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Essays in Law and Economics

Ádám Fehér

The first two papers of my PhD thesis focus on non-competition agreements, while the final chapter examines the liability of digital social media platforms for user-generated content. All three papers develop a microeconomic model grounded in standard labor economics theory to investigate how regulatory measures regarding noncompetes and digital platform liability could enhance social welfare.

Ádám Fehér holds a BSc in Economics from Corvinus University of Budapest and an Mphil degree in Economics from the Tinbergen Institute. In 2018, he commenced his PhD studies at the University of Amsterdam supervised by Giuseppe Dari-Mattiacci and Enrico Perotti. Adam currently works as a post-doctoral researcher at the Institute for Labour Law and Industrial Relations in the European Union, based at Trier University in Germany.

Essays in Law and Economics Ádám Fehér

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Essays in Law and Economics

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Contents

1 Introduction **1**

2 Non-competition Agreements and Dedicated Human Capital **3**

2.1 Introduction 3

2.2 Related Literature 9

2.3 Model 12

2.3.1 Description 12

2.3.2 Timeline 14

2.3.3 Objectives 16

2.4 Contracts 17

2.4.1 Possible Contracts 17

2.4.2 Optimal contract 20

2.4.3 Comparative statics 24

2.4.4 Expected probability to stay with the firm 25

2.4.5 Employee's utility 25

2.4.6 Cost of employment 26

2.5 Regulation of noncompete 27

2.5.1 Position dependent regulation 28

2.5.2 Uniform regulation 31

2.6 Multiple periods 35

2.6.1 Unanticipated second period 36

2.6.2 Optimal contract for the two period model 39

2.7 Extensions 43

2.7.1 Relaxing rationality of the agents . . . 43
2.7.2 Multiple firms . . . 44
2.8 Conclusion . . . 44

A Appendix **47**
A.1 Motivating evidence . . . 47
A.1.1 Data . . . 47
A.1.2 Hierarchy measure . . . 47
A.1.3 Statistical test . . . 48
A.1.4 Robustness checks . . . 49
A.1.5 Wage premium . . . 53
A.2 Extension . . . 55
A.2.1 Continuous noncompete . . . 55
A.2.2 Relaxing rationality of agents . . . 56
A.2.3 Multiple firms . . . 64
A.2.4 Effort . . . 66
A.2.5 Correlated production . . . 67
A.3 Figures from simulations of the model . . . 70
A.3.1 Sophistication . . . 71
A.4 Proofs . . . 73
A.4.1 Proof of Lemma 1 . . . 73
A.4.2 Proof of Lemma 2 . . . 73
A.4.3 Proof of Lemma 2.4 . . . 73
A.4.4 Proof of Proposition 2.3 . . . 74

3 Guarding Expertise and Assets: Non-competition Agreements and Their Implications **79**
3.1 Introduction . . . 79
3.2 Model . . . 86
3.2.1 Setup . . . 86
3.2.2 Outside option . . . 89

3.2.3 Payoffs . . . 91
3.2.4 Participation constraint . . . 92
3.2.5 Actions and outcomes . . . 92
3.2.6 Parameter assuption . . . 93
3.3 Optimal contract - Baseline model . . . 93
3.3.1 Low ability . . . 93
3.3.2 High ability . . . 97
3.3.3 Firm size . . . 98
3.3.4 Investment . . . 102
3.4 Different outside option than firm damage . . . 103
3.4.1 Wage . . . 106
3.4.2 Wage to induce staying . . . 111
3.4.3 Firm size in terms of firm damage and employee's outside option . . . 112
3.5 Efficiency of noncompete . . . 113
3.5.1 Firm damage is larger . . . 114
3.5.2 Employee's outside option is larger . . . 114
3.6 Conclusion . . . 116

B Appendix **117**

B.1 Figures . . . 117
B.2 Proofs . . . 118
B.2.1 Proof of Proposition 3.1 . . . 118
B.2.2 Proof of Proposition 3.2 . . . 120
B.2.3 Proof of Proposition 3.3 . . . 122
B.2.4 Proof of Lemma 3.6 . . . 123
B.2.5 Proof of Proposition 3.4 . . . 123
B.2.6 Proof of Lemma 3.8 . . . 125
B.2.7 Proof of Lemma 3.9 . . . 126
B.2.8 Rearranging first order condition of equation 3.43 . . . 127
B.3 Parameter values . . . 128

