cost of an NCA is close to its benefit, policymakers may at least be reassured that for any firms which continue to hire workers without NCAs, the total surplus of the firm will increase. This recommendation may be refined by continuing to identify firms which benefit most from NCA use: for example, those most able to invest in assets which NCAs may protect.

This paper also highlights a potentially unintended consequence of minimum wage laws, as our results suggest a higher minimum wage leads to an increased use of NCAs. Many papers have sought to estimate the effects of the minimum wage on employment and wages. A smaller literature has investigated the effect of the minimum wage on non-wage job attributes, such as Acemoglu and Pischke (2003), who find no strong evidence of an increase or decrease in on-the-job training associated with increases in the minimum wage, and Simon and Kaestner (2004), who find no evidence that an increase in the minimum wage leads to a reduction in fringe benefits of low-wage workers. Our results point to a previously overlooked component of nonwage compensation that employers can adjust in response to minimum wage increases. If we take as given that minimum wage laws are desirable for equity or welfare reasons (Lang, 1987; Rebitzer and Taylor, 1995), policymakers must be aware of employers' abilities to extract surplus from workers in other ways, especially using contract provisions like NCAs that potentially limit workers' future employment opportunities.

Future research may seek to estimate the magnitude of the costs and benefits of NCA use. Although this paper develops a test to determine whether NCAs cause a surplus loss, the global efficiency of NCA use is left ambiguous, which is an important factor in policymaking and a promising avenue for future work. Finally, increased exploration of ways that NCAs benefit firms that employ low-wage employees will help policy makers identify occupations, industries, or other subsets of the labor market for whom NCAs are most likely not to maximize surplus. In order to do so, new data containing more detailed information on NCA use are required.

Chapter 2

Noncompete Agreements and Labor Market Dynamics

2.1 Introduction

If an employer adjusts a non-wage amenity (e.g., health insurance, workplace safety, or pension generosity) of a worker in response to a change in the minimum wage, that adjustment typically does not have external labor market effects. One exception is an adjustment to on-the-job training: if an employer adjusts levels of on-the-job training of her employees when the minimum wage changes (e.g., as hypothesized in Acemoglu and Pischke (2003)), the levels of human capital accumulation in the labor market as a whole are affected. Another exception is a change in the use of noncompete agreements (hereafter, NCAs): contractual elements which restrict employee mobility[1]. By limiting reentry of currently employed individuals into occupation-specific labor markets, NCAs may affect labor market composition and relative market power.

A segment of the empirical literature on NCAs has focused on this channel: for example, mobility in Silicon Valley (Fallick et al., 2006), mobility of workers in Michigan following a reform in NCA laws (Marx et al., 2009), and mobility of technical workers (Marx, 2011). In the opposite direction, abundant labor has been shown to increase prevalence of NCAs in the presence of constraints on utility transferability via the wage, such as the minimum wage (as shown in Chapter 1). This bidirectional

[1] See Bishara and Starr (2016) for a review of the literature on NCAs.

causality has implications for labor markets and the welfare of both workers and firms. In this paper, I construct a model of dynamic labor markets in which NCA use and labor supply are jointly determined over time.

The basic mechanism of the model is as follows: when the market clearing wage is constrained (e.g., by a minimum wage or the inability of an employee to borrow requisite funds to "purchase" his or her job: see, for example, Scheinkman and Weiss (1986)), an NCA may be used to allocate surplus to an employer by worsening the bargaining position of her employee in future wage negotiations. Increased prevalence of NCAs limits reentry into the labor market for employees that undergo job separation. If there is a constraint on the ability of new employees to enter the labor market, labor supply may decrease in periods following high use of NCAs. Low labor supply may cause the market clearing wage to be locally unconstrained, causing firms to use adjustments to the wage instead of NCAs to clear the labor market. In the absence of prevalent NCAs, entry into the labor market (including reentry of separated workers not bound by NCAs) dominates exit, and labor supply may eventually return to its former size, causing the market clearing wage to once again become constrained. When entry into the market by potential employees is unlimited, the labor market may achieve a steady state, either with or without NCAs, since flows out of the market of separated employees with NCAs will be balanced by flows into the market of new employees.

From a welfare perspective, the enforceability of NCAs poses a tradeoff both socially and from the point of view of employers. Socially, NCAs that are only used when the market clearing wage is constrained reduce each individual firm's joint surplus relative to a contract with no NCAs: if this were not the case, NCAs would be used universally. But, NCAs may temporarily increase employment levels by allowing the labor market to clear, and in turn, increase the measure of suppliers in the goods market. Many recent policy initiatives have sought to limit NCA use among low-wage workers[2]. The results in this paper may inform that discussion from a social optimality point of view.

To fully explore the interactions summarized above, the model incorporates wage constraints in a competitive labor market with potentially limited entry by new employees. Since the measure of firms in the market may change due to entry and exit, the market for the good produced by firms is also modeled, leading to endogenous goods prices. Sustained employment generates a surplus which is split between employers and employees in the absence of a noncompete agreement, and accrues only to employers when the firm uses a NCA. This structure is a simplification of a bargaining game played by employers and employees who may be bargaining, for example, over quasi-rents generated by avoiding paying a hiring cost. Employees' outside options are compromised by an NCA, forcing them to yield their portion of the quasi-rent. The results generated in this paper, however, are not specific to situations in which NCAs are motivated by hiring costs. NCAs may assign control rights to a client list, solve a hold-up problem, or protect trade secrets. Critically, in all of these cases and more, noncompete agreements cause the continuation payoff of an employer to improve while the continuation payoff of the employee may improve, worsen, or remain the same. Whenever an employer's continuation payoff improves, noncompete agreements may be used to transfer surplus in the presence of wage constraints. Of course, the extent to which NCAs increase or decrease the payoffs of employers and employees affects the welfare tradeoffs of society and employers.

This model follows the incomplete contracting literature pioneered by Grossman and Hart (1986), Hart and Holmström (1986), and Hart and Moore (1990). NCAs may be viewed as an imperfect method to allocate future surplus when contingent

[2]See http://www.natlawreview.com/article/which-states-are-likely-to-enact-laws-restricting-non-compete-agreements-2017 for a summary of recent or planned legislation at the state level.

contracting or the wage itself are unable to do so. The model presented here is similar to the static model presented in Legros and Newman (2008), with changes implemented to highlight one unique aspect of NCAs as opposed to other contractual elements: that they dynamically change the structure of the market itself. While no other papers have focused on labor market dynamics when NCAs are used among low wage workers, Rauch (2015) and Rauch and Watson (2015) analyze some of the effects of contracting with NCAs in similar incomplete contracting environments.

In Section 2.2, the model and the definition of equilibrium are introduced. In Section 2.3, I reduce the properties which hold true in any equilibrium of the model, solve for labor supply and demand within a given period, and characterize single period equilibrium, which takes as given future prices, contracts, and measures of agents. In Section 2.4, I characterize the dynamics of the model, proving the existence of NCA cycles. In Section 2.5, I analyze when a policy of NCA nonenforcement is most likely to be socially beneficial. Section 2.6 concludes.

2.2 Model

The model has infinite discrete periods, indexed by t. In each period, employees (E) and employers (R) frictionlessly form “firms” (comprised of one E and one R) in order to produce a consumer good, which is sold in a competitive market. The items of primary importance are the single-period contracts in each period for each firm, $\{w_t, A_t\}$, each of which must be agreed to by an E and an R. The wage, w_t, is an uncontingent payment made instantly from R to E which is required to be greater than l, the wage constraint. The second contractual element, $A_t \in \{0, 1\}$, represents an NCA: if $A_t = 1$, the employee is bound by an NCA. Upon separation from her employer, an employee with an NCA is forced out of the labor market. If $A_t = 0$, the employee is free to move to other firms in future periods.

Within each period, there are three dates. At date 1, preexisting firms may agree to contracts or separate, and new firms may form. Firms are comprised of one E and one R. All E not previously bound by an NCA and all R are eligible to form new firms, including members of a preexisting firm which fails to agree to a contract. In order to form a new firm at time t, an R/E pair must both accept the market contract, $\{w_t, A_t\}$. If an agent is unable to, or chooses not to, agree to a contract, that agent receives her outside option for that period, which is equal to Π for E, and normalized to zero for R. Agents at preexisting firms have three options: they may opt to agree to the contract $\{w_t + m^W, 0\}$ if $A_{t-1} = 0$ or $\{w_t, 0\}$ if $A_{t-1} = 1$; they may opt to return to the open market and agree to the market contract as part of a new firm (except for E with $A_{t-1} = 1$); or each may opt to receive her outside option. In other words, E receives a wage bonus if she remains with her firm, contingent on not having a noncompete agreement. Though wage negotiation is not explicitly modeled, the lack of a wage increase with an NCA should be understood as E's inability to negotiate a wage increase due to her compromised outside option[3]. Since the wage payment is made instantly and without an explicit mechanism to commit to future behaviors, I implicitly assume that any future action is noncontractible. This assumption reflects the realistic contracting environment in which it is too costly or complicated to write contingent contracts planning for all eventualities.

At date 2, each R matched with an E produces exactly one unit of a homogeneous consumer good at exogenous cost $\gamma \in \{\gamma_L, \gamma_H\}$, where a proportion p of R have γ_L as their cost, $1-p$ have γ_H, and $\gamma_H > \gamma_L$. Since E's wage has already been paid, γ is the

[3] The structure of wage setting for preexisting firms is predicated on rather strong assumptions made for tractability. A more complicated model in which preexisting firms Nash bargain over a relationship-specific quasi-rent (perhaps induced by a hiring cost which must be paid by new firms) via wages in each period generates a similar environment, though. In that setting, the endogenous wage bonus turns out not to be purely additive, and additional assumptions are required on the size of the productivity bonus firms accrue in order to ensure that $A = F$ for preexisting firms. However, the qualitative implications are unchanged in such a model, and the model is far more complicated to solve.

marginal cost of production for the firm. The price of the consumer good, P_t, is determined in a competitive goods market, in which consumers maximize a quasi-concave utility function, yielding inverse demand function $P(Q_t)$, where Q_t is the measure of firms at time t, as each firm produces one unit of the good. Preexisting firms earn an additional m^p, a relationship-specific quasi-rent which may be interpreted, for example, as a decrease in the marginal cost of production, as an increase in the price paid by consumers due to a higher quality product, or as the size of a hiring cost which need not be paid by preexisting firms.

Finally, at date 3, each E that is a member of a firm exogenously separates from their matched R with probability s. An exogenous measure of E equal to Ω, who had not previously participated in the labor market are allowed to enter the labor market by paying a cost of c. Each E outside the labor market in period t may only enter the market in that period, or else receives her outside option in perpetuity–there is no delayed labor market entry. It is assumed that the total measure of R, μ_R, is exogenous and fixed[4]. Any E with $A_t = 1$ that experiences exogenous separation must exit the labor market, receiving her outside option, Π, in all future periods.

2.2.1 Definition of Equilibrium

An equilibrium is, in each period, a market contract for unmatched agents, a price in the goods market, participation decisions for all agents (receive their outside option, form a firm under the market contract, or accept the corresponding contract for preexisting firms), and entry decisions for employees outside of the market such that in each period, correctly anticipating future contracts, prices, participation decisions, and entry decisions:

[4]The assumption that no additional R may enter the market is relatively benign. Ultimately, without change in the demand function or the outside options of agents, there is a market size above which agents will not wish to enter, as the accruable rents in the market sum only to just enough to cover the entry costs of the agents.

1. participation decisions are stable/contracts are Pareto optimal: there do not exist an E and an R and a contract which yields strictly greater discounted utility to one of the two agents, and discounted utility that is at least as great for the other member;

2. agents enter the labor market if entry yields discounted expected utility strictly greater than the expected discounted utility of remaining out of the labor market, and agents do not enter the labor market if entry yields discounted expected utility strictly less than the expected discounted utility of remaining out of the labor market; and

3. the goods market price clears the goods market.

An equilibrium is a *steady state equilibrium* if the measure of firms induced by participation decisions and new market pre-contracts remain constant over time. That is, $\forall t$ and $\forall t'$:

$$\{Q_t, w_t, A_t\} = \{Q_{t'}, w_{t'}, A_{t'}\}$$

where Q_t is the measure of firms in the market in period t induced by entry decisions and matching.

An equilibrium is a *ϕ-cyclical equilibrium* if there exists $\phi \in \{2, 3, ...\}$ such that the size of the market and new market contracts repeat every ϕ periods. That is, $\forall t$ and $\forall n \in \mathbb{N}$:

$$\{Q_t, w_t, A_t\} = \{Q_{t+n\phi}, w_{t+n\phi}, A_{t+n\phi}\}$$

2.3 Equilibrium Characterization

In this section, I characterize equilibrium contracts. In the model, agents take as given labor market pre-contracts ($\{w_t, A_t\}$) and the goods market price (P_t). The choice variables for each agent are the decision whether or not to enter the labor market (for agents not already in the labor market), the decision whether to accept the market contract or receive her outside option (for unmatched agents), or the decision whether to accept the corresponding preexisting firm contract, the market contract, or receive her outside option (for matched agents). The state variables of the model at the beginning of a given period, t, are the measures of E and R with $A_{t-1} = 0$ and $A_{t-1} = 1$, respectively, which are denoted $\mu^F_{E,t}$, $\mu^N_{E,t}$, $\mu^F_{R,t}$, and $\mu^N_{R,t}$, and the measure of unmatched E and R which are denoted $\mu^U_{E,t}$ and $\mu^U_{R,t}$. Each agent's participation status (out of the market, unmatched, matched under a contract with $A_{t-1} = F$, or matched under a contract with $A_{t-1} = 1$) serves as an additional state variable for that agent.

At time t, given goods market price P_t, production cost γ, and contract $\{w, A\}$ (if matched), an employer, R, receives a period payoff normalized to zero if she is not a member of a firm, $P_t - \gamma - w$ if she is a member of a newly formed firm, and $P_t + m^p - \gamma_i - w$ if she is a member of a preexisting firm. An employee receives Π if he is not a member of a firm, w if he is, and additionally pays a cost c if he entered the market in period t.

2.3.1 Definition of Value Functions

Let $V^U_t(\gamma)$ represent the expected discounted value to an unmatched R of being in the market at the outset of period t. Let $V^F_t(\gamma)$ and $V^N_t(\gamma)$ be the analagous value functions for R who were previously matched under contracts with $A_{t-1} = 0$ or $A_{t-1} = 1$. These value functions are given by:

$$\begin{aligned}
V_t^U(\gamma) &= \max\Big\{\delta V_{t+1}^U(\gamma), P_t - \gamma - w_t \\
&\quad + \delta\Big[sV_{t+1}^U(\gamma) + (1-s)(A_t V_{t+1}^N(\gamma) + (1-A_t)V_{t+1}^F(\gamma))\Big]\Big\} \\
V_t^F(\gamma) &= \max\Big\{V_t^U(\gamma), P_t + m^p - \gamma - w_t - m^w + \delta\Big[sV_{t+1}^U(\gamma) + (1-s)V_{t+1}^F(\gamma)\Big]\Big\} \\
V_t^N(\gamma) &= \max\Big\{V_t^U(\gamma), P_t + m^p - \gamma - w_t + \delta\Big[sV_{t+1}^U(\gamma) + (1-s)V_{t+1}^F(\gamma))\Big]\Big\}
\end{aligned}$$

An unmatched R has the option of receiving her outside option and waiting until period $t+1$ or joining a new firm in period t. A matched R (with $A_{t-1} = F$ or N, respectively) also may wait until period $t+1$ or join a new firm, but additionally has the option of remaining with her matched E and using the corresponding time $t+1$ contract.

E has three comparable endogenous value functions, W_t^U, W_t^F, and W_t^N. They are given by:

$$\begin{aligned}
W_t^U &= \max\Big\{\Pi + \delta W_{t+1}^U, w_t + \delta\Big[s(A_t\frac{\Pi}{1-\delta} + (1-A_t)W_{t+1}^U) \\
&\quad + (1-s)(A_t W_{t+1}^N + (1-A_t)W_{t+1}^F)\Big]\Big\} \\
W_t^F &= \max\Big\{W_t^U, w_t + m^w + \delta\Big[sW_{t+1}^U + (1-s)W_{t+1}^F\Big]\Big\} \\
W_t^N &= \max\Big\{\frac{\Pi}{1-\delta}, w_t + \delta\Big[sW_{t+1}^U + (1-s)W_{t+1}^F\Big]\Big\}
\end{aligned}$$

Notably, an E with $A_{t-1} = N$ may only be a member of a firm with his matched R: he does not have the option of reentering the labor market to form a new firm.

2.3.2 Formal Equilibrium Conditions

The first equilibrium condition states that matches are stable/Pareto optimal for the firm: $\nexists\{\tilde{w}, \tilde{A}\}$ such that one of the following two conditions is satisfied (where γ may be γ_L or γ_H, and i may be F or N):

$$P_t - \tilde{w} - \gamma + \delta\Big[sV^U_{t+1}(\gamma) + (1-s)(\tilde{A}V^N_{t+1}(\gamma) + (1-\tilde{A})V^F_{t+1}(\gamma))\Big] \geq V^U_t(\gamma) \quad (2.1)$$

$$P_t + m^p - \tilde{w} - \gamma + \delta\Big[sV^U_{t+1}(\gamma) + (1-s)(\tilde{A}V^N_{t+1}(\gamma) + (1-\tilde{A})V^F_{t+1}(\gamma))\Big] \geq V^i_t(\gamma), \quad (2.2)$$

the following condition is satisfied for either $j = U$ or $j = F$:

$$\tilde{w} + \delta\Big[s(\tilde{A}\frac{\Pi}{1-\delta} + (1-\tilde{A})W^U_{t+1}) + (1-s)(\tilde{A}W^N_{t+1} + (1-\tilde{A})W^F_{t+1})\Big] \geq W^j_t, \quad (2.3)$$

and at least one condition is satisfied with strict inequality. Note that, as E with $A_{t-1} = N$ is unable to change firms, the right hand side of the last inequality does not include W^N_t. However, a firm with $A_{t-1} = N$ is able to renegotiate a contract internally. Therefore, it must be true that $\nexists\{\tilde{w}, \tilde{A}\}$ such that Inequality 2.2 holds for $i = N$ and Inequality 2.3 holds for $j = N$, with one of the two holding strictly.

The next equilibrium condition pertains to labor market entry. In any period, E enter if the expected value of entry is greater than the value of remaining out of the market. If no E enter the labor market, it must be the case that entry yields weakly less value than nonentry. If the maximal measure, Ω, enters, it must be the case that entry yields weakly greater value than nonentry. If a strictly positive measure of E enter that is less than the maximal measure, it must be the case that entry yields value exactly equal to the value of nonentry. Let $\bar{\mu}_t$ represent the measure of entering E in period t. In equilibrium, entry decisions must satisfy:

$$\text{If } \bar{\mu}_t = 0, \text{ then } \delta W_{t+1}^U - c \leq \frac{\delta \Pi}{1-\delta} \tag{2.4}$$

$$\text{If } \bar{\mu}_t \in (0, \Omega), \text{ then } \delta W_{t+1}^U - c = \frac{\delta \Pi}{1-\delta} \tag{2.5}$$

$$\text{If } \bar{\mu}_t = \Omega, \text{ then } \delta W_{t+1}^U - c \geq \frac{\delta \Pi}{1-\delta} \tag{2.6}$$

2.3.3 Single Period Equilibrium

Ignoring intertemporal aspects of the model, I first investigate market contracts for unmatched agents within a given period. In this model, NCAs transfer surplus from E to R by removing the wage bonus, m^w, if the firm remains together. With unconstrained transferability of utility via the wage, any transfer made using an NCA could alternatively be made with the wage. NCAs, however, have a negative future effect for E: if E is bound by an NCA, upon separation, E receives his outside option in perpetuity. If the value of labor market participation is greater than E's outside option in any future period, this is a loss for E that is not captured by R. In other words, when l is nonbinding, any contract with $A_t = 1$ will be dominated by a contract with $A_t = 0$. When l binds, contracts with $A_t = 0$ or $A_t = 1$ may be optimal. This intuition is captured in the following lemma:

Lemma 2.3.1. *Consider an equilibrium in which entry strictly dominates nonentry in a given period. Then, contracts without NCAs are Pareto optimal for newly formed firms. Contracts with NCAs are Pareto optimal if and only if the transferability constraint is binding.*

2.3.4 Labor Demand and Labor Supply

In this section, I construct the labor demand and labor supply curves of unmatched agents which will be used to identify equilibrium contracts within a given period. Standard labor demand and labor supply curves identify the measure of agents willing to participate at a given wage, and therefore exist in two-dimensional space. With two-dimensional contracts, I extend the space to three-dimensions. In theory, given an equilibrium, one may calculate the measure of E or R willing to participate in the market for any contract. However, since agents will not use Pareto dominated contracts, I will leverage Lemma 2.3.1 to generate an inverse labor demand function which is a curve in three-dimensional space, as any Pareto optimal contract will either have the form $\{w, 0\}$ with $w \geq l$ or $\{w, 1\}$ with $w < l + \delta(1-s)m^w$. That inverse labor demand curve, along with the labor supply surface, will be used to find equilibrium contracts.

Labor Demand

Taking future value functions as given, an unmatched R is willing to agree to the contract $\{w, A\}$ in period t if the value of hiring an employee under the contract $\{w, A\}$ is greater than $\delta V^U_{t+1}(\gamma)$. The willingness to pay of R with production cost γ is found when the value of hiring exactly equals the value of delaying market participation one period. This expression is given by:

$$P_t - \gamma - w + \delta\Big[sV^U_{t+1}(\gamma) + (1-s)(AV^N_{t+1}(\gamma) + (1-A)V^F_{t+1}(\gamma))\Big] = \delta V^U_{t+1}(\gamma) \quad \text{(PCR)}$$

This expression may be satisfied two ways since both w and A are contractual instruments. Optimal contracts that yield R no net surplus will maximize E's value:

$$\max_{w,A} w + \delta\Big[s(A\frac{\Pi}{1-\delta} + (1-A)W^U_{t+1}) + (1-s)(AW^N_{t+1} + (1-A)W^F_{t+1})\Big], \qquad (2.7)$$

subject to the limited transferability constraint ($w \geq l$ (LTC)), Equation PCR (which functions as the participation constraint of R), and the participation constraint of E, which is slack, as E's utility is being maximized. Ignoring the limited transferability constraint, PCR binds and may be substituted into Expression 2.7. With unlimited transferability, the solution to this problem dictates that $A = 0$ whenever

$$(1-s)\Big(V^N_{t+1}(\gamma) - V^F_{t+1}(\gamma)\Big) < s\Big(W^U_{t+1} - \frac{\Pi}{1-\delta}\Big) + (1-s)(W^F_{t+1} - W^N_{t+1})$$

$$W^U_{t+1} > \frac{\Pi}{1-\delta} \tag{2.8}$$

i.e., the net expected cost of an NCA exceeds its net expected benefit, and $A = 1$ otherwise. Index R by i, where indexation occurs in order of increasing costs (i.e., if R_i has $\gamma = \gamma_H$ and $R_{i'}$ has $\gamma = \gamma_L$, then $i > i'$). The greatest wage R is willing to pay in the unconstrained environment, $\hat{w}^D_t(i, A)$, is given by meeting R_i's participation constraint:

$$\hat{w}^D_t(i, A) = P_t - \gamma(i) + \delta(1-s)\Big[AV^N_{t+1}(\gamma(i)) + (1-A)V^F_{t+1}(\gamma(i)) - V^U_{t+1}(\gamma(i))\Big],$$

where $\gamma(i)$ is the marginal production cost of R_i.

The case in which Inequality 2.8 is satisfied is the case on which this paper is focused. In Section 2.4, I explain when this assumption is satisfied in equilibrium. Under the alternative assumption, NCAs are surplus-maximizing contracts and are used by all firms, as no constraints introduced in this paper hinder their use.

The constraint LTC, however, affects NCA use when the net expected cost exceeds the net expected benefit in the following way: for some firms, LTC and PCR may only be simultaneously satisfied when $A = 1$. For example, for R_i with $\gamma = \gamma_H$, LTC and PCR are simultaneously satisfied only when

$$P_t - \gamma_H - l + \delta(1-s)\Big[AV^N_{t+1}(\gamma_H) + (1-A)V^F_{t+1}(\gamma_H) - V^U_{t+1}(\gamma_H)\Big] > 0$$

If $P_t - \gamma_H - l + \delta(1-s)\Big[V^F_{t+1}(\gamma_H) - V^U_{t+1}(\gamma_H)\Big] < 0$ but $P_t - \gamma_H - l + \delta(1-s)\Big[V^N_{t+1}(\gamma_H) -$

$V^U_{t+1}(\gamma_H)\Big] > 0$, only contracts with $A = 1$ are acceptable for R_i with $\gamma = \gamma_H$.

Let $\hat{\imath}_t \in \{0, p\mu^U_{R,t}, \mu^U_{R,t}\}$ denote the employer index that serves a demarcation between R who will accept a contract with $A = 0$ and those that will not, where $\mu^U_{R,t}$ is the measure of unmatched R at the beginning of period t[5]. Then, when Inequality 2.8 is satisfied, and taking into account the wage constraint, inverse labor demand is given by:

$$\{w^D_t(i), A^D_t(i)\} = \begin{cases} \{\hat{w}^D_t(i,0), 0\} & \text{if } i \leq \hat{\imath}_t \\ \{\hat{w}^D_t(i,1), 1\} & \text{otherwise.} \end{cases} \tag{2.9}$$

It is assumed, here, that $\hat{w}^D_t(i,1) > l \ \forall i$: i.e., a contract with $A = 1$ may simultaneously satisfy LTC and PCR.

Labor Supply

The labor supply surface may be constructed similarly to the method used for labor demand, by calculating the contract which yields surplus identical to E's outside option. Since unmatched E are homogeneous, inverse labor supply will be horizontal. Furthermore, insofar as labor supply will be used as a tool to identify equilibrium contracts at its intersection with labor demand, since all contracts on the labor demand curve calculated above satisfy LTC and Pareto optimality, I may ignore those concerns here.

The worst acceptable contracts for E solve:

$$w + \delta[s(A\frac{\Pi}{1-\delta} + (1-A)W^U_{t+1}) + (1-s)(AW^N_{t+1} + (1-A)W^F_{t+1})] = \Pi + \delta W^U_{t+1}$$

The inverse labor supply surface is given by $w^S_t(i, A)$, whose domain is $[0, \mu^U_{E,t}] \times \{0, 1\}$ (where $\mu^U_{E,t}$ represents the measure of unmatched E at the beginning of period

[5]It must be the case that $\hat{\imath}_t \in \{0, p\mu^U_{R,t}, \mu^U_{R,t}\}$ since R_i and $R_{i'}$ with identical γ will both either have acceptable or not have acceptable contracts with $A = 0$.

t):

$$w_t^S(i,A) = \Pi + \delta\Big[(1-s(1-A))W_{t+1}^U - sA\frac{\Pi}{1-\delta} - (1-s)(AW_{t+1}^N + (1-A)W_{t+1}^F)\Big] \tag{2.10}$$

Single Period Equilibrium

Given equilibrium contracts and prices from period $t+1$ onwards, I use $w_t^D(i)$, $A_t^D(i)$, and $w_t^S(i,A)$ to characterize period t equilibrium contracts. I make the following assumptions, which are necessary (but not sufficient) conditions to ensure that E is able to cover his cost of entry:

Assumption 3. $\mu_{R,t}^U > \mu_{E,t}^U$

Assumption 4. $w_t^D(\mu_{E,t}^U) > w_t^S(\mu_{E,t}^U, A_t^D(\mu_{E,t}^U))$

Assumption 3 simply says that there are more unmatched R than unmatched E at time t. Assumption 4 ensures that there exists a contract simultaneously acceptable to E and $R_{\mu_{E,t}^U}$. Essentially, these assumptions guarantee that labor demand and labor supply intersect at $i = \mu_{E,t}^U$. This condition is not essential to the analysis: it is simply made for tractability.

Given Assumptions 3 and 4, the intersection occurs on the demand curve, and the equilibrium contract for unmatched agents is $\{w_t, A_t\} = \{w_t^D(\mu_{E,t}^U), A_t^D(\mu_{E,t}^U)\}$. If $\mu_{E,t}^U < \hat{\imath}_t$, this contract is $\{\hat{w}_t^D(\mu_{E,t}^U), 0\}$, and if $\mu_{E,t}^U > \hat{\imath}_t$, this contract is $\{\hat{w}_t^D(\mu_{E,t}^U), 1\}$. In other words, the existence of NCAs is a function of labor supply: when $\mu_{E,t}^U$ is large, the market contract will have an NCA.

2.4 Labor Market Dynamics

In this section, I characterize labor market dynamics by considering the intertemporal effects of contract structures. Contracts with $A = 1$ internally allocate surplus to R, and are used when the terms of trade in the market favor R but can not be met by the wage alone. However, NCAs have an external effect, as well: E are forced out of the labor market when they are bound by NCAs. The ability of the market to replenish itself will play a large role in determining labor market dynamics.

I begin by introducing the laws of motion of the measures of agents in the labor market. Next, I note the existence of steady state equilibria with and without NCAs. Finally, I show that noncompete cycles may emerge when labor market entry is limited for E.

2.4.1 Laws of Motion

In the most general case of the model, any agent may opt not to participate in the market. However, since all E and R for $i \leq \mu^U_{E,t}$ may form profitable firms by Assumptions 3 and 4, all unmatched agents except unmatched R with $i > \mu^U_{E,t}$ will participate in a given period. Members of preexisting firms will also opt to participate, as they earn an additional quasi-rent equal to m^p.

Whenever Assumptions 3 and 4 are satisfied, the laws of motion simplify to:

$$\begin{aligned}
\mu^U_{E,t+1} =& \bar{\mu}_t + s((1-A_t)\mu^U_{E,t} + \mu^F_{E,t} + \mu^N_{E,t}) \\
\mu^F_{E,t+1} =& (1-s)((1-A_t)\mu^U_{E,t} + \mu^F_{E,t} + \mu^N_{E,t}) \\
\mu^N_{E,t+1} =& (1-s)A_t\mu^U_{E,t} \\
\mu^U_{R,t+1} =& s(\mu^U_{E,t} + \mu^F_{R,t} + \mu^N_{R,t}) + \mu^U_{R,t} - \mu^U_{E,t} \\
\mu^F_{R,t+1} =& (1-s)((1-A_t)\mu^U_{E,t} + \mu^F_{R,t} + \mu^N_{R,t}) \\
\mu^N_{R,t+1} =& (1-s)A_t\mu^U_{E,t},
\end{aligned}$$

where $\mu^\theta_{\psi,t}$ represents the measure of type ψ agents in period t that are unmatched ($\theta = U$), members of preexisting firms with $A_{t-1} = 0$ ($\theta = F$), or members of preexisting firms with $A_{t-1} = 1$ ($\theta = N$). These laws of motion may be interpreted as follows: unmatched agents at time $t+1$ are entering agents and separating agents, excepting E with $A_t = 1$. Agents involved in matches with or without NCAs are simply those who signed those contracts in the prior period, net of those matches that separated.

2.4.2 Steady State Equilibria

The existence of steady state equilibria is straightforward. When wages are unconstrained (l is extremely low), no contract will have $A = 1$, since $\hat{\imath}_t = \mu^U_{R,t}$. If agents anticipate that their values in all states in all future periods are identical, then labor supply and labor demand will be identical in each period, leading to identical market contracts and identical expected value of entry. There will be no exit since no E are forced out of the market, and there is no incentive to exit given that all agents may earn their outside option while participating in the market. If the expected value of entry is no greater than the cost of entry, net of an agent's outside option, then entry will not occur, ensuring that the expectation that values in all states in all future periods are identical is fulfilled.

Proposition 2.4.1. *When the transferability limitation is low, a steady state equilibrium exists in which no market contracts have NCAs.*

When the wage constraint binds, contracts will have $A = 1$, and some exit will occur. However, if the measure of new E able to enter the labor market is high, labor supply can replenish each period to its former level. That level may yield expected future surplus for R and E that exactly covers the cost of entry: if the market is small, expected future surplus will be high, and entry will lower P_t (by increasing goods market supply), decreasing the amount of surplus available to R and E. If the expected value of entry and nonentry are equal, the size of the market will remain the same each period, generating an environment much like the unconstrained wage scenario.

Proposition 2.4.2. *When the transferability limitation is high and potential entry is high, a steady state equilibrium exists in which all market contracts have NCAs.*

Based on this intuition, two things must be true in order for a steady state equilibrium not to exist for a given set of parameters: first, wages must be constrained. Second, entry of E must be limited. Indeed, these two conditions not only rule out steady state equilibria; they also allow cyclical equilibria to exist, as described in the following section.

2.4.3 Cyclical Equilibria

When the wage is constrained and NCAs are used, some E are forced to exit the market. If entry of E is limited, labor supply will be low in the next period, driving up the market-clearing wage. If the wage is no longer constrained when labor supply is low, all market contracts will have $A = 0$, and over time, labor supply may increase, since E are not forced out of the market. As labor supply increases, the wage falls, and eventually may become constrained once again, leading to market contracts with $A = 1$. At this point, the cycle repeats as E are forced out of the market once again.

For purposes of exposition, I consider 2-cyclical equilibria. Recall the definition from Section 2.3: in a 2-cyclical equilibrium, $\{Q_t, w_t, A_t\} = \{Q_{t+2n}, w_{t+2n}, A_{t+2n}\}$ $\forall t, n$. For the remainder of this section, I will suppose the existence of a 2-cyclical equilibrium, derive some important features of it, and then show conditions under which it exists. Since all variables and functions in the posited equilibrium repeat cyclically, the subscripts 0 and 1 on equilibrium variables and functions will correspond to periods $t + 2n$ (even periods) and periods $t + 2n + 1$ (odd periods), $\forall n \in \mathbb{N}$.

The equilibrium is given by, for $t \in \{0, 1\}$: contracts $\{w_t, A_t\}$, where $A_0 = 0$ and $A_1 = 1$; measures $\{\mu^\theta_{E,t}, \mu^\theta_{R,t}\}$ for $\theta \in \{U, F, N\}$; goods market prices $P_0 = P(Q_0)$ and

$P_1 = P(Q_1)$ where $Q_t = \mu^U_{E,t} + \mu^F_{E,t} + \mu^N_{E,t}$; marginal R indices $\bar{\imath}_t = \mu^U_{E,t}$ such that all R with $i \leq \bar{\imath}_t$ participate in period t; entry of E in even periods equal to $\bar{\mu}$, and entry of E in odd periods equal to Ω. Finally, all E in the market participate in each period.

Cyclical Equilibria Laws of Motion and Entry Condition

In any 2-cyclical equilibrium, the laws of motion may be reduced by accounting for the cyclicality. Consider a hypothetical equilibrium in which $A_{t+2n} = 0$ and $A_{t+2n+1} = 1\ \forall n$, and entry of E in periods $t + 2n + 1$ is equal to Ω, as posited above. Let $\mu^\theta_{\psi,0} = \mu^\theta_{\psi,t+2n}$ and $\mu^\theta_{\psi,1} = \mu^\theta_{\psi,t+2n+1}$ for $\theta \in \{U, F, N\}$ and $\psi \in \{E, R\}$. If Assumptions 3 and 4 hold, then measures of E in each period, as functions of the measures of E entering in each period, reduce to:

$$\begin{aligned}
\mu^U_{E,0} &= \frac{1}{s}\left[(1-s)^2\bar{\mu} + \Omega\right] \\
\mu^F_{E,0} &= \frac{(1-s)^2}{s^2}\left[(1-s)\bar{\mu} + \Omega\right] \\
\mu^N_{E,0} &= \frac{1-s}{s}\left[\bar{\mu} + \Omega\right] \\
\mu^U_{E,1} &= \frac{1}{s}\left[\bar{\mu} + \Omega\right] \\
\mu^F_{E,1} &= \frac{1-s}{s^2}\left[(1-s)\bar{\mu} + \Omega\right] \\
\mu^N_{E,1} &= 0
\end{aligned}$$

The measures of R in preexisting firms in each period are simply equal to their E counterparts: $\mu^\theta_{R,t} = \mu^\theta_{E,t}$ for $\theta \in \{F, N\}$ and $t \in \{0, 1\}$. The measure of unmatched R in each period, $\mu^U_{R,0}$ and $\mu^U_{R,1}$, are determined by the laws of motion and the exogenously given total measure of R, μ_R. In particular, these measures are the residual R in each period:

$$\mu^U_{R,0} = \mu_R - \mu^U_{E,0} - \mu^F_{E,0} - \mu^N_{E,0}$$

$$\mu_{R,1}^U = \mu_R - \mu_{E,1}^U - \mu_{E,1}^F - \mu_{E,1}^N$$

Substituting in the simplified laws of motion above, this simplifies to $\mu_{R,0}^U = \mu_R - \frac{1}{s^2}((1-s)\bar{\mu} + \Omega)$ and $\mu_{R,1}^U = \mu_R - \frac{1}{s^2}((1-s(1-s))\bar{\mu} + \Omega)$.