4 How to Enforce Platforms' Liability? 129

4.1 Introduction . . . 129

4.2 Related Literature . . . 133

4.2.1 Empirical evidence for cherry-picking . . . 136

4.3 Model . . . 138

4.3.1 Model Description . . . 138

4.3.2 Comments on the model setup . . . 141

4.4 Analysis . . . 143

4.4.1 Baseline model . . . 144

4.4.2 Cherry-picking . . . 146

4.4.3 Improving technology . . . 150

4.5 Extending the regulator's strategy . . . 151

4.5.1 Weighting users . . . 152

4.5.2 Type dependent fine . . . 153

4.5.3 Fines as a function of relative type . . . 154

4.5.4 First best with sufficiently high fine against cherry-picking (f_1) . . . 156

4.6 Model extensions . . . 158

4.6.1 Compliant agents . . . 158

4.6.2 Platform's imperfect technology . . . 160

4.6.3 User liability . . . 162

4.7 Additional application . . . 162

4.8 Conclusion . . . 163

C Appendix 165

C.1 Proofs . . . 165

C.1.1 Proof of Lemma 4.1 . . . 165

C.1.2 Proof of Lemma 4.2 . . . 165

C.1.3 Proof of Proposition 4.1 . . . 166

C.1.4 Proof of Proposition 4.2 and 4.3 . . . 167

C.1.5 Proof of Lemma 4.3 . . . 168

C.1.6 Proof of Lemma 4.4 168
C.1.7 Proof of Lemma 4.5 169
C.1.8 Proof of Proposition 4.5 169
C.1.9 Proof of Proposition 4.6 171
C.1.10 Proof of Proposition 4.7 173

5 Summary **175**

Chapter 1

Introduction

The first two papers of my PhD thesis focus on non-competition agreements (noncompetes), while the final chapter examines the liability of digital social media platforms for user-generated content. All three papers develop a microeconomic model grounded in standard labor economics theory to investigate how regulatory measures regarding noncompetes and digital platform liability could enhance social welfare.

The chapter "Non-competition Agreements and Dedicated Human Capital" explores how the optimal stringency of a noncompete varies with the employee's position inside a firm's hierarchy. I find that in equilibrium, employees at both the top and bottom positions are subject to a noncompete while those in middle positions are free from the covenant. My analysis also contributes to the heated debate on whether noncompetes should be banned, particularly for bottom positions. I demonstrate that prohibiting noncompete agreements for bottom position of the firm's hierarchy could bolster social welfare, provided that the expected quality of labor is moderate.

In "Guarding Expertise and Assets: Non-competition Agreements and Their Implications" I examine the contracting problem between a firm and potential employees, highlighting a key distinction from the previous chapter: the firm's lesser maturity. Therefore, the choice of which agent to hire based on ability and the degree of access granted to the firm's critical assets is crucial. I demonstrate that firms, conditional on hiring lower ability agents, primarily compensate them through access, coupled with the minimum wage and the most stringent noncompete. For higher ability agents, the maximum degree of access

is provided, while the wage and stringency of the noncompete depends on the damage the employee causes with competing. For low damages, the firm offers a lax noncompete with lower wages. Conversely, high potential damage necessitates higher wages and a stricter noncompete. The study's findings are consistent with observed patterns in CEO contracts.

The final chapter, titled "How to Enforce Platforms' Liability?", delves into the liability of social media platforms for user-generated content, a subject that has attracted significant attention alongside the introduction of new regulations like the Digital Services Act. This chapter develops a theoretical model to explore how such regulatory frameworks influence the economic incentives of social media platforms dealing with users of varying popularity. The chapter argues that oversimplified regulations may worsen the problem of cherry-picking, where platforms penalize only low type users and not high type ones for violations. The paper proposes that regulators enhance their technology to monitor more content and adjust fines based on the audience size of users, observable ex post. Intriguingly, under this approach, the optimal fine might be reduced when more users commit violations.

Chapter 2

Non-competition Agreements and Dedicated Human Capital

2.1 Introduction

"Curtail the unfair use of non-compete clauses and other clauses or agreements that may unfairly limit worker mobility", said President Joe Biden when instructing the Federal Trade Commission to regulate the use of non-competition agreements (noncompetes).[1,2] The reason for the heated policy debate about the regulation of noncompetes [Krueger and Posner, 2018, Lobel, 2019, Barnett and Sichelman, 2020, Lemley and Lobel, 2021] is the recent surge in their frequency [Johnson and Lipsitz, 2020, Prescott et al., 2021], while the welfare impacts of them are unclear. The evidence also shows that not only have noncompetes been popular to retain top employees [Garmaise, 2009, Kini et al., 2021] but low-paid workers are also subject to them [Prescott and Starr, 2021, Shubber, 2018].[3] Studies also provide mixed results on the impact of noncompetes on wages. Some conclude that a decrease in the enforceability of noncompetes increases wages [Johnson et al., 2021, Lipsitz and Starr, 2021, Starr et al., 2019], while others find the opposite effect [Kini et al., 2021, Lavetti et al., 2019, Guimaraes et al., 2021].