The entry conditions for E simplify in a 2-cyclical equilibrium, as well. Since, in odd periods, there is maximal entry, the entry condition is:

$$\delta W_0^U - c_E \geq \frac{\delta \Pi}{1-\delta} \tag{2.11}$$

At even times, the entry condition is:

$$\delta W_1^U - c_E = \frac{\delta \Pi}{1-\delta}$$

Cyclical Equilibrium Value Functions

In addition to the laws of motion, the equilibrium value functions of agents are affected by the oscillations of the market. Continuing to consider a 2-cyclical equilibrium in which $A_0 = 0$ and $A_1 = 1$, I may rewrite R's equilibrium value functions as follows:

$$V_0^U(\gamma) = \begin{cases} P(Q_0) - \gamma - w_0 + \delta(sV_1^U(\gamma) + (1-s)V_1^F(\gamma)) \text{ if } i < \mu_{E,0}^U \\ \delta V_1^U(\gamma) \text{ otherwise} \end{cases}$$
$$V_0^F(\gamma) = P(Q_0) + m^p - \gamma - w_0 - m^w + \delta(sV_1^U(\gamma) + (1-s)V_1^F(\gamma))$$
$$V_0^N(\gamma) = P(Q_0) + m^p - \gamma - w_0 + \delta(sV_1^U(\gamma) + (1-s)V_1^F(\gamma))$$
$$V_1^U(\gamma) = \begin{cases} P(Q_1) - \gamma - w_1 + \delta(sV_0^U(\gamma) + (1-s)V_0^N(\gamma)) \text{ if } i < \mu_{E,1}^U \\ \delta V_0^U(\gamma) \text{ otherwise} \end{cases}$$
$$V_1^F(\gamma) = P(Q_1) + m^p - \gamma - w_1 - m^w + \delta(sV_0^U(\gamma) + (1-s)V_0^F(\gamma))$$
$$V_1^N(\gamma) = P(Q_1) + m^p - \gamma - w_1 + \delta(sV_0^U(\gamma) + (1-s)V_0^F(\gamma))$$

Similarly, E's value functions may be written as:

$$W_0^U = w_0 + \delta(sW_1^U + (1-s)W_1^F)$$
$$W_0^F = w_0 + m^w + \delta(sW_1^U + (1-s)W_1^F)$$
$$W_0^N = w_0 + \delta(sW_1^U + (1-s)W_1^F)$$
$$W_1^U = w_1 + \delta(s\frac{\Pi}{1-\delta} + (1-s)W_0^N)$$
$$W_1^F = w_1 + m^w + \delta(sW_0^U + (1-s)W_0^F)$$
$$W_1^N = w_1 + \delta(sW_0^U + (1-s)W_0^F)$$

Existence of 2-Cyclical Equilibria

In order for a 2-cyclical equilibrium to exist, two conditions must be satisfied: first, the market contract must have a noncompete agreement in odd periods, which requires that no wage greater than l may clear the market when $A = 0$. Second, entry of new employees must not cover the measure of employees that exit ($\Omega_E < s\mu_{E,1}^U$) but must cover that measure over two periods. Finally, one further assumption is useful:

Assumption 5. $(1 + \delta(1 - s))(\gamma_H - \gamma_L) \geq \delta^2(1 - s)^2 m^w$

Assumption 6. $m^p - (1 + \delta(1 - s))m^w > 0$

Assumption 5 ensures that, in equilibrium, R with γ_L earn a larger payoff than those with γ_H, as R with γ_H are more likely to have $A = 1$. This is important because, otherwise, firms with γ_L would prefer to separate prior to odd periods in order to mimic firms with γ_H. Assumption 6 guarantees that R who are members of preexisting firms in odd periods prefer to remain together, as opposed to taking advantage of the benefits which accumulate due to having a contract with $A = 1$.

Formally:

Proposition 2.4.3. *When Assumptions 5 and 6 are satisfied, a 2-cyclical equilibrium exists when the transferability limitation and potential entry are neither too large nor too small. In that 2-cyclical equilibrium, all previously unmatched firms have NCAs in periods $t + 2n + 1$, and do not have NCAs in periods $t + 2n$, for $n \in \mathbb{N}$.*

Figure 2·1 shows how the equilibrium types (steady state with $A = 0$, steady state with $A = 1$, or 2-cycle) that exist vary according to parameterization. For large l, steady states with $A = 0$ do not exist, as only contracts with $A = 1$ clear the market. For small l, steady states with $A = 1$ do not exist since contracts with $A = 0$ clear the market and dominate contracts with $A = 1$. Steady states with $A = 1$ also do not exist for low Ω, since labor supply is unable to replenish in one period. Finally, 2-cycles do not exist when Ω is large, as labor supply has the opportunity to replenish in one period, and do not exist when Ω is small, as labor supply takes more than two periods to replenish[6].

[6]The area in the bottom right of Figure 2·1 contains (unlabeled) areas in which ϕ-cycles exist for $\phi > 2$.

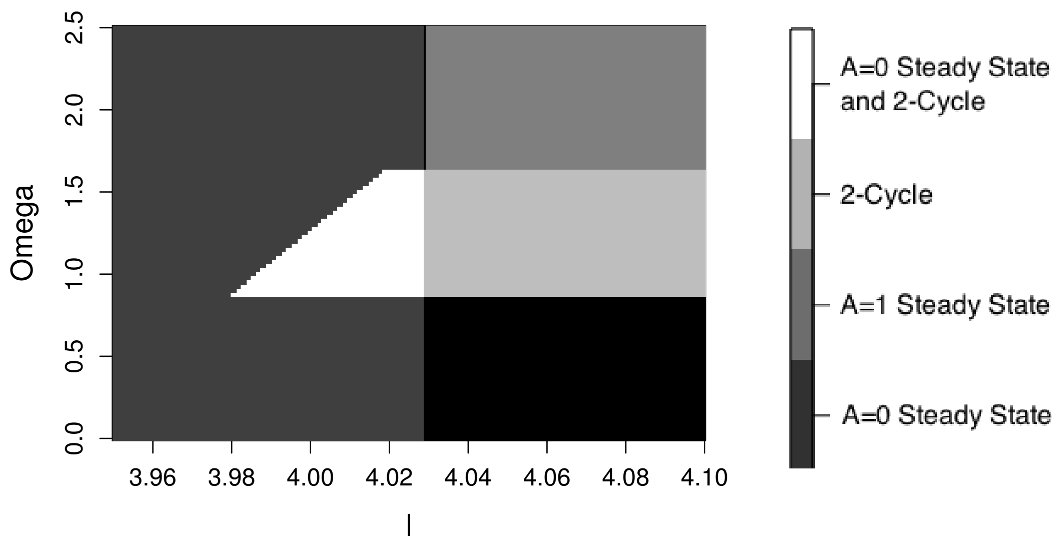


Figure 2·1: Areas for which there exist steady state equilibria (with or without NCAs) and 2-cyclical equilibria.

2.5 Policy Analysis

In this section, I analyze the welfare effects of implementation of a policy prohibiting NCAs. Such a policy is under consideration for low wage workers at both national and state levels; however, little is known about whether it would enhance or diminish welfare. The fundamental welfare tradeoff is as follows: NCAs allow markets to clear, increasing the level of production in the goods market (which may increase both consumer and producer surplus). However, NCAs are not surplus maximizing at the firm level, and so there is a surplus loss associated with firms who would have participated in the market if NCAs were prohibited. In the model described in this paper, the loss exhibits as an increase in the total entry cost paid by new workers in each period. I consider this welfare tradeoff separately for steady state equilibria when NCAs are used and for 2-cycles. The key difference is that, in a cyclical equilibrium, the increase in the level of production in the goods market exists only in periods in which the market is large ("odd" periods, in which firms use NCAs), and the market may be smaller in the intervening (even) periods.

In this section, markets bound by a wage constraint may not clear without the ability to use NCAs. I assume that, in each period, each unmatched employee's objective and subjective probability of joining a firm is equal to the anticipated measure of newly formed firms divided by the total measure of unmatched employees: $\frac{Q_t-\mu_t^F-\mu_t^N}{\mu_E^U}$.

2.5.1 Steady State Welfare Comparison

In evaluating NCA policy, I assume that a social welfare maximizing policymaker weights all agents' welfare equally–employers, employees, and consumers. It should be noted throughout this section that such weights may not reflect the goals of actual policymakers, who may place greater weight on the welfare of low-wage employees than that of their employers. I perform welfare comparisons on a per-period basis, and therefore, all time subscripts are dropped in this section.

When the welfare of all agents is weighted equally, the social surplus generated under a given policy is equal to the sum of all production realized, net of all costs paid. Social surplus, then, has five components: the first four are gross consumer surplus (CS), employer production bonus (RB), employer costs (RC), and employee entry costs (EC). The final component is employees' outside options (home production). Since all employees in the model's universe who are not members of firms earn Π each period, for purposes of comparing surplus under two policies, the relevant comparison is in the difference in the lost potential home production of employees who are members of firms. It is this employee loss (EL) that I use in calculating social surplus under each policy, understanding that it represents relative loss as opposed to absolute loss.

CS is given by the area below the demand curve for all units of the consumer good sold:

$$CS \equiv \int_0^Q P(Q)dQ = P_{int}Q - \frac{1}{2}(P_{int} - P(Q))Q = P_{int}Q + \frac{\rho}{2}Q^2$$

RB is given by $RB \equiv m^p(\mu^F + \mu^N)$. RC is given by the measures of employers paying marginal costs γ_L and γ_H respectively times the size of those costs. Let μ_H and μ_L represent the measures of matched R with costs γ_H and γ_L, respectively: $RC \equiv \mu_H\gamma_H + \mu_L\gamma_L$. EC is given by the entry cost times the measure of entering employees: $EC \equiv \bar{\mu}c$. Finally, EL is given by the measure of matched employees (equal to the measure of firms) times their outside option: $EL \equiv \Pi\mu$. Taken together, (relative) per-period social surplus (S) is given by

$$S \equiv CS + RB - RC - EC - EL.$$

Consider a steady state equilibrium in which $A = 1$ in all contracts of newly formed firms. I assume that the intersection of labor supply and labor demand occurs at $i > p\mu_R$: the marginal employer has cost γ_H[7]. Since any employer with γ_H is unwilling to pay l without an NCA (as is necessary for $A = 1$ to be an equilibrium contract), the size of the market under a policy of NCA prohibition is $Q^x = p\mu_R$ (assuming that market has reached its steady state). Denote the market size without such a policy as $\hat{Q}$, where $\hat{Q} > Q^x$ by assumption. Then, the difference in surplus generated with a prohibition on NCAs versus without, assuming the economy would be in a steady state equilibrium with $A = 1$ in market contracts is given by:

[7]In a steady state equilibrium with $A = 1$ in market contracts, if the marginal employer had marginal cost γ_L, no employers would form firms since the greatest wage employers are willing to pay without an NCA is less than l. Social surplus under a policy of NCA prohibition is zero in such a case.

$$\begin{aligned}
SDIFF_{SS} \equiv S^x - \hat{S} &= (CS^x - \hat{CS}) + (RB^x - \hat{RB}) + (\hat{RC} - RC^x) \\
&+ (\hat{EC} - EC^x) + (\hat{EL} - EL^x) \\
&= (Q^x - \hat{Q})P_{int} + \frac{\rho(Q^{x2} - \hat{Q}^2)}{2} + ((1-s)Q^x m^p - (1-s)\hat{Q}m^p) \\
&+ (p\mu_R\gamma_L + (\hat{Q} - p\mu_R)\gamma_H - Q^x\gamma_L) + s^2\hat{Q}c + (\hat{Q}\Pi - Q^x\Pi) \\
&= (p\mu_R - \hat{Q})P_{int} + \frac{\rho((p\mu_R)^2 - \hat{Q}^2)}{2} + (1-s)m^p(p\mu_R - \hat{Q}) \\
&+ (\hat{Q} - p\mu_R)\gamma_H + s^2\hat{Q}c + \Pi(\hat{Q} - p\mu_R)
\end{aligned}$$

Depending on the values of the parameters, $SDIFF_{SS}$ may be positive or negative. Indeed, exact calculations of surplus leave out many important elements of NCA use not encapsulated in this model (e.g., the endogeneity of separation and NCA use, both as it relates to the lock-in effect of NCAs on poor matches and as it relates to the increased ability of firms to realize benefits from employee retention). However, the effect of variation in exogenous parameters on $SDIFF_{SS}$ is unaffected by those external elements as long as they do not interact with those parameters. In this model, changes in $SDIFF_{SS}$ are monotonic with respect to changes in many exogenous parameters, as summarized in the following proposition:

Proposition 2.5.1. *$SDIFF_{SS}$ is increasing in γ_H, Π, and s, and decreasing in m^p and P_{int}.*

Proposition 2.5.1 yields insight into what occupations may be more likely to benefit from policy intervention, and which would not. Most notably, assuming an occupation's labor market is in a steady state equilibrium in which NCAs are used, those occupations which experience high rates of exogenous separation are more likely to benefit, from a social perspective, from policy intervention prohibiting use of NCAs. This result coincides with the motivation of policymakers who have introduced legislation limiting enforceability of NCAs: they would likely prefer to limit NCA use when separation rates are high, as their primary concern is fairness to workers who need to find new jobs post-separation.

Counterintuitively, NCA nonenforcement is more likely to be optimal when employees' outside options are high. One might imagine that, when workers have strong outside options, strong NCA enforcement may be unimportant to workers and socially optimal due to NCAs' ability to help labor markets clear. However, the negative impact of employees' outside option on the size of the market as a whole decreases the positive impact of NCA enforcement in the model. A similar argument explains the impact of the marginal employer's marginal cost, γ_H, the production bonus for firms that remain together, m^p, and the position of the goods demand curve, P_{int}.

2.5.2 Two-Cycle Welfare Comparison

In a cyclical equilibrium, per-period welfare comparisons depend on which stage of the cycle is under consideration. In this section, I separately consider the difference in social surplus at each of the two stages of a 2-cycle, and additionally consider the difference in social surplus of an economy with a prohibition on NCA use versus the unweighted average of the two stages of the cycle[8]. The major difference in the calculation of surplus in a steady state with NCAs versus a cycle with NCAs is that, in the periods in which the market is small, social surplus does not benefit from the ability of NCAs to help markets clear.

Odd Periods ($A = 1$)

In odd periods of a 2-cycle, NCAs are used in market contracts and the market is relatively large. Intersection of labor supply and labor demand occurs where marginal

[8]If discounting were applied in the calculation of the average, the comparison of surplus would depend on which stage is assumed to be first. To avoid this technicality, I instead consider the unweighted average surplus of the two periods.

cost is equal to γ_H, and l binds the market wage that would occur if NCAs were not used in that period ($\hat{w}_1^D(\mu_{E,1}^U)$). With a prohibition on NCA use, the market clearing wage may be greater than or less than $\hat{w}_1^D(\mu_{E,1}^U)$: this is because, in a cycle, employees anticipate greater wages in the next period conditional on remaining in the market, but also face the risk of forced exit. For the purposes of illustrating the differences in surplus, I remain agnostic on which of the two wages is greater, but assume that the market clearing wage with a prohibition on NCAs is bound by l[9]. This causes the market size when NCAs are prohibited to be $p\mu_R$, as in Section 2.5.1.

Let $\hat{S}_1$ represent social surplus, and $\hat{Q}_0$ and $\hat{Q}_1$ represent market size in even and odd periods of a 2-cycle, respectively. Then, utilizing the definitions of the components of social surplus defined above, the difference in social surplus is given by:

$$\begin{aligned} SDIFF_{cyc1} \equiv S^x - \hat{S}_1 &= (Q^x - \hat{Q}_1)P_{int} + \frac{\rho(Q^{x2} - \hat{Q}_1^2)}{2} \\ &+ ((1-s)Q^x m^p - (1-s)\hat{Q}_0 m^p) \\ &+ (p\mu_R\gamma_L + (\hat{Q}_1 - p\mu_R)\gamma_H - Q^x\gamma_L) + \Omega c + (\hat{Q}_1\Pi - Q^x\Pi) \\ &= (p\mu_R - \hat{Q}_1)P_{int} + \frac{\rho((p\mu_R)^2 - \hat{Q}_1^2}{2} + (1-s)m^p(p\mu_R - \hat{Q}_0) \\ &+ (\hat{Q}_1 - p\mu_R)\gamma_H + \Omega c + \Pi(\hat{Q}_1 - p\mu_R) \end{aligned}$$

Note that, since $\hat{Q}_0 < p\mu_R$, each of the difference components of $SDIFF_{cyc}$ are positive except for the difference in CS: this stands in contrast to when the economy is in a steady state with NCAs, in which case the benefit for firms which remain together is also greater without an NCA prohibition.

Comparative statics in odd periods of a 2-cycle are identical to that in steady state, with one exception: the model in a 2-cycle is highly sensitive to changes in s,

[9] In particular, $l > \Pi + \frac{c}{\delta} - \delta(1-s)m^w$.

and the response of social surplus depends in a complex fashion on model parameters. The results are summarized in the following proposition:

Proposition 2.5.2. *$SDIFF_{cyc1}$ is increasing in γ_H and Π, and decreasing in m^p and P_{int}.*

Even Periods ($A = 0$)

In even periods of a 2-cycle, NCAs are not used in market contracts and the market is relatively small. Intersection of labor supply and labor demand occurs where marginal cost is equal to γ_L, and l does not bind the market wage.

Let $\hat{S}_0$ represent social surplus. Then, the difference in social surplus is given by:

$$\begin{aligned} SDIFF_{cyc0} \equiv S^x - \hat{S}_0 &= (Q^x - \hat{Q}_0)P_{int} + \frac{\rho(Q^{x2} - \hat{Q}_0^2)}{2} \\ &+ ((1-s)Q^x m^p - (1-s)\hat{Q}_1 m^p) \\ &+ (\hat{Q}_0\gamma_L - Q^x\gamma_L) + \bar{\mu}c + (\hat{Q}_0\Pi - Q^x\Pi) \\ &= (p\mu_R - \hat{Q}_1)P_{int} + \frac{\rho((p\mu_R)^2 - \hat{Q}_0^2}{2} + (1-s)m^p(p\mu_R - \hat{Q}_1) \\ &+ (\hat{Q}_0 - p\mu_R)\gamma_L + \bar{\mu}c + \Pi(\hat{Q}_0 - p\mu_R) \end{aligned}$$

Comparative statics in even periods of a 2-cycle are identical to those in odd periods, resulting in the following proposition:

Proposition 2.5.3. *$SDIFF_{cyc0}$ is increasing in γ_H and Π, and decreasing in m^p and P_{int}.*

As the comparative statics on even and odd periods of a 2-cycle are identical, so are the comparative statics on the average of the two. This prediction is friendly to policymakers, as it suggests that, regardless of whethers labor markets are in a steady state or a cycle with NCAs, the same types of industries (those with high relative costs for marginal employers, large outside options for employees, low benefit to continued employment, and relatively low product demand) will benefit from policy intervention.

2.6 Conclusion

Policymakers have largely focused on fairness concerns associated with noncompete agreements for low-wage workers, and little is known about their effects on the labor market or their efficiency from a social perspective. In this paper, I construct a dynamic model of the labor market which addresses these questions and highlights the potential effects on social surplus.

When noncompete agreements are used purely to transfer surplus, they are not surplus maximizing for the firm whenever employees suffer a loss from being forced out of the labor market. In the model in this paper, this is true whenever there is a positive cost of entry into the labor market for employees. When noncompete agreements do not maximize social surplus, they are used when transferability constraints prevent equilibration of labor markets via the wage alone. This will occur when labor supply is high, as the market clearing wage with no noncompete agreement is low in that case, and more likely to be constrained.

Due to the bidirectional causality between NCA use and labor supply, NCAs may cause cyclical labor market behavior in which high NCA use is observed at a given point in time, followed by diminished labor supply and low use of NCAs. As labor supply replenishes, NCA use returns to a high level. Such cycles cause corresponding cycles in associated goods markets, which result in periods of decreased production and decreased consumer surplus.

While policies that prohibit NCA use may or may not be optimal, I highlight parameters that positively and negatively impact the social benefit of such a policy: all else equal, when the marginal cost of high-cost employers is large, the size of employees' outside options is great, the benefit realized by firms from continued employment is low, and goods demand is low, NCA prohibition is more likely to be optimal.

Future work may seek to assess other facets of NCA use, especially including the endogenous separation decision of employees. When workers are bound by NCAs, they may not separate from jobs in which their match quality is low. However, if continued employment induces a large benefit (due to accumulation of specific human capital, for example), decreased levels of separation may be beneficial. Empirically, future work may seek to test for whether NCAs are causing labor market cycles, as described in this paper. Time series data on industry- or occupation-specific NCA use may be required for such a test.

Chapter 3

Effortless Employee Retention: The Impact of Noncompete Agreements on Productivity

3.1 Introduction

In the literature pertaining to noncompete agreements (contractual agreements that limit employees from competing with an employing firm after separation), little attention has been paid to the effects such agreements have during an employee's tenure. Noncompete agreements may serve as a way to allocate ownership of a production asset: a client list, human capital, trade secrets, or the employee him- or herself. In this capacity, noncompete agreements act as a bulk purchase of specific rights that falls short of being a purchase of residual rights (in the sense used in Grossman and Hart (1986)). A bulk purchase of specific rights may distort investment in assets similarly to a purchase of residual rights. That distortion, especially as it pertains to the incentives for an employee to exert production-enhancing effort, is the topic of this paper.

Consider a service professional who may exert effort that enhances the future production value of a client list, possibly by encouraging continued patronage. The professional may exert effort for a variety of reasons: a wage contract contingent on effort or some correlated measure (Mirrlees, 1976; Holmström, 1979; Lazear, 2000), a relational contract (Baker et al., 2002; Levin, 2003), or the desire to leverage the valuable client list into increased wages or an entrepreneurial venture (Gibbons and Murphy, 1992; Holmström, 1999). If wage contracts are difficult or impossible to write due to commitment problems, unobservability, or noncontractibility (Gibbons, 1987; Baker, 1992; Baker et al., 1994) and relational contracts fail (perhaps due to underpowered punishments), effort may still be incentivized by the ability of an employee to spin off as an entrepreneur. However, if an employee spins off, the firm may not be able to capture any of the revenue associated with the spin off. A noncompete agreement allocates future value to the firm, but simultaneously diminishes the incentive for the employee to exert effort.

Although I do not explictly model the client interaction, I assume that the value created by effort exertion is employee-specific, as may be the case with a client list. This is especially salient in the case of physicians: effort exertion by a physician may increase the relationship-specific value of their client list. If the physician spins off to create her own practice, the clients may follow that physician. Physicians, furthermore, serve as a pertinent motivating example for this paper, as effort exertion among physicians has been discussed from a variety of angles. Much of the literature has focused on how payment schemes may avoid "those twin traps of overtreatment and therapeutic nihilism"[1] (Dranove, 1988; Ma and McGuire, 1997; McGuire, 2000). However, high effort need not imply overtreatment: for example, if effort is not intended to increase the amount charged for services, but rather associated with future profits due to client satisfaction and retention. Effort also may have positive externalities if payment mechanisms undervalue patient outcomes (Ellis and McGuire, 1986).

The issue of noncompete agreements for physicians has become a topic of conversation in the medical community: the American Medical Association has issued an opinion speaking out against noncompete agreements, also known as covenants-not-

[1]Modern Hippocratic Oath by Dr. Louis Lasagna, available at http://www.aapsonline.org/ethics/oaths.htm; accessed March 6, 2017.

to-compete: "Covenants-not-to-compete restrict competition, can disrupt continuity of care, and may limit access to care."[2] This recommendation follows the longstanding recommendation of the American Bar Association for lawyers not to enter into noncompete agreements: "A lawyer shall not participate in offering or making... [an] agreement that restricts the right of a lawyer to practice after termination..."[3] The justification for this prohibition is that it "...limits [lawyers'] professional autonomy [and] limits the freedom of clients to choose a lawyer."[4] For further discussion of physician noncompete agreements, see Lavetti et al. (2016).

In spite of the opinions of the aforementioned professional associations, little attention has been given in the economic literature to the effects of noncompete agreements on service occupations, and physicians in particular. The inattention is not due to a lack of use of noncompete agreements: while the estimates vary (19% of physicians in a nationally representative survey of workers in all occupations (Bishara and Starr, 2016) and 45% in a survey of primary care physicians (Lavetti et al., 2016)), a significant portion of physicians work under a noncompete agreement.

In this paper, the relationship-specificity of the value of production creates a bilateral monopoly between employer and employee: if the employee quits, the asset's productive value is lost to the firm. However, the employee may not use the asset to spin off a new firm if she has a noncompete agreement. This bilateral monopoly introduces incentives for the employee to exert effort even in the presence of a noncompete agreement. The optimal effort level, though, is generally lower than that

[2] American Medical Association Opinion E 9.02. Available at https://www.ama-assn.org/sites/default/files/media-browser/public/hod/i14-ceja-reports_0.pdf; accessed March 5, 2017.

[3] American Bar Association Rule 5.6. Available at http://www.americanbar.org/groups/professional_responsibility/publications/model_rules_of_professional_conduct/rule_5_6_restrictions_on_rights_to_practice.html; accessed March 5, 2017.

[4] American Bar Association Comment on Rule 5.6. Available at http://www.americanbar.org/groups/professional_responsibility/publications/model_rules_of_professional_conduct/rule_5_6_restrictions_on_rights_to_practice/comment_on_rule_5_6.html; accessed March 5, 2017.

when the employee may spin off or threaten to spin off, as she is only able to appropriate a portion of the rents generated from effort exertion. Without a noncompete agreement, effort may move closer to the first best but may also exceed first best effort levels. Even if the agent does not intend to spin off, she may exert effort in an attempt to increase her bargained wage, which is a function of both incumbent profits and potential spin off profits. These skewed incentives may counterintuitively create an environment in which noncompete agreements are optimal when the value of a spin off is low (i.e., when spin off is an empty threat) even if they are suboptimal otherwise. I also show that effort is never first best when the firm uses a noncompete agreement, but may be first best (or close) when the value of a spin off is high, or the marginal contribution of effort to profit is close for the incumbent firm and a spin off.

If the value of a spin off is unknown when effort is exerted, noncompete agreements which are optimal ex ante may inefficiently lock agents in ex post if the spin off ultimately has high value. Taking as given whether or not a contract includes a noncompete agreement and assuming that an employee would choose to spin off if able, the ex post efficiency difference under a contract with a noncompete agreement versus without is greater in a decentralized equilibrium versus under the first best: since the agent's effort exertion suffers with a noncompete agreement compared with first best effort, there is an additional efficiency loss from using a noncompete agreement.

The two papers most closely related to this one are Motta and Roende (2002) (MR) and Kräkel and Sliwka (2009) (KS). In both of those papers, effort increases the probability of valuable innovation. Both papers show that noncompete agreements eliminate a principal's ability to commit to increasing an agent's wage following an innovation, which decreases the agent's incentives to exert effort in the first place. The deviation of this paper is the nature of the asset and the ramifications thereof.

While MR and KS assume that effort increases the probability of an innovation which is a general asset (i.e., an asset which may be used by the incumbent firm with or without the employee or by any new firm), I assume that the value of production is specific to the employee. This partially alleviates the commitment problem suggested under noncompete agreements in MR and KS, since the agent will appropriate some portion of production via bargaining in the bilateral monopoly created.

Other related papers in the noncompete agreement literature include Lavetti et al. (2016), in which the ability of principals to lease a client list to agents, instead of selling it, causes noncompete agreements to result in optimal allocation of clients within firms. That paper considers effort exertion, but does not consider effort exertion which increases the value of production, over which an employee can bargain at a later time period. Two papers which model the decision of whether or not to include a noncompete agreement in a contract are Rauch and Watson (2015) and Chapter 1: the former models the decision of a firm to include a noncompete agreement to protect the value of client relationships, but does not model the effort decision of employees. The latter considers low-wage labor markets and shows that noncompete agreements which do not maximize a firm's surplus may be used when the firm faces wage constraints.

Finally, in the incomplete contracting literature, many papers have considered the value of noncontractible investments, including Hart and Moore (1988), Aghion and Tirole (1994), Nöldeke and Schmidt (1995), Tirole (1999), and Che and Hausch (1999). This paper contributes to that literature by applying the theory of noncontractible investment directly to effort decisions under a particular type of ownership structure: the noncompete agreement, which, in this context, allocates ownership of a client list to the principal. Furthermore, the necessity of retaining the agent for production, assumed in this paper, departs from the classical research and development framework in which the innovation may be used by the principal alone. This departure highlights the role of noncompete agreements, which provide protection for assets specific to the agent.

In Section 3.2, I introduce the model. In Section 3.3, I derive, from the perspective of a social-surplus-maximizing planner, the first best effort and spin off decisions of an agent given contract type (with a noncompete agreement or without), and consider the first best contracting decision of the firm. In Section 3.4, I analyze the decentralized equilibrium of the model given contract type, including a comparison of effort levels, and analyze the problem of the firm by endogenizing contract type. Section 3.5 compares first best effort levels to those chosen in the decentralized equilibrium. Section 3.6 extends the model by including uncertainty in the value of an agent's spin off, and Section 3.7 concludes.

3.2 Model

The model has two actors: a principal (P) and an agent (A). There are two time periods indexed by t, and two decisions in the model: at $t = 1$, A decides on an effort level, $e \in [0, \infty)$. A's effort, known only to A, determines the value of production at $t = 2$ and may therefore be interpreted as investment in a crucial production asset.

At $t = 2$, A decides whether to remain with her current firm ($D = 0$), spin off to create a new firm ($D = 1$), or become unemployed ($D = 2$). If A has a noncompete ($NCA = 1$), A is not allowed to spin off. This decision occurs after A's second period wage, $w_2(NCA, e)$, has been negotiated, but prior to production (since production depends on whether A stays or spins off).

Payoffs consist of production, wages (paid from P to A in each period), and effort cost. P receives the value of production at $t = 1$: π_1. At $t = 2$, if $D = 0$, P receives the value of production, $\pi_2(e)$. If $D = 1$, A receives the value of spin off production,

$V(e)$, and P receives π_n, the value of production without A. If $D = 2$, A receives her outside option, V_A, and P receives π_n.

The firm's contract in $t = 1$, $\{w_1, NCA\}$, is initially considered to be exogenous, where w_1^F represents the $t = 1$ wage when A is free to spin off ($NCA = 0$) and w_1^N represents the $t = 1$ wage when A may not compete ($NCA = 1$). In Sections 3.3.2 and 3.4.4, I consider endogenous contract choice in the planner's problem and the decentralized equilibrium, respectively. The second period wage, $w_2(NCA, e)$, is determined endogenously via Nash bargaining, where P's outside option is π_n and A's outside option is the greater of $V(e)$ and V_A when $NCA = 0$, and is V_A when $NCA = 1$. P's (exogenous) Nash bargaining coefficient is $\alpha \in [0, 1]$ and A's is $1 - \alpha$. This form of wage determination represents the bilateral monopoly induced by the specificity of production: a given value of e induces different levels of production at the incumbent firm versus a spin off firm, and additionally, if A leaves the firm, P receives a lower value of production unrelated to e.

The cost of effort, borne by A at $t = 1$, is given by $c(e)$. P and A discount at common rate δ.

For the purposes of highlighting the interaction between A remaining with her current firm versus spinning off, I assume that V_A is low and thus, $D = 2$ is never optimal. V_A therefore simply represents A's outside option in Nash bargaining when $NCA = 1$, and I omit payoffs when $D = 2$ from the payoff function.

Payoffs may be written as:

$$\begin{aligned}
Z_A(w_1, NCA, e, D) =& w_1 - c(e) + \delta(\mathbb{1}(D = 0 \text{ or } NCA = 1) w_2(NCA, e) \\
& + \mathbb{1}(D = 1 \text{ and } NCA = 0) V(e)) \\
Z_P(w_1, NCA, e, D) =& \pi_1 - w_1 + \delta(\mathbb{1}(D = 0 \text{ or } NCA = 1)(\pi_2(e) - w_2(NCA, e)) \\
& + \mathbb{1}(D = 1 \text{ and } NCA = 0)\pi_n)
\end{aligned}$$

I assume that production, effort and the spin off decision are noncontractible. While e may technically be calculated from $\pi_2(e)$ or $V(e)$ if those functions are invertible, inclusion of a white noise term along with risk aversion on the part of A renders contracts based on production subject to moral hazard (Holmström, 1979). For the purpose of highlighting the effort decision as it is motivated by wage at the current firm or spin off profits, I omit these considerations and simply assume that actors may not write forward compensation contracts on future production. Forward compensation contracts are also subject to a commitment problem: once effort is sunk, P may renege on the contract if it is profitable.

Furthermore, I assume that $c'(e) > 0$, $V'(e) > 0$, and $\pi_2'(e) > 0$: effort is costly but it increases production values. I also assume that $V(e) > V_A \; \forall e$: at worst, a spin off is more valuable than A's outside option (which may be, for example, in a different field than A's area of expertise). Similarly, I assume that $\pi_2(e) > V_A + \pi_n \; \forall e$: a firm's production is greater than the sum of its members' outside options. These assumptions ensure that $D = 2$ is never chosen in equilibrium, as mentioned above. I assume that all functions are twice continuously differentiable.

Finally, I assume that contracts are ex-post nonrenegotiable. While A may be able to buy out of a noncompete agreement, such a process is likely wrought with frictions: for example, informational asymmetries (if, for example, A may observe the value of her investment and P may not), constraints on available funds (such as an inability to borrow), the cost of the time spent renegotiating (which may deplete the value of the effort exertion if production does not occur during that time), or legal fees associated with writing a new contract[5]. See Rauch and Watson (2015) for more

[5] Additionally, buyout may not change the qualitative predictions of the model, but may simply reduce their magnitude: if A were to be able to buyout of a noncompete contract, the bilateral monopoly would still exist due to the noncompete agreement. Incumbent firm productivity would enter into the bargaining problem only if bargaining breakdown is assumed to result in A returning to the incumbent firm. If bargaining breakdown is assumed to result in each actor receiving her outside option (as may be the case if the ill will created through failed bargaining causes a breakdown

discussion of liquidity constraints and ex post noncompete agreement renegotiation.

In Sections 3.3, 3.4, and 3.5, equilibrium is given as follows: when initial contracts are taken as exogenous (i.e., $\{w_1, NCA\}$ is given), an equilibrium is given by $\{e, D\}$ such that $\{e, D\}$ maximizes $Z_A(w_1, NCA, e, D)$. When initial contracts are endogenous, an equilibrium is $\{w_1, NCA, e, D\}$, where $\{e, D\}$ maximizes $Z_A(w_1, NCA, e, D)$ and the initial contract, $\{w_1,\ NCA\}$, is Pareto optimal given e and D: i.e., there does not exist another contract $\{w', NCA'\}$ such that

$$Z_A(w', NCA', e, D) \geq Z_A(w_1, NCA, e, D)$$

and

$$Z_P(w', NCA', e, D) \geq Z_P(w_1, NCA, e, D),$$

with one inequality holding strictly. Note that $w_2(NCA, e)$ is the result of a noncooperative bargaining game; however, I omit it from the definition of equilibrium. In the planner's problem, it is simply a transfer between P and A and does not affect total surplus. In the decentralized problem, it is simply given by the solution to the Nash bargaining problem. Further discussion is provided in the relevant sections.

In Section 3.6, D may be a function of the idiosyncratic shock to spin off value, ε (which is described in detail in Section 3.6). Furthermore, given the uncertainty in the model, e must maximize $E[Z_A(w_1, NCA, e, D)]$, and $\{w_1, NCA\}$ must be Pareto optimal over $E[Z_A(w_1, NCA, e,\ D(\varepsilon))]$ and $E[Z_P(w_1, NCA, e, D(\varepsilon))]$.

First, I consider the problem from the perspective of a social planner whose goal is to maximize the sum of agents' utilities. Then, I consider the decentralized problem and compare the outcome with that of the planner's problem.

in P and A's relationship), the incumbent firm's productivity would not enter into the bargained buyout.

3.3 Planner's Problem

Consider a social planner whose goal is to maximize the objective function

$$Z_A(w_1, NCA, e, D) + Z_P(w_1, NCA, e, D).$$

I first consider the optimal action of the planner taking the firm's initial contract as given and simply selecting $\{e, D\}$, and then consider the optimal action of the planner allowing the planner to also choose the contract of the firm, i.e., when the planner may choose $\{w_1, NCA, e, D\}$.

3.3.1 Exogenous Contracts

When the initial contract of a firm, $\{w_1, NCA\}$, is taken as exogenous by the planner, the planner simply chooses e and D in order to maximize the firm's joint surplus. When $NCA = 0$, this problem quickly simplifies to:

$$\max_{e,D} \pi_1 - c(e) + \delta\left[\mathbb{1}(D = 0)\pi_2(e) + \mathbb{1}(D = 1)(V(e) + \pi_n)\right] \tag{3.1}$$

Since wages are simply transfers between agents, both w_1 (which is given exogenously) and w_2 drop out of the planner's problem: in particular, even taken as a choice variable, any value of w_2 may be part of any solution to the planner's problem.

The solution to Problem 3.1, the first best values of e and D, may be found by maximizing over e for each possible value of D, and then taking the overall maximum over values of D. Assume that second order conditions are satisfied locally. Then, for $D = 0$, the optimal effort level is $\bar{e}_0^F$, which solves $c'(\bar{e}_0^F) = \delta\pi_2'(\bar{e}_0^F)$. For $D = 1$, the optimal effort level is $\bar{e}_1^F$, which solves $c'(\bar{e}_1^F) = \delta V'(\bar{e}_1^F)$.

The planner selects D^F, the first best spin off decision, by comparing:

$$D = 0: \ -c(\bar{e}_0^F) + \delta(\pi_2(\bar{e}_0^F))$$
$$D = 1: \ -c(\bar{e}_1^F) + \delta(V(\bar{e}_1^F) + \pi_n)$$

When $NCA = 1$, the planner maximizes:

$$\max_{e,D} \pi_1 - c(e) + \delta\pi_2(e) \tag{3.2}$$

The optimal value of e is $\bar{e}^N$ which solves $c'(\bar{e}^N) = \delta\pi_2'(\bar{e}^N)$. The planner selects $D^N = 0$ by default, since $D^N = 1$ is not available.

3.3.2 Endogenous Contracts

Given the planner's choices of e and D, it is immediate to extend the planner's problem to the choice of the firm's initial contract:

Proposition 3.3.1. *For a social planner, an initial contract with $NCA = 0$ always weakly dominates an initial contract with $NCA = 1$.*

3.4 Decentralized Equilibrium with Exogenous Contracts

I begin by analyzing the decentralized equilibrium when first period contracts are given exogenously. While this analysis is primarily performed to highlight the role of noncompete agreements in limiting implicit effort incentives, it may be the case that noncompete agreements are written into contracts for reasons which are orthogonal to the model at hand. For example, noncompete agreements may promote general human capital investment. While human capital investment certainly may affect firm production, the mechanism by which noncompete agreements eliminate incentives created by future spin off opportunities will remain. Furthermore, once the noncompete agreement portion of a contract is decided, firms may act as price takers in wage determinations, causing wages to be exogenous to firms' internal decisions.

3.4.1 The Model with $NCA = 0$

Without a noncompete agreement, A's ability to spin off affects payoffs at $t = 2$ directly if A ultimately chooses $D = 1$, or indirectly by changing the Nash bargaining outside option of A. This direct effect changes A's incentives at $t = 1$, since the marginal benefit of additional effort exertion now includes the increase in spin off production.

I solve the model backwards, beginning with $t = 2$. A will select $D = 0$ if $w_2(0, e) > V(e)$ and otherwise select $D = 1$. Given e, the Nash bargaining problem is:

$$w_2(0, e) = \max_w (\pi_2(e) - w - \pi_n)^\alpha (w - V(e))^{1-\alpha}$$

The solution is $w_2(0, e) = (1 - \alpha)(\pi_2(e) - \pi_n) + \alpha V(e)$. Bargaining breaks down whenever $\pi_2(e) - \pi_n < V(e)$ (the total value of agents' outside options is greater than the value of a successful bargaining process), which is exactly equivalent to $w_2(0, e) < V(e)$. Therefore, bargaining succeeds and $D = 0$ whenever $\pi_2(e) - \pi_n > V(e)$. Bargaining fails and $D = 1$ otherwise.