[1] CNBC, 22-07-2021

[2] "[N]on-compete agreements are contracts between workers and firms that delay employees' ability to work for competing firms." ([US-Treasury, 2016], p.3).

[3] I provide further motivating evidence based on individual firm's hierarchies in Appendix A.1.

In this paper, I study how the employee's position inside a firm determines the optimal contract, including the stringency of the noncompete. I analyze whether the firm provides a compensating differential[4] for including a noncompete in the employee's contract. Moreover, I contribute to the ongoing policy debate on the regulation of noncompetes by formally highlighting the tradeoffs from a social perspective. A regulator bans noncompetes for the bottom of the hierarchy if the match between the firm and the employee is expected to be moderate, that is, neither too good nor too bad. When the match is good, allowing the employee to compete would lead to lower productivity and, consequently, reduced social welfare. On the other hand, if the match is bad, the firm only has a high enough expected profit to employ the agent if noncompetes are permitted. Therefore, with a moderate match, allowing the employee the opportunity to compete can enhance productivity and increase social welfare, while still ensuring the firm maintains sufficient expected profit to employ the agent. Furthermore, optimal regulation entails more stringent noncompete provisions for top positions compared to bottom positions. In the case of Uniform regulation of noncompete agreements, a complete ban, as proposed by the Federal Trade Commission [Federal Trade Commission, 2023], is likely to be the optimal approach.

The theoretical model builds on the core idea that both the firm and the employee (she) may hold up the other party. The firm may dismiss the employee, while the employee can leave the firm to work for a competitor. The holdup problem [Williamson, 1979] arises when both parties make an irreversible decision during employment. On the one hand, the firm provides training to the agents hired from a homogeneous labor market. The training is a combination of firm specific and industry specific knowledge, with the composition being determined by exogenous industry characteristics.[5] Training is the determinant of the employee's position inside the firm's hierarchy. On the other hand, the employee faces the irreversible decision of choosing whether to exert effort or to shirk.[6] The concept of effort refers to the employee's commitment to invest time and energy in enhancing her value, not

[4]In other words, a wage premium.

[5]This part of the modeling approach is similar to Lazear [2009].

[6]Earlier literature uses the notions of exerting effort and shirking [Amir and Lobel, 2013],[Barnett and Sichelman, 2020], [Barnett and Sichelman, 2016] Important is that not only has exerting effort a return inside the firm but also outside of it. Therefore, the notion of generic and specific human capital investment [Becker, 1962] is also suitable for the model with a modification that specific investment denotes industry specific in the current context and not firm specific.

only to the firm but also to potential competitors. By exerting effort, the employee can increase her value both inside and outside the firm. In contrast, shirking entails not putting in the required effort, resulting in no change in the employee's baseline value in the industry. However, shirking is accompanied by private benefits that provide additional outside options in another industry. To illustrate, consider the example of a programmer who decides to specialize in search engine optimization. While this specialization enhances her value to her current IT firm and its competitors, it limits her ability to expand her more generic IT knowledge. As a result, she becomes more valuable to firms that can benefit from her new skills, while her value is less significant to firms that do not require or utilize those skills.[7]

An important feature of the model is the impact of noncompete agreements on the employee's incentives to exert effort. A noncompete restricts the employee's ability to utilize her effort at a competitor within the same industry. However, it does not impede the employee's ability to join firms outside the industry. As a result, an employee who is subject to a noncompete has greater incentives to shirk.

In equilibrium, the firm includes a noncompete in the contracts of employees in top positions and restores their incentives to exert effort by providing high compensation. The marginal productivity of effort is highest in these positions, and correspondingly, the firm faces the highest costs in terms of forgone production and potential competition. As a result, employees in top positions are subject to noncompete agreements to reduce the likelihood of their departure. Nevertheless, the expected wage compensates employees for the noncompete, incentivizing them to exert effort. This finding aligns with the arguments made by Barnett and Sichelman [2016, 2020], who suggest that firms can restore incentives through alternative forms of compensation. In the current model, increasing the wage is equivalent to providing conditional rewards such as bonuses or stock options, given the linear utility function of the agent.