Moving to $t = 1$, choice of e affects the extensive margin of whether to spin off or remain, as well as the intensive margins of $V(e)$ and $w_2(0, e)$. A selects e to maximize her discounted payoff:

$$e^* = \arg\max_e w_1^F - c(e) + \delta \max\{V(e), (1 - \alpha)(\pi_2(e) + \varepsilon - \pi_n) + \alpha(V(e))\}$$

I rewrite the problem by separately considering values of e for which $V(e) < w_2(0, e)$ and $V(e) > w_2(0, e)$, and then taking the greater of the two. Assuming the former, optimal effort, e_0^*, is given by the solution to

$$\delta((1-\alpha)\pi_2'(e_0^*) + \alpha V'(e_0^*)) = c'(e_0^*) \tag{3.3}$$

whenever the second order condition, $\delta((1-\alpha)\pi_2''(e_0^*)+\alpha V''(e_0^*)) < c''(e_0^*)$, is satisfied[6].

Assuming that $V(e) + \varepsilon > w_2(0, e)$, optimal effort, e_1^*, is given by the solution to

$$\delta V'(e_1^*) = c'(e_1^*) \tag{3.4}$$

whenever the second order condition, $\delta V''(e_1^*) < c''(e_1^*)$, is satisfied.

The equilibrium is:

$$\{e^*, D^*\} = \begin{cases} \{e_0^*, 0\} \text{ if } V(e_1^*) < \pi_2(e_0^*) - \pi_n \\ \{e_1^*, 1\} \text{ otherwise} \end{cases}$$

3.4.2 The Model with $NCA = 1$

When $NCA = 1$, A will always, by assumption, choose $D = 0$. The relevant Nash bargaining problem is given by

$$w_2(1, e) = \max_w (\pi_2(e) - w - \pi_n)^\alpha (w - V_A)^{1-\alpha}$$

The solution is $w_2(1, e) = (1-\alpha)(\pi_2(e) - \pi_n) + \alpha V_A$.

At $t = 1$, A chooses e by solving

$$\max_e w_1^N - c(e) + \delta w_2(1, e) \tag{3.5}$$

The optimal value, e^{**}, is given by the solution to $\delta(1-\alpha)\pi_2'(e^{**}) = c'(e^{**})$ whenever the second order condition, $\delta(1-\alpha)\pi_2''(e^{**}) < c''(e^{**})$, is satisfied. The equilib-

[6] Of course, there may be a multiplicity of solutions to this and subsequent maximizations. In the following section, I impose assumptions that guarantee a unique solution to each maximization problem.

rium, then, is $\{e^{**}, 0\}$.

3.4.3 Comparison of e^* and e^{**}

Without further assumptions, it is difficult to compare e^* and e^{**}. The following assumption simplifies the analysis greatly, allowing for straightforward comparative statics:

Assumption 7. *The solutions to Problems 3.3, 3.4, and 3.5 exist and are unique.*

One sufficient condition for uniqueness is that $c''(e) > 0$, $\pi_2''(e) < 0$, and $V''(e) < 0$ $\forall e$: i.e., that effort cost is globally convex and production values are globally concave.

When Assumption 7 is satisfied, whether A selects $D = 0$ or $D = 1$ under $NCA = 0$ becomes critically important. When $D^* = 0$, the effect of NCAs on effort is unambiguous. Since A's incentive to exert effort in order to increase her bargained wage by increasing $\pi_2(e)$ exists with or without an NCA, the added incentive from increasing her bargained wage by increasing $V(e)$ (his effective outside option) causes effort levels to be greater under $NCA = 0$.

Proposition 3.4.1. *Under Assumption 7, when A remains at her firm, effort is greater with no NCA than with an NCA.*

When $D^* = 1$, a comparison of effort levels with $NCA = 0$ versus $NCA = 1$ depends on the marginal contribution of effort to $V(e)$ versus $\pi_2(e)$. In particular, if A must remain with her firm because $NCA = 1$, her marginal benefit of effort is her bargained portion of the increase in $\pi_2(e)$. If $NCA = 0$, her marginal benefit of effort is the marginal benefit of effort to spinning off.

Proposition 3.4.2. *Under Assumption 7, when A spins off, effort is greater with no NCA than with an NCA if $V'(e) > (1 - \alpha)\pi_2'(e)$.*

Due to the bilateral monopoly induced by differential values of production, when A does not spin off, effort is unambiguously greater with no noncompete agreement, even though the incentive provided by spinning off is mediated by wage bargaining. When A does spin off, the difference in effort is dependent on the difference in the marginal benefits to production for the incumbent firm versus a spin off firm.

3.4.4 Decentralized Equilibrium Analysis with Endogenous Contracts

In this section, I analyze the contracting decision of the firm. With no contracting frictions, choice of NCA will maximize the surplus of the firm, subject to A's effort and spin off decisions: correctly anticipating e and D, firms will select $NCA = 1$ if the net benefit of the NCA is positive.

Proposition 3.4.3. *If A does not spin off, contracts with NCAs uniquely maximize surplus if and only if $\delta(\pi_2(e^{**}) - V(e_1^*) - \pi_n) > c(e^{**}) - c(e_1^*)$. If A spins off, contracts with NCAs uniquely maximize surplus if and only if $\delta(\pi_2(e^{**}) - \pi_2(e_0^*)) > c(e^{**}) - c(e_0^*)$.*

3.5 Planner's Problem versus Decentralized Equilibrium

In addition to comparing effort levels across contract types, effort levels in the decentralized problem may be compared to the first best levels achieved in the planner's problem given contract type. Effort may vary for two reasons: first, if A and P remain partnered, A's marginal benefit of effort is not identical to the marginal social benefit of effort. Second, the choice of D is based on different objective functions in the two different problems. Anticipated choice of D affects choice of e by changing A's marginal benefit of effort.

On the intensive margin, effort level in the decentralized equilibrium meets the first best established by the planner's problem when $NCA = 0$ and $D^F = D^* = 1$ (i.e., $\bar{e}_1^F = e_1^*$). This is because the marginal social and marginal private benefits of effort are both $V'(e)$ when A creates a spin off.

When $NCA = 0$ and $D^F = D^* = 0$, the marginal social benefit of effort is the marginal contribution of effort to $\pi_2(e)$. The marginal private benefit to A is the marginal contribution of effort to the Nash bargained wage, which contains a convex combination of $\pi_2(e)$ and $V(e)$. Compare this with the effort levels when $NCA = 1$. The planner's problem is unchanged. However, there is no contribution to marginal private benefit from $V(e)$, since A does not have the option to spin off. This implicit incentive, which in some cases may allow decentralized effort decisions to be closer to first best, is eliminated when $NCA = 1$.

Proposition 3.5.1. *Assume that A does not spin off in the decentralized equilibrium or the planner's problem. Then, $e^{**} < e^* < \bar{e}_0^F = \bar{e}^N$ if $V'(\bar{e}_0^F) < \pi_2'(\bar{e}_0^F)$, and $e^{**} < \bar{e}_0^F = \bar{e}^N < e^*$ if $V'(\bar{e}_0^F) > \pi_2'(\bar{e}_0^F)$.*

In the case that $V'(\bar{e}_0^F) > \pi_2'(\bar{e}_0^F)$, effort may be quite close to the effort chosen in the planner's problem if $V'(\bar{e}_0^F) - \pi_2'(\bar{e}_0^F)$ is not large, though a precise comparison depends on the exact functions.

At the extensive margin, the marginal parameter values at which the planner would change from $D^F = 0$ to $D^F = 1$ are different than the analagous marginal parameter values when A determines D: not only are effort levels different (as described above), there is also a wedge introduced because, to A at $t = 2$, the cost of effort is sunk, whereas the planner optimizes over e and D jointly. Even if $\bar{e}_0^F = e_0^*$ and $\bar{e}_1^F = e_1^*$, if parameter values were such that A ended up indifferent between $D = 0$ and $D = 1$ at $t = 2$, the planner would have chosen $D = 1$ if $\bar{e}_0^F > \bar{e}_1^F$, and $D = 0$ otherwise, since the planner would simply select the value of D that induces the lowest cost of effort[7].

The more interesting comparison at the extensive margin is of the difference between the decentralized problem and the planner's problem for $NCA = 0$ versus $NCA = 1$, as summarized in the following proposition:

Proposition 3.5.2. *When $NCA = 1$, effort in a decentralized equilibrium is never first best. When $NCA = 0$, effort in a decentralized equilibrium is first best whenever*

[7]The condition that $e_0^P > e_1^P$ is satisfied, roughly speaking, whenever the marginal benefit of effort to π_2 is greater than the marginal benefit of effort to V.

A spins off in the decentralized equilibrium and the planner's problem, or when the marginal contribution of effort to incumbent and spinoff production is equal.

The three possible conditions state that the marginal benefit of effort must be equivalent: either the planner and A both seek to maximize $V(e) - c(e)$ (as in Condition 1), or the marginal benefits of effort for the incumbent firm and the spin off are equal, in which case the marginal increase of the bargained wage due to effort is identical to the marginal increases in productivity (as in Conditions 2 and 3). While Conditions 2 and 3 are unlikely to hold exactly, if $\pi_2'(e)$ and $V'(e)$ are close for all e, e^* will be close to the first best level. Additionally, if the value of a spin off is high, effort will be first best with no noncompete agreement. The same is not true when the firm has a noncompete agreement.

3.6 Idiosyncratic Shocks to Productivity

Prior to this section, I have assumed that $V(e)$ is nonstochastic. This assumption is reasonable if markets are relatively stable and effort is a strong indicator of future value. All previous analysis does not change if a common shock additively affects $\pi_2(e)$ and $V(e)$: in this case, the shock is meant to model a market-level productivity shock or a shock to the productivity of the relationship between A and her clients. However, an alternative assumption is that $V(e)$ is subject to an idiosyncratic shock (or the shocks affecting the two production functions are idiosyncratic). To this end, for the remainder of this section, I assume that $V(e)$ is subject to an idiosyncratic spin off shock, ε[8]. The shock is distributed according to distribution G (i.e., $\varepsilon \sim G(\varepsilon)$).

[8]The model prior to this point could have contained a common shock, ε_c, which is realized at $t = 2$ and added to $V(e)$ and $\pi_2(e)$. Since the common shock does not affect decisions, it has no effect on the analysis and is therefore omitted. It may, however, serve as a justification for the noncontractibility of effort: P may deduce effort from nonstochastic production if $\pi_2(e)$ or $V(e)$ is invertible, but may not do so when production is stochastic, leading to an inability to use severe punishments for deviations from optimal effort. If one were to use the common shock above and maintain it in this section, addition of the idiosyncratic shock to $V(e)$, ε, would result in the same analysis as is presented here.

I assume that $G(\varepsilon)$ is continuously differentiable. Denote the associated probability density function by $g(\varepsilon)$. Finally, I use the normalization $E_G[\varepsilon] = 0$.

The goal of this section is to highlight the lock-in effect of NCAs: while NCAs may maximize a firm's surplus ex ante, they may be ex post inefficient if the idiosyncratic shock to spin off productivity is large. I also highlight the effect of effort on the extensive margin, which is incalculable ex ante, in contrast with Sections 3.3 and 3.4.

3.6.1 Planner's Problem

The major difference in the analysis of the stochastic model is that A can not calculate the optimal level of D prior to realization of the shocks. Therefore, her choice of e must be based on the expectation of future actions. I assume this to be true for the planner, as well: while the planner may write contingency plans based on the level of the shock, $D(\varepsilon)$, she must select e prior to realization of the shocks.

Therefore, when $NCA = 0$, the planner's problem is:

$$\bar{e}^F = \arg\max_e \pi_1 - c(e) + \delta E\left[\mathbb{1}(D^F(\varepsilon) = 1)(V(e) + \varepsilon + \pi_n) + \mathbb{1}(D^F(\varepsilon) = 0)(\pi_2(e))\right] \tag{3.6}$$

where $D^F(\varepsilon)$ maximizes $t = 2$ joint utility. In particular, $D^F(\varepsilon) = 1$ whenever $\varepsilon > \pi_2(e) - V(e) - \pi_n$. The following assumption regarding the right hand side of that expression simplifies matters significantly:

Assumption 8. *Let $B(e) \equiv \pi_2(e) - V(e) - \pi_n$. $B(e)$ is strictly monotonic on its domain (either $B'(e) > 0$ or $B'(e) < 0$).*

Assumption 8 simply requires that effort either increase or decrease the value of a spin off *relative* to the value of incumbent firm production. Under Assumption 8, the ex ante probability that $D^F(\varepsilon) = 1$ is equal to $1 - G(B(e))$. Proceeding under

Assumption 8 and substituting $D^F(\varepsilon)$, Problem 3.6 reduces to:

$$\bar{e}^F = \arg\max_e \pi_1 - c(e) + \delta\left[(1 - G(B(e)))(V(e) + \mu^H(e) + \pi_n) + G(B(e))\pi_2(e)\right]$$

where $\mu^H(e) = E[\varepsilon|\varepsilon > B(e)]$.

Therefore, $\bar{e}^F$ solves:

$$\begin{aligned} c'(\bar{e}^F) = \delta \Big[&(1 - G(B(\bar{e}^F)))(V'(\bar{e}^F) + \mu^{H'}(\bar{e}^F)) + G(B(\bar{e}^F))\pi_2'(\bar{e}^F) \\ &- G(B(\bar{e}^F))B'(\bar{e}^F)(V(\bar{e}^F) - \pi_2(\bar{e}^F) + \mu^H(\bar{e}^F) + \pi_n)\Big]. \end{aligned}$$

The terms on the first line of the right hand side represent the increase in production, as well as the change in the conditional expectation of ε, given an increase in e. The second line reflects the change in the probability that $D^F = 0$ versus 1. Substituting the values of $B(e)$ and $\mu^{H\prime}$ (given by $\mu^{H\prime}(e) = \frac{B'(e)G(B(e))(\mu^H(e)-B(e))}{1-G(B(e))}$) yields a reduced definition of $\bar{e}^F$:

$$c'(\bar{e}^F) = \delta\left[(1 - G(B(\bar{e}^F)))V'(\bar{e}^F) + G(B(\bar{e}^F))\pi_2'(\bar{e}^F)\right]$$

When $NCA = 1$, the problem is nearly identical to that given when $NCA = 1$ in Section 3.3.1, and $\bar{e}^N$ solves $c'(\bar{e}^N) = \delta\pi_2'(\bar{e}^N)$.

3.6.2 Decentralized Equilibrium and Contract Choice

In a decentralized equilibrium, the effort choice of A reflects uncertainty over the optimal choice of D, similar to the planner's problem. Mirroring the analysis in Section 3.4, the incentive for A to exert effort is diminished when $NCA = 1$ versus when $NCA = 0$ due to the inability to spin off and the inability to leverage the threat of spinning off.

When $NCA = 0$, the second period bargaining problem results in $w_2^*(e) = (1 - \alpha)(\pi_2(e) - \pi_n) + \alpha(V(e) + \varepsilon)$. A selects $D^* = 1$ whenever $V(e) + \varepsilon > w_2^*(e)$, which reduces to $\varepsilon > B(e)$. Given e, A's choice of D matches the planner's choice.

Equilibrium effort solves:

$$c'(e^*) = \delta E\left[g(B(e))B'(e)(w_2^*(e) - V(e) - \mu^H(e) - \pi_n) + V'(e)\right.$$
$$\left.+G(B(e))((1-\alpha)(\pi_2'(e) - V'(e)) + \mu^{H\prime}(e)\right]$$

Define $\mu^L(e) = E[\varepsilon|\varepsilon < B(e)]$. The derivative of $\mu^L(e)$ is given by

$$\mu^{L\prime}(e) = \frac{B'(e)G(B(e))(B(e) - \mu^L(e))}{G(B(e))}$$

Substituting for $w_2^*(e)$, $B(e)$, $\mu^{H\prime}(e)$, and subsequently, $\mu^{L\prime}(e)$, the equation defining e^* reduces to:

$$c'(e^*) = G(B(e^*))((1-\alpha)\pi_2'(e^*) + \alpha V'(e^*)) + (1 - G(B(e^*)))V'(e^*)$$

When $NCA = 1$, equilibrium effort solves $c'(e^{**}) = \delta(1-\alpha)\pi_2'(e^**)$ and $D^{**} = 0$ (by default).

Comparison of effort levels under the two contract types in both the planner's problem and the decentralized equilibrium hinges in large part on $B'(e)$: when the marginal increase in spin off production is greater than the marginal increase in incumbent production (i.e., $B'(e) < 0$), the contract with $NCA = 0$ yields greater effort in both the planner's problem and the decentralized equilibrium than the contract with $NCA = 1$. Additionally, effort exertion under $NCA = 0$ is greater in the decentralized equilibrium than the planner's problem and lower when $NCA = 1$:

Proposition 3.6.1. *If $B'(e) < 0$, then A overexerts effort with no NCA and underexerts effort with an NCA, relative to the planner's problem.*

In other words, as long as the marginal contribution of effort to spin off production is greater than the marginal contribution of effort to incumbent production, effort is greater than first best with no noncompete agreement, and lower than first best with a noncompete agreement.

3.6.3 Ex Post Efficiency

Another way to compare contracts with $NCA = 0$ to contracts with $NCA = 1$ is to compare ex post surplus–i.e., the joint surplus generated conditional on knowledge of the shock. When production is nonstochastic, simply assuming that production occurs (either at the incumbent firm or at a spin off firm) is enough to ensure that ex ante surplus maximization implies ex post surplus maximization. However, with idiosyncratic shocks, A may become locked in by an NCA, causing the efficient decision under a large realization of ε (which is for A to spin off) to be unavailable.

In the planner's problem, the ex post efficiency loss of $NCA = 1$ versus $NCA = 0$ is due primarily to the loss of option value: the lock-in of a contract with an NCA. In the decentralized equilibrium, there is a secondary loss due to the wedge between marginal cost and marginal benefit of effort driven by the more P friendly nature of the bilateral monopoly at $t = 2$ caused by the NCA. Furthermore, effort incentives under $NCA = 0$ in the decentralized equilibrium include the value of spin off profit in the bargained wage, bringing e^* closer to the effort level that would be optimal if $D = 1$ was known at $t = 1$.

Therefore, when comparing surplus ex post under values of ε such that $D = 1$ if $NCA = 0$ in the planner's problem and the decentralized equilibrium, the difference in ex post surplus for contracts with $NCA = 0$ versus $NCA = 1$ is always greater in the decentralized equilibrium than it is in the planner's problem. This is true even when $NCA = 1$ is ex ante surplus maximizing in the decentralized equilibrium.

Proposition 3.6.2. *The surplus loss from the contract $NCA = 1$ versus $NCA = 0$ is greater under the decentralized equilibrium than the planner's problem.*

This proposition highlights the lock-in effect of noncompete agreements: the ex post efficiency loss may be extremely high if ε is able to take high values which are relatively unlikely. This loss would be mitigated if A were able to buy out of her noncompete agreement with no additional costs (such as bargaining costs, borrowing costs, or legal fees).

3.7 Conclusion

In this paper, I have investigated the effects of noncompete agreements on the effort of employees who may entrepreneurially spin off to create their own firms. Noncompete agreements diminish the implicit incentives for employees to exert effort due to their inability to start their own firms. In a decentralized equilibrium, effort may be close to or equal to the first best when employees do not have noncompete agreements, but is always strictly less than the first best when they do. Noncompete agreements may also cause an ex post inefficiency due to lock-in (the inability to spin off a more productive firm). This inefficiency is larger when decisions are decentralized, compared with the first best.

Noncompete agreements may arise for a variety of reasons. If the mechanisms described in this paper exhaustively describe the costs and benefits of noncompete agreements, there is no need for policymakers to intervene by encouraging or discouraging use of noncompete agreements: in the absence of contracting frictions or externalities, any efficient decision made by private actors will be socially efficient. However, if noncompete agreements arise for reasons external to this model, the effort and spin off decisions made by private agents may not be socially efficient. In either case, use of noncompete agreements may cause large efficiency losses ex post if spin off value turns out to be quite large but agents are prohibited from spinning off. This loss is exacerbated by the inefficient effort exertion when agents recoup only a portion of the value of production. Furthermore, if there are positive externalities associated with agents' effort levels, encouraging greater effort is achievable by prohibiting use of noncompete agreements.

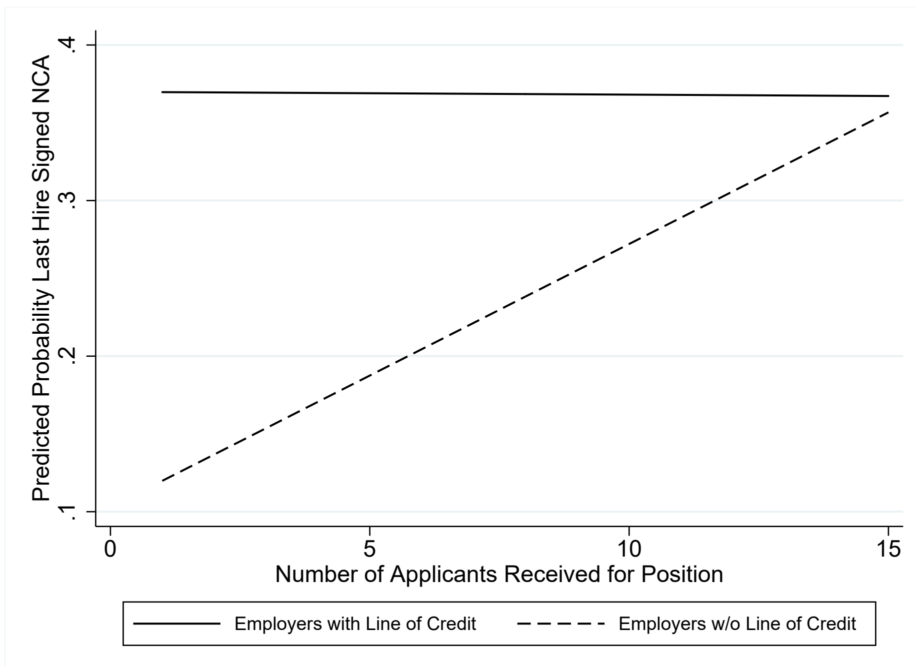
Future work may seek to incorporate models of effort exertion with other models describing the costs and benefits of noncompete agreements. Empirical analysis of the mechanism described in this paper requires a method for assessing effort, which may be possible in some industries or occupations. Finally, further work describing when noncompete agreements are socially efficient or inefficient, compared with when they are used in practice, could go far in informing policy debates surrounding noncompete agreements.

Appendix A

Appendices

A.1 Main Tables and Figures

Figure A·1: How Access to a Line of Credit Moderates the Effect of Labor Supply Shifts on NCA Use



The figure shows the average predicted probability that employers with and without a line of credit had their most recent hire sign an NCA, for different values of the number of applicants received for the position. The predicted probabilities are generated from the regression corresponding to Column 3 in Table A.6. The range shown for Number of Applicants across the x-axis is 1 to 15, which are the 10th and 90th percentiles in our sample, respectively.

Table A.1: Summary Statistics

	n	mean	sd	median	min	max
Last Hire Signed NCA	218	0.30	0.46	0.00	0.00	1.00
Ever used NCA	218	0.39	0.49	0.00	0.00	1.00
Num stylists working in salon	218	7.13	8.79	4.00	0.00	52.00
Salon 2014 annual revenue, 000s	218	379.00	390.53	250.00	25.00	1500.00
% of stylists hired out of school, bin avg	218	42.33	36.65	32.69	5.00	95.00
Appointment only	218	0.32	0.47	0.00	0.00	1.00
Years in beauty industry	218	27.39	13.29	27.00	1.00	59.00
Emp-based salon	218	0.48	0.50	0.00	0.00	1.00
Bishara State NCA score, standardized	218	0.62	0.33	0.76	0.07	1.00
Line of Credit	218	0.50	0.50	0.50	0.00	1.00
# applicants for last vacancy	195	6.79	9.37	4.00	0.00	60.00
# applicants fewer than usual	218	0.31	0.46	0.00	0.00	1.00
# applicants same as usual	218	0.50	0.50	0.50	0.00	1.00
# applicants more than usual	218	0.10	0.30	0.00	0.00	1.00
Num beauty salons in county, 2012	218	386.68	498.22	183.50	1.00	1762.00

Revenue, Number of Applicants, and Number of Salons in County topcoded at 99th percentile.

Table A.2: The Relationship Between Shifts in Labor Supply and NCA Use

	(1)	(2)	(3)
	DV=last hire signed NCA		
# applicants for last vacancy	0.012	0.0097	0.0082
	(0.0038)***	(0.0037)***	(0.0034)**
Bishara State NCA score, standardized	0.31	0.27	0.16
	(0.087)***	(0.10)***	(0.091)*
Emp-based salon		0.17	0.053
		(0.071)**	(0.061)
% of stylists hired out of school, bin avg		0.0011	0.00034
		(0.00095)	(0.00074)
Num stylists working in salon		-0.0024	-0.0049
		(0.0047)	(0.0042)
Age of owner		-0.0031	-0.0061
		(0.0033)	(0.0027)**
Num beauty salons in county, 2012, 000s		-0.024	0.0069
		(0.070)	(0.050)
Used NCAs prior to most recent hire			0.59
			(0.073)***
Constant	0.029	0.12	0.28
	(0.059)	(0.19)	(0.16)*
Observations	195	195	195
R^2	0.099	0.148	0.418
Mean Dep Var	0.303	0.303	0.303
Bishara Score	Y	Y	Y

The dependent variable is a dummy equal to 1 if the most recently hired stylist signed a NCA.
Bishara score is a standardized measure of each state's enforceability of NCAs.
Linear Probability Model. Robust SEs in parentheses. ***P<.01., **P<.05, *P<.1

Table A.3: The Effect of the Local Unemployment Rate on NCA Use

	(1)	(2)	(3)
	DV = last hire signed NCA		
Local Unemployment Rate 2012	0.014		
	(0.015)		
Change in local Unemployment Rate 2006-2012		0.041	0.040
		(0.022)*	(0.024)*
Used NCAs in 2006 or earlier			0.46
			(0.11)***
Observations	218	218	202
R^2	0.105	0.117	0.242
Mean Dep Var	0.298	0.298	0.287
Bishara Score	Y	Y	Y
Other Controls	Y	Y	Y

The dependent variable is a dummy equal to 1 if the most recently hired stylist signed a NCA. In Column 3, the sample is restricted to owners who reported being in the beauty industry since 2006.
Bishara score is a standardized measure of each state's enforceability of NCAs. Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs clustered by county in parentheses. ***P<.01., **P<.05, *P<.1

Table A.4: The Relationship Between The Minimum Wage and NCA Use

	(1)	(2)	(3)
	DV = has ever used NCA		
Minimum Cash Wage in 2014	0.030	0.050	0.032
	(0.013)**	(0.015)***	(0.021)
Emp-based salon=1 × Minimum Cash Wage in 2014			0.057
			(0.026)**
Observations	218	218	218
R^2	0.044	0.141	0.229
Mean Dep Var	0.385	0.385	0.385
Bishara Score	Y	Y	Y
Other Controls	N	Y	Y

Emp-based salon is a dummy if the salon hires stylists as employees, as opposed to independent contractors.
Bishara score is a standardized measure of each state's enforceability of NCAs.
Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs clustered by state in parentheses. ***P<.01., **P<.05, *P<.1

Table A.5: The Relationship Between NCA Use and the Investment Holdup Problem

	(1)	(2)	(3)	(4)	(5)	(6)
	Outcomes related to investment in client attraction					
	Social Media	Web-site	Deal sites	Email Promotions	Other Marketing	Trains workers
Ever used NCA	-0.036	0.059	0.11	0.11	0.081	0.11
	(0.057)	(0.062)	(0.052)**	(0.066)	(0.069)	(0.043)**
Observations	218	218	218	218	218	218
R^2	0.110	0.154	0.063	0.207	0.052	0.301
Mean Dep Var	0.807	0.720	0.115	0.583	0.362	0.798
Bishara Score	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y

The dependent variable in each column is a dummy for whether the employer indicated using the corresponding tool. Columns 1-5 are tools to attract clients, and Column 6 is a simple sum of the responses from Columns 1-5.
Bishara score is a standardized measure of each state's enforceability of NCAs.
Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs in parentheses. ***P<.01., **P<.05, *P<.1

Table A.6: The Moderating Effect of Employer Financial Constraints on NCA Use

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	DV = last hire signed NCA					DV = any hire signed NCA		
Line of Credit	0.15	0.17	0.27	0.11	0.43	0.11	0.10	0.31
	(0.065)**	(0.064)**	(0.072)***	(0.066)*	(0.16)***	(0.068)	(0.061)*	(0.13)**
# applicants for last vacancy		0.010	0.017					
		(0.0039)***	(0.0029)***					
Line of Credit=1 × # applicants for last vacancy			-0.016					
			(0.0062)***					
Change in local Unempl. Rate 2006-2012				0.041	0.083			
				(0.022)*	(0.023)***			
Line of Credit=1 × Change in local Unempl. Rate					-0.083			
					(0.034)**			
Minimum Cash Wage in 2014							0.049	0.067
							(0.015)***	(0.016)***
Line of Credit=1 × Minimum Cash Wage in 2014								-0.038
								(0.016)**
Observations	195	195	195	218	218	218	218	218
R^2	0.139	0.177	0.200	0.130	0.150	0.121	0.151	0.163
Mean Dep Var	0.303	0.303	0.303	0.298	0.298	0.385	0.385	0.385
Bishara Score	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y

Bishara score is a standardized measure of each state's enforceability of NCAs.
Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs clustered by county in Columns 4-5 and by state in Columns 6-8, in parentheses. ***P<.01., **P<.05, *P<.1

A.2 Appendix Tables and Figures

Table A.7: State Tabulation

State	Number	State	Number
AL	5	MT	1
AZ	3	NC	3
CA	54	NE	1
CO	5	NH	1
CT	4	NJ	5
DC	1	NM	1
FL	15	NV	1
GA	3	NY	9
IA	3	OH	5
IL	19	OK	1
IN	7	OR	2
KS	2	PA	10
KY	2	RI	1
LA	2	SC	1
MA	4	SD	1
MD	5	TN	2
ME	2	TX	9
MI	3	VA	5
MN	4	WA	3
MO	6	WI	7
		Total	218

Table A.8: The Relationship Between Within-Owner Shifts in Labor Supply and Within-Owner Changes in NCA Use

	(1)	(2)
	DV=change in NCA use	
# applicants more than usual	0.12	0.12
	(0.086)	(0.096)
# applicants fewer than usual	-0.013	0.013
	(0.067)	(0.067)
Observations	195	195
R^2	0.008	0.093
Mean Dep Var	0.036	0.036
Bishara Score	Y	Y
Other Controls	N	Y

The dependent variable is the difference between a dummy indicating whether an owner had its most recently hired stylist sign an NCA, and a dummy indicating whether the owner reported using NCAs prior to its most recent hire.

Number of applicants more (fewer) is a dummy if the number of applicants the owner received for its most recent vacancy was more (fewer) than it received for similar vacancies in the past.

Bishara score is a standardized measure of each state's enforceability of NCAs.

Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.

Linear Probability Model. Robust SEs in parentheses. ***P<.01., **P<.05, *P<.1

Table A.9: The Relationship Between The Minimum Wage and NCA Use At Time Of Most Recent Hire

	(1)	(2)	(3)
	DV = last hire signed NCA		
Minimum Cash Wage in year of last hire	0.029	0.038	0.027
	(0.012)**	(0.014)***	(0.019)
Emp-based salon=1 × Minimum Cash Wage in year of last hire			0.036
			(0.034)
Observations	218	218	218
R^2	0.047	0.124	0.166
Mean Dep Var	0.298	0.298	0.298
Bishara Score	Y	Y	Y
Other Controls	N	Y	Y

Emp-based salon is a dummy if the salon hires stylists as employees, as opposed to independent contractors.
Bishara score is a standardized measure of each state's enforceability of NCAs.
Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs clustered by state in parentheses. ***P<.01., **P<.05, *P<.1

Table A.10: The Interaction Effect of the Minimum Wage and Labor Supply on NCA Use

	(1)	(2)	(3)	(4)
	DV = last hire signed NCA			
	Emp-based salons		Not emp-based salons	
# applicants for last vacancy	0.014	-0.00100	0.0092	0.0082
	(0.0039)***	(0.013)	(0.0082)	(0.017)
Minimum Cash Wage in 2014	0.064	0.046	0.025	0.024
	(0.024)***	(0.028)	(0.022)	(0.023)
# applicants for last vacancy × Minimum Cash Wage in 2014		0.0020		0.00022
		(0.0016)		(0.0034)
Observations	100	100	95	95
R^2	0.180	0.192	0.156	0.156
Mean Dep Var	0.410	0.410	0.189	0.189
Bishara Score	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y

The dependent variable is a dummy equal to 1 if the most recently hired stylist signed a NCA. In columns 1-2 the sample is restricted to salons which are employment-based, and in columns 3-4 the sample is non-employment-based salons.

Bishara score is a standardized measure of each state's enforceability of NCAs.

Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the owner's age, the number of stylists working in the salon, and the number of salons in a respondent's county.

Linear Probability Model. Robust SEs in parentheses. ***P<.01., **P<.05, *P<.1

Table A.11: The Correlation Between Employers' Access to a Line of Credit or Banking Relationship and Investment in Client Attraction and Worker Training

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Outcomes related to investment in client attraction						
	Social Media	Web-site	Deal sites	Email Promotions	Other Marketing	Sum of marketing	Trains workers
Line of Credit	0.12	0.10	0.095	0.21	0.15	0.68	0.084
	(0.051)**	(0.060)*	(0.047)**	(0.063)***	(0.066)**	(0.17)***	(0.049)*
Observations	218	218	218	218	218	218	218
R^2	0.113	0.131	0.037	0.221	0.048	0.220	0.285
Mean Dep Var	0.807	0.720	0.115	0.583	0.362	2.587	0.798
Bishara Score	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y

The dependent variable in each column is a dummy for whether the employer indicated using the corresponding tool. Columns 1-5 are tools to attract clients, and Column 6 is a simple sum of the responses from Columns 1-5.
Bishara score is a standardized measure of each state's enforceability of NCAs.
Other controls include the percent of a salon's stylists hired directly out of school, a dummy for employment-based salons, the number of years the owner has been in the beauty industry, and the number of salons in a respondent's county.
Linear Probability Model. Robust SEs in parentheses. ***P<.01., **P<.05, *P<.1

A.3 The Theoretical Impact of Changes in the Minimum Wage on NCA Use

Suppose that utility transferability and the employee's outside option are both functions of the minimum wage, m: $l(m)$ and $\pi_E(m)$. We assume that $l'(m) > 0$: increases in the minimum wage unambiguously decrease monetary utility transferability. When $B < C$, the condition that ensures that equilibrium contracts have $A = 1$ ($\gamma(\mu_E)P - \pi_R < l(m)$) is not a function of $\pi_E(m)$. Since $l'(m) > 0$ by assumption, increases in m allow this condition to be satisfied more easily: the willingness to pay of R_{μ_E} is more easily bound by l. Thus, increases in the minimum wage may only increase NCA use through this channel, which we call the Bindingness Effect (BE).

Changes in m also affect Assumption 2. If an increase in m causes a decrease in $\pi_E(m)$, the assumption will continue to hold unambigiously if m increases. However, if an increase in m causes an increase in $\pi_E(m)$ (such as, for example, if the employee may easily find a job in another industry that pays the minimum wage), the assumption may be violated if the corresponding increase in productivity of $\hat{\imath}(l(m))$ is not large enough. We call these two competing effects the Outside Option Effect and the Transferability Effect, respectively. A sufficient condition for increases in the minimum wage not to decrease NCA use is that the Transferability Effect (TE) dominates the Outside Option Effect (OOE):

Proposition A.3.1. *Suppose that there exists an equilibrium in which $B < C$ and $A = 1$ in all contracts when the minimum wage is m. If the minimum wage increases from m to $\tilde{m}$, in the new equilibrium, $A = 1$ in all contracts if the TE dominates the OOE: $l(\tilde{m}) - l(m) \geq \pi_E(\tilde{m}) - \pi_E(m)$.*

Proof. By Proposition 1.2.1, $\mu_E > \hat{\imath}(l(m))$, since the equilibrium under m has $A = 1$ in all contracts. Since $l'(m) > 0$ and $\tilde{m} > m$, $l(\tilde{m}) > l(m)$, and therefore $\hat{\imath}(l(\tilde{m})) < \hat{\imath}(l(m))$. So, $\mu_E > \hat{\imath}(l(\tilde{m}))$. Thus, if Assumption 2 is satisfied under $\tilde{m}$ when the TE dominates the OOE, the equilibrium will have $A = 1$ in all contracts.

Assumption 2 under m states that $\gamma(\hat{\imath}(l(m)))P + B - \pi_R > \pi_E(m) + C$, which is equivalent to $l(m)+B > \pi_E(m)+C$ by the definition of $\hat{\imath}(l(m))$. Adding $l(\tilde{m})-l(m)$ to the left hand side and adding $\pi_E(\tilde{m})-\pi_E(m)$ to the right hand side preserves the inequality, since the TE dominates the OOE. Reducing, we are left with

$$l(\tilde{m}) + B > \pi_E(\tilde{m}) - C$$

$$\gamma(\hat{\imath}(l(\tilde{m}))) + B - \pi_R > \pi_E(\tilde{m}) - C,$$

which is Assumption 2 under $\tilde{m}$. Therefore, all contracts have $A = 1$ in equilibrium under $\tilde{m}$. □

The interpretation of Proposition A.3.1 is straightforward. As long as a one dollar increase in the minimum wage does not increase an employee's outside option by *more* than one dollar, NCA use will not decrease. If NCAs were not used prior to an increase, they may be used after if the conditions of Proposition 1.2.1 become satisfied. Assumption 2 may become satisfied if the TE outweighs the OOE, or the BE may cause the inequality $\gamma(\mu_E) - \pi_R < l(m)$ to hold.

A.4 Proofs

Proposition 1.2.1

Proof. Assuming that $B < C$, I will show that when $\mu_E < \hat{\imath}(l)$, all firms' equilibrium contracts have $A = 0$, and if $\mu_E > \hat{\imath}(l)$, all firms' equilibrium contracts have $A = 1$.