For positions in the middle of the firm's hierarchy, the firm does not include a noncompete in the contract to provide the maximum incentives to exert effort, while keeping the wage low. The marginal productivity of effort is high enough for middle positions that the firm offers a contract to induce effort. By allowing the employee to compete freely, the employee's benefit

[7]The example is similar to one of the motivations for open source projects by Lerner and Tirole [2005].

from exerting effort is higher compared to the case when she is subject to a noncompete. Therefore, a lower wage is sufficient to induce effort. If the employee stays with the firm ex post, the firm only needs to pay a low wage for her production, while if she leaves, her forgone production and damage are not as high as for employees at the top.

The noncompete reappears for employees at the bottom of the firm's hierarchy, and the employees shirk on effort. In these positions, the employee's production within the industry is only slightly higher than outside of it. If the employee exerts effort, she forgoes the outside industry option. The wage that incentivizes effort is too expensive for the firm compared to the employee's expected productivity with the firm. Therefore, the firm anticipates that the employee will shirk on effort. Imposing a noncompete decreases the probability that the employee leaves for the competitor in the industry and hence increases the profit of the firm. The wage offered is high enough to prevent the employee from leaving the industry if the firm prefers to retain her.

This finding aligns with anecdotal evidence suggesting that employees at the bottom of the firm often sign noncompete agreements when requested by the firm, without receiving any additional compensation [Prescott and Starr, 2021, Arnow-Richman, 2011]. Therefore, an employee in a lower position within the firm's hierarchy is consistently worse off when asked to sign a noncompete by the firm.

The regulator overseeing the stringency of noncompetes trades off the following two main effects. On the one hand, a more stringent noncompete incentivizes the provision of training from the firm ex ante, resulting in a larger firm size [Lipsitz and Johnson, 2018, Rauch, 2015] that increases social welfare. On the other hand, the noncompete hinders the employee from leaving for a competitor ex post. Whether the prevention of employee departure increases or decreases social welfare depends on the employee's productivity at the competing firm. If the employee is more productive inside the firm but has a better outside option than her wage, she chooses to join the competitor. Noncompete can block this inefficient action. However, the opposite scenario can also arise, in which case noncompete decreases the employee's payoff and overall social welfare. Hence, a crucial parameter of the model is the relative productivity of the agent at the competitor compared to the firm. Therefore, in cases where the employee's productivity with the firm is high enough to incentivize training provision,

but also low enough that allowing competition could lead to improved social welfare, it is optimal to prohibit noncompetes.

A ban on noncompetes for bottom positions has sparked intense debate, as evidenced by the research of Krueger and Posner [2018], Lemley and Lobel [2021]. Lobel [2019], Barnett and Sichelman [2020] provide a comprehensive review of recent legislative changes and initiatives in this area. During the period of 2014-2019, a total of 24 changes to state laws regarding noncompetes were enacted. While the majority of these changes aimed to reduce the enforceability of noncompetes, there were also 6 changes that increased their enforceability. The issue gained even more attention following an executive order by the US President in July 2021.[8] The Federal Trade Commission (FTC) has shown interest in regulating the usage of noncompetes, as indicated in its strategic plan for 2022-2026 [Federal Trade Commission, 2021].[9] In line with this, the FTC proposed a complete ban on noncompetes in January 2023 [Federal Trade Commission, 2023]. Boeri et al. [2022] shows that the prevalence of noncompetes is not US specific. It is worth noting that the prevalence of noncompetes extends beyond the United States. Boeri et al. [2022] reveals that 16% of private sector employees in Italy are subject to noncompetes, which is slightly lower than the corresponding figure in the US, as reported by Prescott et al. [2021].

Subsequently, I extend the baseline model to multiple periods to illustrate how the bargaining power of the firm may increase over time. This issue was highlighted in a class action suit against the fast food restaurant company Jimmy Johns, where employees argued that the firm developed holdup power over time.[10]The theoretical model supports similar conclusions. Specifically, it predicts that employees in lower positions earn lower than the market wage in subsequent periods, despite an increase in their expected productivity with the firm. The rationale is as follows: subject to a noncompete, these employees face a reduced, yet positive, positive probability of securing better-paying jobs in the industry, obviating the need for the firm to increase wages. Similarly, employees in higher positions may face a more severe holdup problem in the second period if they exerted effort in the first period,

[8]CNBC, 22-07-2021
[9]WSJ, 09-06-2022
[10]Case Number 18-cv-0133-MJR-RJ

potentially deterring them from exerting effort in the first place.[11] As a response, the firm may induce effort by increasing the first period wage of the employee, or only includes a lax noncompete in the contract as a commitment device to avoid holding up the employee. In cases where including a more lenient noncompete is not beneficial for the firm, reducing the stringency of noncompetes through regulation could enhance welfare.