When $\mu_E < \hat{\imath}(l)$, the intersection of $D(i)$ and $S(i)$ occurs at $i_0^* = \mu_E$ (since $D(i) > S(i)\ \forall i < \hat{\imath}(l)$ by Assumption 2). Since $\mu_E < \hat{\imath}(l)$, the optimal contract for the marginal firm is $\{w_0^* \equiv \gamma(\mu_E) - \pi_R, 0\}$. No R_i for $i > \mu_E$ is willing to form a firm, and all R_i with $i < \mu_E$ are willing to form firms under that contract, since $\gamma(\cdot)$ is decreasing. Furthermore, the optimal contract for each firm with $i < \mu_E$ has $A = 0$. Therefore, no firm will deviate from the marginal firm's contract, all E are employed receiving the same surplus, and no unmatched R can offer a better contract to an E. So, an equilibrium in which $A = 0$ in all contracts exists when $\mu_E < \hat{\imath}(l)$. Since the optimal contract for all $i \leq i_0^*$ has $A = 0$, equilibria with $A = 1$ in any contract do not exist.

When $\mu_R > \mu_E > \hat{\imath}(l)$, the intersection of $D(i)$ and $S(i)$ occurs at $i_1^* > \hat{\imath}(l)$: if $D(\mu_E) > S(\mu_E)$, then $i_1^* = \mu_E$ (all E are able to form firms). If $D(\mu_E) < S(\mu_E)$, then i_1^* solves $\gamma(i_1^*)P + B - \pi_R = \pi_E + C$ (which solution exists by Assumption 2). Since $i_1^* > \hat{\imath}(l)$, the marginal firm's contract is $\{w_1^* \equiv \gamma(i_1^*)P + B - \pi_R, 1\}$. For any $i \in (\hat{\imath}(l), \mu_E]$, firm i's optimal contract has $A = 1$, and competition drives the wage to w_1^*. However, for $i \leq \hat{\imath}(l)$, firm i's optimal contract has $A = 0$. Consider the most profitable contract for such a firm with $A = 0$: $\{l, 0\}$. That contract yields surplus to R_i equal to $\gamma(i)P - l$. The marginal firm's contract yields surplus to R_i equal to $\gamma(i)P - (\gamma(i_1^*)P + B - \pi_R) + B$. R_i prefers the contract $\{l, 0\}$ whenever:

$$\gamma(i)P - l > \gamma(i)P - (\gamma(i_1^*)P + B - \pi_R) + B$$

$$\gamma(i_1^*)P - \pi_R > l.$$

However, $l = \gamma(\hat{\imath}(l))P - \pi_R > \gamma(i_1^*)P - \pi_R$, since $i_1^* > \hat{\imath}(l)$. Therefore, there does not exist a contract with $A = 0$ that any R_i prefers to $\{w_1^*, 1\}$, and competition ensures that all firms use that contract. So, all equilibrium contracts have $A = 1$ when $\mu_R > \mu_E > \hat{\imath}(l)$.

Finally, when $\mu_E > \mu_R$, the logic of the preceding paragraph holds; however, the wage determined by the intersection of $D(i)$ and $S(i)$ may be lower than l if $\pi_E + C < \underline{\gamma}P + B - \pi_R < l$. In that case, the equilibrium market contract is $\{l, 1\}$, and the proof is nearly identical. □

Lemma 2.3.1

Proof. I will show that, in any equilibrium in which $W_{t+1}^U > \frac{\Pi}{1-\delta}$, the contract $\{w, 0\}$ is Pareto optimal for a newly formed firm at time t, and the contract $\{w, 1\}$ is Pareto optimal if and only if $w - \delta(1-s)m^w < l$.

I first show that any contract $\{w, 0\}$ is Pareto optimal.

Consider an arbitrary deviation contract $\{w', A'\}$. If $A' = 0$, any increase from w to w' decreases R's payoff by exactly the amount of the increase, and any decrease from w to w' decreases E's payoff by exactly the amount of the decrease. Thus, no contract $\{w', 0\}$ may be a profitable deviation contract.

Now, consider the deviation contract $\{w', 1\}$. It is a mutually beneficial deviation contract if it is beneficial for each agent, which is true when:

$$w - w' + \delta(1-s)(V_{t+1}^N(\gamma) - V_{t+1}^F(\gamma)) > 0, \text{ and}$$

$$w' - w + \delta\Big[s(\frac{\Pi}{1-\delta} - W^U_{t+1}) + (1-s)(W^N_{t+1} - W^F_{t+1}(\gamma))\Big] > 0.$$

Such a contract may only exist if

$$(1-s)\Big[V^N_{t+1}(\gamma) + W^N_{t+1} - V^F_{t+1}(\gamma) - W^F_{t+1}\Big] > s\Big[W^U_{t+1} - \frac{\Pi}{1-\delta}\Big].$$

The continuation payoffs following period $t+1$ are identical regardless of whether $A_t = 0$ or $A_t = 1$ ($sV^U_{t+2}(\gamma) + (1-s)V^F_{t+2}(\gamma)$ for E and $sW^U_{t+2} + (1-s)W^F_{t+2}$ for E). Furthermore, the joint period payoff at $t+1$ is also the same for the two contracts: $P_{t+1} - \gamma$. Therefore, $V^N_{t+1}(\gamma) + W^N_{t+1} - V^F_{t+1}(\gamma) - W^F_{t+1} = 0$. Since $W^U_{t+1} > \frac{\Pi}{1-\delta}$ by assumption, there does not exist a contract $\{w', p'\}$ that is a mutually profitable deviation, and $\{w, 0\}$ is Pareto optimal.

Next, I show that the contract $\{w, 1\}$ is Pareto optimal if $w - \delta(1-s)m^w < l$. Again, since increases or decreases in w are simply transfers between agents, a change in the wage alone is not enough to generate a Pareto improvement on $\{w, 1\}$. Therefore, consider an arbitrary contract $\{w', 0\}$ where $w' > l$. Suppose, for the sake of contradiction, that $\{w', 0\}$ Pareto dominates $\{w, 1\}$.

Since $\{w', 0\}$ improves R's payoff, it must be the case that:

$$P_t - w' - \gamma + \delta\Big[sV^U_{t+1} + (1-s)V^F_{t+1}\Big] \geq P_t - w - \gamma + \delta\Big[sV^U_{t+1} + (1-s)V^N_{t+1}\Big]$$

$$w' < w - \delta(1-s)(V^N_{t+1} - V^F_{t+1})$$

Since $V^N_{t+1} - V^F_{t+1} = m^w$, $w' < w - \delta(1-s)m^w$. However, by assumption, $w - \delta(1-s)m^w < l$, so $w' < l$. This is not an allowable contract, and is therefore a contradiction, so there exists no profitable deviation contract for R. Thus, $\{w, 1\}$ is Pareto optimal if $w - \delta(1-s)m^w < l$.

I now show that if $\{w, 1\}$ is Pareto optimal, then $w - \delta(1-s)m^w < l$. Suppose for the sake of contradiction that $w - \delta(1-s)m^w > l$. Then, the contract $\{w', 0\}$, where $w' = w - \delta(1-s)m^w$ is both allowable and generates equal value for R. E prefers $\{w', 0\}$ if:

$$(w - \delta(1-s)m^w) + \delta\Big[sW^U_{t+1} + (1-s)W^F_{t+1}\Big] > w + \delta\Big[s\frac{\Pi}{1-\delta} + (1-s)W^N_{t+1}\Big]$$

$$s\Big(W^U_{t+1} - \frac{\Pi}{1-\delta}\Big) + (1-s)(W^F_{t+1} - W^N_{t+1}) > (1-s)m^w$$

$$s\Big(W_{t+1}^U - \frac{\Pi}{1-\delta}\Big) > 0,$$

where the last line follows because $W_{t+1}^F - W_{t+1}^N = m^w$. By assumption, $W_{t+1}^U > \frac{\Pi}{1-\delta}$, which contradicts Pareto optimality of $\{w, 1\}$. Therefore, if $\{w, 1\}$ is Pareto optimal, then $w - \delta(1-s)m^w < l$. □

Proposition 2.4.1

Proof. I will show that when l is low, a steady state equilibrium exists in which $A = 0$ in all market contracts.

The equilibrium values are given by the solution to the linear system:

$$\begin{aligned} \delta W^U - c =& \frac{\delta\Pi}{1-\delta} \\ V^U =& 0 \end{aligned}$$

where

$$\begin{aligned} V^U &= P(Q) - w - \gamma + \delta(sV^U + (1-s)V^F) \\ V^F &= P(Q) + m^p - w - m^w - \gamma + \delta(sV^U + (1-s)V^F) \\ W^U &= w + \delta(sW^U + (1-s)W^F) \\ W^F &= w + m^w + \delta(sW^U + (1-s)W^F) \\ Q &= \mu^U + \mu^F \\ \mu^U &= sQ \\ \mu^F &= (1-s)Q \\ \bar{\mu} &= 0 \end{aligned}$$

for $\gamma = \gamma_H$ if $Q > p\mu_R$ or $\gamma = \gamma_L$ if $Q < p\mu_R$[1]. □

Proposition 2.4.2

Proof. I will show that $\exists l_{SS}$ and Ω_{SS} such that, when $l > l_{SS}$ and $\Omega \geq \Omega_{SS}$, a steady state equilibrium exists in which $A = 1$ in all market contracts.

[1]Note that, for steady states with or without NCAs, neither solution may exist, in which case the wage would be on the vertical portion of labor demand and $Q = p\mu_R$.

The equilibrium values are given by the solution to the following linear system:

$$\delta W^U - c = \frac{\delta \Pi}{1-\delta}$$
$$V^U = 0$$

where

$$\begin{aligned}
V^U &= P(Q) - w - \gamma + \delta(sV^U + (1-s)V^N) \\
V^F &= P(Q) + m^p - w - m^w - \gamma + \delta(sV^U + (1-s)V^F) \\
V^N &= P(Q) + m^p - w - \gamma + \delta(sV^U + (1-s)V^F) \\
W^U &= w + \delta(s\frac{\Pi}{1-\delta} + (1-s)W^N) \\
W^F &= w + m^w + \delta(sW^U + (1-s)W^F) \\
W^N &= w + \delta(sW^U + (1-s)W^F) \\
Q &= \mu^U + \mu^F + \mu^N \\
\mu^U &= \bar{\mu} + s(\mu^F + \mu^N) \\
\mu^F &= (1-s)(\mu^F + \mu^N) \\
\mu^N &= (1-s)\mu^U \\
\bar{\mu} &= s\mu^U
\end{aligned}$$

for $\gamma = \gamma_H$ if $Q > p\mu_R$ or $\gamma = \gamma_L$ if $Q < p\mu_R$.

In order for the above to be an equilibrium, the market clearing wage with $A = 0$ must be bound by l. This market clearing wage is given by the solution to

$$w^{mc} = P(Q) - \gamma + \delta(sV^U + (1-s)V^F)$$

In this case, the solution is

$$w^{mc} = \Pi + \delta(1 + \delta(1-s))m^w + \frac{c}{\delta}(1 - \delta(1-s)(1+\delta s)) \equiv l_{SS}.$$

Additionally, $\bar{\mu}$ must not be bound by Ω. Here:

$$\bar{\mu} = \frac{s^2}{-\rho}(P_{int} + \delta(1-s)m^p - \gamma - \Pi - \frac{c}{\delta}(1 - \delta(1-s)(1+\delta s)) \equiv \Omega_{SS}.$$

$\square$

Proposition 2.4.3

Proof. I will show that, when Assumptions 5 and 6 are satisfied, there exist $\underline{l}(\Omega)$, $\bar{l}(\Omega)$, $\underline{\Omega}$, and $\overline{\Omega}$ such that, whenever $\underline{l}(\Omega) < l < \bar{l}(\Omega)$ and $\underline{\Omega} < \Omega < \overline{\Omega}$, a 2-cyclical equilibrium exists. In that 2-cyclical equilibrium, $A = 1$ in all previously unmatched firms' contracts in periods $t+2n+1$, and $A = 0$ in all such contracts in periods $t+2n$, for $n \in \mathbb{N}$.

A vector $\{w_0, w_1, \bar{\mu}\}$ induces a 2-cyclical equilibrium as described in Section 2.4.3 if it satisfies single period equilibrium conditions in even and odd periods, the odd period equality entry condition for E, even period inequality entry conditions for E, $w_1^D(\mu_{E,1}^U) < l < w_0^D(\mu_{E,0}^U)$, and the laws of motion guarantee that labor supply replenishment occurs over two periods. The first three conditions generate the following system of equations:

$$w_0^* = w_0^D(\mu_{E,0}^U) \tag{A.1}$$
$$w_1^* = w_1^D(\mu_{E,1}^U) \tag{A.2}$$
$$\delta W_1^U - c_E = \frac{\delta}{1-\delta}\Pi \tag{A.3}$$

The final conditions are:

$$\hat{w}_1^D(\mu_{E,1}^U) < l$$
$$\hat{w}_0^D(\mu_{E,0}^U) > l$$
$$\bar{\mu}_{E,0} \leq \Omega \leq s\mu_{E,1}^U$$
$$\delta W_0^U - c_E \geq \frac{\delta}{1-\delta}\Pi$$

Solution to Equations A.1 - A.3

First, I show that there exists a solution, $\{w_0^*, w_1^*, \bar{\mu}\}$, to the system defined by Equations A.1 - A.3. Equations A.1 and A.2 reduce to

$$w_0^* = P(Q_0) - \gamma_L + \delta(1-s)(m^p - m^w(1 + \delta(1-s))) \tag{A.4}$$
$$w_1^* = P(Q_1) - (1 + \delta(1-s))\gamma_H + \delta(1-s)(P(Q_0) - w_0^* \tag{A.5}$$
$$+ (1 + \delta(1-s))(m^p - \delta(1-s)m^w)) \tag{A.6}$$

Since $P(Q_0)$, $P(Q_1)$, W_0^U, and W_1^U are linear in $\bar{\mu}$, w_0, and w_1, the system is linear in those parameters, and therefore has a solution for almost all values of the exogenous parameters.

Proof that $\boldsymbol{\hat{w}_1^D(\mu_{E,1}^U) < l < w_0 = \hat{w}_0^D(\mu_{E,0}^U)}$

Next, I show that $\hat{w}_1^D(\mu_{E,1}^U) < l < w_0 = \hat{w}_0^D(\mu_{E,0}^U)$. Since all relevant equations are independent of l, as long as $w_0 > \hat{w}_1^D(\mu_{E,1}^U)$, there exists a wage constraint, l, that induces $A_0 = 0$ and $A_1 = 1$ whenever $l \in (\hat{w}_1^D(\mu_{E,1}^U), w_0)$.

In the posited equilibrium, $\hat{w}_1^D(\mu_{E,1}^U) = P(Q_1) - \gamma_H + \delta(1-s)(V_0^F(\gamma_H) - V_0^U(\gamma_H))$. So:

$$\begin{aligned} &w_0 - \hat{w}_1^D(\mu_{E,1}^U) = \\ &\quad P(Q_0) - P(Q_1) + \gamma_H - \gamma_L + \delta(1-s)(V_1^F(\gamma_L) - V_1^U(\gamma_L) + V_0^U(\gamma_H) - V_0^F(\gamma_H)) \end{aligned}$$

Substituting based on the value function reductions in Section 2.4.3:

$$V_1^F(\gamma_L) - V_1^U(\gamma_L) = m^p - m^w(1 + \delta(1-s))$$

$$V_0^F(\gamma_H) - V_0^U(\gamma_H) = P(Q_0) - w_0 - \gamma_H + (1+\delta(1-s))m^p - (1+\delta(1-s)+\delta^2(1-s)^2)m^w$$

Substituting and reducing, $w_0 - \hat{w}_1^D(\mu_{E,1}^U) > 0$ whenever

$$P(Q_0) - P(Q_1) + \gamma_H - \gamma_L - \delta^2(1-s)^2 m^w) > 0,$$

which is true by Assumption 5. Note that the lower and upper bounds for l, given by $\hat{w}_1^D(\mu_{E,1}^U)$ and $\hat{w}_0^D(\mu_{E,0}^U)$, are functions of Ω via the goods market prices.

Proof that $0 < \bar{\mu}^* \leq \Omega \leq s\mu_{E,1}^U$

Next, I show that $\exists \underline{\Omega}$ and $\overline{\Omega}$ such that, if $\Omega \in [\underline{\Omega}, \overline{\Omega}]$, then $0 < \bar{\mu} \leq \Omega$. In order to do so, let $\bar{\mu}(\Omega)$ represent the value of $\bar{\mu}$,that solves Equations $A.1$ - $A.3$, taken as a function of the exogenous parameter Ω. I show that $\bar{\mu}'(\Omega) < 0$ and that $\bar{\mu}(0) > 0$. These two conditions ensure that the graph of $\bar{\mu}$ as a function of Ω crosses the positive part of the 45 degree line. Therefore, since $\bar{\mu}^*$ is continuous with respect to Ω, $\bar{\mu}^* \leq \Omega$ and $\bar{\mu}^* > 0$ for $\Omega \in [\underline{\Omega}, \overline{\Omega})$, where $\underline{\Omega}$ solves $\bar{\mu}(\underline{\Omega}) = \underline{\Omega}$ and $\overline{\Omega}$ solves $\bar{\mu}(\overline{\Omega}) = 0$.

Differentiating $\bar{\mu}(\Omega)$ yields:

$$\bar{\mu}'(\Omega) = -\frac{1 + \delta(1-s)(1-\delta s)}{1 + \delta(1-s)^3 - \delta^2(1-s)s}$$

Since $\{\delta, s\} \in [0,1] \times [0,1]$, $\bar{\mu}'(\Omega) < 0$.

To show that $\bar{\mu}(0) > 0$, consider the case if entry in odd periods were zero and $\bar{\mu} =$

0. Then, $Q_0 = Q_1 = 0$, and $P(Q_0) = P(Q_1) = P_{int}$. An atomic E entering the market would capture all surplus, therefore earning more than $P_{int} - \gamma_L$ or $P_{int} - \gamma_L + m^P$ in each round. Since $P_{int} - \gamma_L > \Pi$, entry is profitable, and therefore, $\bar{\mu}(0) > 0$ if $\Omega = 0$. Since $\bar{\mu}(0) > 0$, $\bar{\mu}'(\Omega) < 1$, and $\bar{\mu}(\Omega)$ is continuous, $\exists\{\underline{\Omega}, \overline{\Omega}\}$ (where $\underline{\Omega}$ solves $\bar{\mu}^*(\underline{\Omega}) = \underline{\Omega}$ and $\overline{\Omega}$ solves $\bar{\mu}^*(\overline{\Omega}) = 0$) such that $0 < \bar{\mu} \leq \Omega$ for all $\Omega \in [\underline{\Omega}, \overline{\Omega})$.

Note that, since $\mu_E^1 = \frac{\Omega + \bar{\mu}}{s}$, the measure of separating agents is $\Omega + \bar{\mu}$. Since $\bar{\mu} > 0$, the market is unable to replenish in one period in the posited equilibrium.

Proof that $\delta W_0^U - c_E \geq \frac{\delta}{1-\delta}\Pi$

I prove this by contradiction. Assume, for the sake of contradiction, that $\delta W_0^U - c_E \leq \frac{\delta}{1-\delta}\Pi$. Since $\delta W_1^U - c_E = \frac{\delta}{1-\delta}\Pi$, $W_0^U \leq W_1^U$. Therefore, using the definitions of the value functions in Section 2.4.3 and Equation A.3:

$$W_1^U - W_0^U = w_1^* - w_0^* - sc_E + \delta(1-s)(W_0^N - W_1^F) \geq 0 \tag{A.7}$$

Using the differences

$$W_0^N - W_1^F = w_0^* - w_1^* - m^w + \delta\left[s(W_1^U - W_0^U) + (1-s)(W_1^F - W_0^F)\right]$$

and

$$W_1^F - W_0^F = \frac{w_1^* - w_0^* + \delta s(W_0^U - W_1^U)}{1 + \delta(1-s)}$$

, I reduce Inequality A.7 to:

$$\frac{1}{1 + \delta(1-s)(1-\delta s)}\left[w_1^* - w_0^* - \delta(1+\delta(1-s))(1-s)m^w - s(1+\delta(1-s))c_E\right] \geq 0 \tag{A.8}$$

An expression for $w_1^* - w_0^*$ is found by Substituting for w_0^* in Equation A.6 using Equation A.4, and subsequently subtracting A.4 from A.6. Substituting this into Inequality A.8 and simplifying yields:

$$\frac{1}{1 + \delta(1-s)(1-\delta s)}\Big[P(Q_1) - P(Q_0) \\ + (1 + \delta(1-s)(\gamma_L - \gamma_H) - s(1+\delta(1-s))c_E \geq 0\Big]$$

Because all coefficients are positive, this implies that either $P(Q_1) > P(Q_0)$, $\gamma_L > \gamma_H$, or $c_E < 0$ (or all three hold with equality). Since each of these is false, the assumption that $\delta W_0^U - c_E \leq \frac{\delta}{1-\delta}\Pi$ is contradicted, and the desired result is proven. $\square$

Proposition 2.5.1

Proof. I will show that $\frac{dSDIFF_{SS}}{d\zeta} > 0$ for $\zeta \in \{\gamma_H, \Pi, s\}$, and $\frac{dSDIFF_{SS}}{d\zeta} < 0$ for $\zeta \in \{m^p, P_{int}\}$.

Recall the equilibrium value of $\hat{Q}$:

$$\hat{Q} = \frac{\delta(\gamma_H + \Pi - P_{int} - \delta m^p(1-s)) + c(1 - \delta(1-s)(1+\delta s))}{\delta\rho}$$

For $\zeta \in \{\gamma_H, \Pi\}$:

$$\frac{dSDIFF_{SS}}{d\zeta} = \frac{d\hat{Q}}{d\zeta}(\gamma_H + s^2c + \Pi - P(\hat{Q}) - (1-s)m^p) + \hat{Q}$$

It suffices to show that $(\gamma_H + s^2c + \Pi - P(\hat{Q}) - (1-s)m^p) \leq 0$. This expression is exactly the negative of the net per-firm surplus that accrues to E and R for R with γ_H. Whenever firms with R whose marginal cost is γ_H exist, this quantity is negative.

Similarly:

$$\frac{dSDIFF_{SS}}{dm^p} = \frac{d\hat{Q}}{dm^p}(\gamma_H + s^2c + \Pi - P(\hat{Q}) - (1-s)m^p) - (1-s)\hat{Q} < 0,$$

since $\frac{d\hat{Q}}{dm^p} > 0$.

Finally:

$$\frac{dSDIFF_{SS}}{ds} = \frac{d\hat{Q}}{ds}(\gamma_H + s^2c + \Pi - P(\hat{Q}) - (1-s)m^p) + (\hat{Q} - Q^x)m^p + 2sc\hat{Q} > 0,$$

since $\frac{d\hat{Q}}{ds} = \frac{\delta m^p + (1-\delta(1-2s))c}{\rho} < 0$. □

Proposition 2.5.2

Proof. I will show that $\frac{dSDIFF_{cyc1}}{d\zeta} > 0$ for $\zeta \in \{\gamma_H, \Pi\}$, and $\frac{dSDIFF_{cyc1}}{d\zeta} < 0$ for $\zeta \in \{m^p, P_{int}\}$.

Noting that, for both $t = 0$ and $t = 1$, $\frac{d\hat{Q}_t}{d\zeta} < 0$ for $\zeta \in \{\gamma_H, \Pi\}$ and > 0 for $\zeta \in \{m^p, P_{int}\}$, this proof follows similar logic to that of Proposition 2.5.1. For $\zeta \in \{\gamma_H, \Pi\}$:

$$\frac{dSDIFF_{cyc1}}{d\zeta} = \frac{d\hat{Q}_1}{d\zeta}(\gamma_H + \Pi - P(Q_1)) - (1-s)m^p\frac{d\hat{Q}_0}{d\zeta} + \hat{Q}_1 > 0.$$

For $\zeta = m^p$:

$$\frac{dSDIFF_{cyc1}}{d\zeta} = \frac{d\hat{Q}_1}{d\zeta}(\gamma_H + \Pi - P(Q_1)) - (1-s)m^p\frac{d\hat{Q}_0}{d\zeta} - (1-s)\hat{Q}_0 < 0.$$

And, for $\zeta = P_{int}$:

$$\frac{dSDIFF_{cyc1}}{d\zeta} = \frac{d\hat{Q}_1}{d\zeta}(\gamma_H + \Pi - P(Q_1)) - (1-s)m^p\frac{d\hat{Q}_0}{d\zeta} - \hat{1}_0 < 0.$$

□

Proposition 2.5.3

Proof. I will show that $\frac{dSDIFF_{cyc0}}{d\zeta} > 0$ for $\zeta \in \{\gamma_H, \Pi\}$, and $\frac{dSDIFF_{cyc0}}{d\zeta} < 0$ for $\zeta \in \{m^p, P_{int}\}$.

First, note that $\frac{d\hat{Q}_0}{d\zeta} = \frac{1-s}{s^2}\frac{d\bar{\mu}}{d\zeta}$ and $\frac{d\hat{Q}_1}{d\zeta} = \frac{s+(1-s)^2}{s^2}\frac{d\bar{\mu}}{d\zeta}$ for all ζ of interest. Therefore, when $\frac{d\bar{m}u}{d\zeta} < 0$ (as is true for $\zeta = \gamma_H$ and Π), $\frac{d\hat{Q}_0}{d\zeta} > \frac{d\hat{Q}_1}{d\zeta}$ and when $\frac{d\bar{m}u}{d\zeta} > 0$ (as is true for m^p and P_{int}), $\frac{d\hat{Q}_0}{d\zeta} > \frac{d\hat{Q}_1}{d\zeta}$.

For $\zeta \in \{\gamma_H, \Pi\}$:

$$\begin{aligned}\frac{dSDIFF_{cyc0}}{d\zeta} =& \frac{d\hat{Q}_0}{d\zeta}(\gamma_L + \Pi - P(Q_0)) - (1-s)m^p\frac{d\hat{Q}_1}{d\zeta} + c\frac{d\bar{m}u}{d\zeta} + \hat{Q}_0 \\ >& \frac{d\hat{Q}_0}{d\zeta}(\gamma_L + \Pi + \frac{s^2}{1-s}c - P(Q_0) - (1-s)m^p) + \hat{Q}_0 > 0,\end{aligned}$$

since $\frac{d\hat{Q}_0}{d\zeta} = \frac{1-s}{s^2}\frac{d\bar{\mu}}{d\zeta}$ and $\frac{d\hat{Q}_0}{d\zeta} > \frac{d\hat{Q}_1}{d\zeta}$.

Similarly, for $\zeta = m^p$:

$$\frac{dSDIFF_{cyc0}}{d\zeta} < \frac{d\hat{Q}_0}{d\zeta}(\gamma_L + \Pi + \frac{s^2}{1-s}c - P(Q_0) - (1-s)m^p) - (1-s)\hat{Q}_0 < 0.$$

And, for $\zeta = P_{int}$:

$$\frac{dSDIFF_{cyc0}}{d\zeta} < \frac{d\hat{Q}_0}{d\zeta}(\gamma_L + \Pi + \frac{s^2}{1-s}c - P(Q_0) - (1-s)m^p) - \hat{Q}_0 < 0.$$

□

Proposition 3.3.1

Proof. A contract with $NCA = 1$ restricts the planner's choice of D and does not change the level of social surplus associated with each choice of D. Therefore, it is weakly dominated by a contract with $NCA = 0$. $\square$

Proposition 3.4.1

Proof. I will show that, under Assumption 7, if $D^* = 0$, then $e^* > e^{**}$.

By Assumption 7, the second order condition for Problem 3.5 must hold: $\delta(1 - \alpha)\pi_2''(e^{**}) < c''(e^{**})$. Since $\pi_2(\cdot)$ and $c(\cdot)$ are continuous and e^{**} is unique, this implies that $\delta(1-\alpha)\pi_2'(e) > c'(e)\ \forall e < e^{**}$ and $\delta(1-\alpha)\pi_2'(e) < c'(e)\ \forall e > e^{**}$. Addition of the positive constant $\delta\alpha V'(e^*)$ to the function $\delta(1-\alpha)\pi_2'(e)$ causes that function's crossing with $c'(e)$ to therefore occur at a greater value of e. By definition, this value is e^* when $D^* = 0$, so $e^* > e^{**}$. $\square$

Proposition 3.4.2

Proof. I will show that, under Assumption 7, if $D^* = 1$, then $e^* > e^{**}$ if $\exists e$ in the closed interval whose endpoints are e^* and e^{**} such that $V'(e) > (1-\alpha)\pi_2'(e)$.

Let $\tilde{e}$ be the value of e such that $V'(\tilde{e}) > (1-\alpha)\pi_2'(\tilde{e})$.

Suppose, for the sake of reaching a contradiction, that $e^{**} > e^*$. Then, by logic explained in the proof of Proposition 3.4.1, $\delta(1-\alpha)\pi_2'(e) > c'(e)\ \forall e < e^{**}$ and $\delta V'(e) < c'(e)\ \forall e > e^*$. Since $e^* < e^{**}$, $\tilde{e} \in [e^*, e^{**}]$. Therefore:

$$\delta(1-\alpha)\pi_2'(\tilde{e}) > c'(\tilde{e}) > \delta V'(\tilde{e})(1-\alpha)\pi_2'(\tilde{e}) > V'(\tilde{e})$$

This contradicts the assumption that $V'(\tilde{e}) > (1-\alpha)\pi_2'(\tilde{e})$. Therefore, $e^* > e^{**}$. $\square$

Proposition 3.4.3

Proof. I will show that, if $D^* = 1$, $NCA = 1$ uniquely maximizes surplus if and only if $\delta(\pi_2(e^{**}) - V(e_1^*) - \pi_n) > c(e^{**}) - c(e_1^*)$. If $D^* = 0$, $NCA = 1$ uniquely maximizes surplus if and only if $\delta(\pi_2(e^{**}) - \pi_2(e_0^*)) > c(e^{**}) - c(e_0^*)$.

I find surplus maximizing contracts by identifying two contracts–one with $NCA = 0$ and one with $NCA = 1$–that yield identical utility to P. I then compare the values of the two contracts to A.

Consider two initial contracts, $\{w^F, 0\}$ and $\{w^N, 1\}$. When $D^* = 1$, these contracts yield identical expected utility to P when:

$$\begin{aligned} \delta\pi_n - w^F &= \delta(\pi_2(e^{**}) - E[w_2(0, e^{**}, \varepsilon)] \\ w^F &= w^N - \delta\alpha(\pi_2(e^{**}) - \pi_n - V_A) \end{aligned}$$

Substituting these wages into A's expected utility and simplifying, A strictly prefers a contract with $NCA = 1$ whenever $\delta(\pi_2(e^{**}) - V(e_1^*) - \pi_n) > c(e^{**}) - c(e_1^*)$ and strictly prefers $NCA = 0$ when the inequality is reversed.

Similarly, when $D^* = 0$, $\{w^F, 0\}$ and $\{w^N, 1\}$ yield equal utility if $w^F = w^N + \delta\alpha(\pi_2(e_0^*) - \pi_2(e^{**}) + V(e^{**}) - V(e_0^*))$. Substituting this into A's expected utility and simplifying, A strictly prefers a contract with $NCA = 1$ whenever $\delta(\pi_2(e^{**}) - \pi_2(e_0^*)) > c(e^{**}) - c(e_0^*)$ and strictly prefers $NCA = 0$ when the inequality is reversed. □

Proposition 3.5.1

Proof. I will show that, when $D^F = D^N = D^* = 0$, then, $e^{**} < e^* < \bar{e}_0^F = \bar{e}^N$ if $V'(\bar{e}_0^F) < \pi_2'(\bar{e}_0^F)$, and $e^{**} < \bar{e}_0^F = \bar{e}^N < e^*$ if $V'(\bar{e}_0^F) > \pi_2'(\bar{e}_0^F)$.

Proposition 3.4.1 establishes that $e^* > e^{**}$. By substitution of the definition of e_0^P, the condition $V'(e_0^P)) < \pi_2'(e_0^P)$ is equivalent to $\delta((1-\alpha)\pi_2'(e_0^P) + \alpha V'(e_0^P)) < c'(e_0^P)$. When that condition holds, $e^* < e_0^P$ by Assumption 7 and continuity of the constituent functions. The reverse is true when $\delta((1-\alpha)\pi_2'(e_0^P) + \alpha V'(e_0^P)) > c'(e_0^P)$ (i.e., when $V'(e_0^P) > \pi_2'(e_0^P)$). □

Proposition 3.5.2

Proof. I will show that, when $NCA = 1$, effort in a decentralized equilibrium is never first best (i.e., $e^{**} \neq \bar{e}^N$). When $NCA = 0$, effort in a decentralized equilibrium is first best whenever any of the following are satisfied:

1. $D^F = D^* = 1$;
2. $\pi_2'(\bar{e}_0^F) = V'(\bar{e}_0^F)$ and $D^F = 0$; or
3. $\pi_2'(\bar{e}_1^F) = V'(\bar{e}_1^F)$, $D^F = 1$, and $D^* = 0$.

Since $D^N \neq 1$, effort when $NCA = 1$ is given by e_0^P and e_0^{**}. The equations that define those effort levels yield different solutions whenever $pi_2'(e) > 0$, and therefore effort is not first best in the decentralized equilibrium when $NCA = 1$.

The equations that define e_1^P and e_1^* are identical ($c'(e) = \delta V'(e)$); thus, when $NCA = 0$ and $D^F = D^* = 1$, e^* is first best.

When $D^F = 0$, effort is defined by $c'(e_0^P) = \delta\pi_2'(e_0^P)$. Since $V'(e_0^P) = \pi_2'(e_0^P)$, $c'(e_0^P) = \delta V'(e_0^P)$. This equation defines e_0^*, so $e_0^* = e_0^P$. Similarly, $c'(e_0^P) = \delta(\alpha V'(e_0^P) + (1-\alpha)\pi_2'(e_0^P))$, which defines e_1^*, so $e_1^* = e_0^P$.

Similarly, when $\pi_2'(e_1^P) = V'(e_1^P)$, the definition of e_1^P may be rewritten as $c'(e_1^P) = \delta(\alpha V'(e_1^P) + (1-\alpha)\pi_2'(e_1^P))$, which also defines e_0^*. So, $e_0^* = e_1^P$. Therefore, in all listed cases, effort is first best. □

Proposition 3.6.1

Proof. I will show that, if $\bar{e}^F$, $\bar{e}^N$, e^*, and e^{**} are unique and $B'(e) < 0$, then $e^* > \bar{e}^F > \bar{e}^N > e^{**}$.

First, I show that $e^* > e_0^P$. The function of e equated with $c'(e)$ to determine e^* lies above the analagous function for e_0^P for a given e if

$$(1 - G(B(e)))V'(e) + G(B(e))((1-\alpha)\pi_2'(e) + \alpha V'(e)) > \\ (1 - G(B(e)))V'(e) + G(B(e))\pi_2'(e),$$

which is true since $B'(e) = \pi_2'(e) - V'(e) < 0$. By uniqueness, $e^* > e_0^P$.

Similarly, $e_0^P > e_1^P$ since $(1 - G(B(e)))V'(e) + G(B(e))\pi_2'(e) > \pi_2'(e)$. Finally, $e_1^P > e^{**}$ since $\pi_2'(e) > (1-\alpha)\pi_2'(e)$. □

Proposition 3.6.2

Proof. Let $S^i_{NCA}(\varepsilon)$ represent ex post joint surplus achieved in the planner's problem ($i = P$) and the decentralized equilibrium ($i = D$) for $NCA = 0$ and $NCA = 1$. Suppose that $c''(e) > 0$, $V''(e) < 0$, and $\pi_2''(e) < 0$. I will show that, when $\varepsilon > B(e)$ for $e \in \{\bar{e}^F, e^*\}$, $S_0^D(\varepsilon) - S_1^D(\varepsilon) > S_0^P(\varepsilon) - S_1^P(\varepsilon)$.

First, I explicitly define $S^i_{NCA}(\varepsilon)$ for values of $\varepsilon > max\{B(e_0^P), B(e^*)\}$:

$$\begin{aligned}
S_0^D(\varepsilon) &= -c(e^*) + \delta(V(e^*) + \varepsilon + \varepsilon_c + \pi_n) \\
S_1^D(\varepsilon) &= -c(e^{**}) + \delta(\pi_2(e^{**}) + \varepsilon_c) \\
S_0^P(\varepsilon) &= -c(e_0^P) + \delta(V(e_0^P) + \varepsilon + \varepsilon_c + \pi_n) \\
S_1^P(\varepsilon) &= -c(e_1^P) + \delta(\pi_2(e_1^P) + \varepsilon_c)
\end{aligned}$$

Note that, since $\varepsilon > max\{B(e_0^P), B(e^*)\}$, $D_0^F = D^* = 1$: A spins off at $t = 2$ when able.

Rearranging the desired inequality to $S_0^D(\varepsilon) - S_0^P(\varepsilon) > S_1^D(\varepsilon) - S_1^P(\varepsilon)$ and cancelling all instances of ε, it may be written as:

$$\begin{aligned} -c(e^*) + \delta(V(e^*) + \varepsilon + \pi_n) + c(e_0^P) - \delta(V(e_0^P) + \varepsilon + \pi_n) \\ > -c(e^{**}) + \delta\pi_2(e^{**}) + c(e_1^P) - \delta\pi_2(e_1^P) \end{aligned} \tag{A.9}$$

Note that the right hand side is negative: e_1^P maximizes $c(e) - \delta\pi_2(e)$ and e^{**} does not.

Now, consider the left hand side. Define e^M as the value of e that maximizes $-c(e) + \delta V(e)$. Then, e^* always lies between e_0^P and e^M: if $V'(e) > \pi_2'(e)$, $e_0^P < e^* < e^M$ (by the logic described in Proposition 3.6.1). This holds in reverse when $V'(e) < \pi_2'(e)$ by the same logic. Since $-c(e)+\delta V(e)$ is concave (as $V(e)$ is convex and $c(e)$ is concave) and e^M is its maximizer, the fact that e^* is closer to e^M implies that $-c(e^*)+\delta V(e^*) > -c(e_0^P)+\delta V(e_0^P)$. Addition of the constant $\varepsilon+\pi_n$ does not change this. Therefore, the left hand side of Inequality A.9 is positive, and by extension, is greater than the right hand side which has been shown to be negative. Therefore, the proposition is proven. $\square$

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CURRICULUM VITAE

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