Furthermore, I consider several additional extensions. First, I analyze a modification to the model where the employee holds incorrect beliefs about the extent of her noncompete agreement. Empirical evidencesuggests that employees often lack knowledge about the specific terms and limitations of their noncompete agreements [Prescott and Starr, 2021]. In this modified setup, the employee may behave as if her noncompete were either more lenient or more restrictive than the actual restriction. The firm can strategically manipulate the employee's belief about the enforceability of the noncompete. Specifically, the extension demonstrates that deceiving agents into believing they are subject to a more restrictive noncompete than the actual restriction can lower the employee's utility.

Subsequently, I introduce heterogeneity to the model by incorporating both naïve and sophisticated agents. Naïve agents underestimate the strictness of the noncompete and exert effort under contracts that sophisticated agents would not. In equilibrium, naïve agents are employed in lower positions, while sophisticated agents occupy higher positions, and all employees exert effort. The misperception of the noncompete mitigates the commitment problem related to effort, making naïve agents an attractive choice for the firm. However, if a regulator were to ban noncompete agreements, the advantage of naïve agents would be eliminated.

I also demonstrate that introducing a second firm into the market at the game's start creates a competitive dynamic between the two firms. Such a scenario may result in an asymmetric equilibrium. Specifically, it is possible for one firm to find it more profitable to act as the competitor, offering a different contract than the incumbent. To delve deeper into

[11] In a setup where the employee can modify their effort choice between the two periods, they cannot be held up, as they can always switch to shirking. Similarly, the classical holdup problem [Williamson, 1979] would also diminish if the players could reverse their investments. Therefore, the usual holdup scenario arises when the employee's first-period action carries over to the second period. The employee can choose to specialize their human capital to the industry or keep it more generic, similar to the classical model by Becker [1962].

this two-firm competition scenario, I analyze the game with two firms and two employees, too. This analysis not only confirms the baseline findings, but also highlights the potential emergence of a prisoner's dilemma situation. In this scenario, both firms face incentives to deviate from the cooperative outcome and compete for the employee.

This paper is structured as follows. Section 2.2 provides a literature review, discussing the connections between my work and existing research. Section 2.3 presents the model, outlining its key assumptions and components. Section 2.4 derives the optimal contract within the model. Section 2.5 examines the regulator's problem and analyzes the implications of different regulatory approaches. Section 2.6 extends the model to incorporate multiple periods. Section 2.7 introduces further extension with bounded rationality and multiple firms. Finally, Section 2.8 concludes the paper.

2.2 Related Literature

Economic theory suggests that noncompetes can help alleviate the hold up problem by aligning the incentives of the employer and employee [Lipsitz, 2017]. The closest model to mine by Ghosh and Shankar [2017] examines the impact of noncompete stringency on firm investment and employee incentives. However, their focus is on a representative employee, while my model considers heterogeneous positions and contracts. Additionally, I incorporate the effect of noncompete on the arrival rate and wage of outside options, distinguishing it from prior research.

Other studies have explored various aspects of noncompete agreements. Shi [2023] examines optimal regulations for top employees, while my paper focuses on employees at the bottom of the hierarchy. Garmaise [2009] studies the tradeoff of co-investment between firms and workers but assumes noncompete as exogenous, while my model endogenizes noncompete and allows for strategic compensation adjustments. Krakel and Sliwka [2009] investigates the incentive effects of noncompete on effort in a group environment, whereas my model examines individual positions within the firm. Lipsitz [2017] explores the impact of centralized decision-making on effort, but differs from my model as they consider noncompete as exogenous.

The early literature predominantly highlights how noncompete affects high-skilled employees [April and Matthew, 2008, Krakel and Sliwka, 2009]. However, low wage workers can be subject to the restriction too, such as physicians [Lavetti et al., 2019], cleaning staff [Shubber, 2018], and sandwich makers [Neil, 2014]. In the models of Lipsitz [2017], Lipsitz and Johnson [2018], the employer is forced to give a minimum wage in each period to the workers. However, the employer values the worker's contribution less than the minimum wage. As the employee learns, his contribution becomes more valuable both inside and outside the firm. A noncompete agreement allows the firm to increase the worker's pay less steeply as his outside opportunity is less lucrative. In my model, however, the result is not driven by an exogenous minimum wage constraint, rather it comes from that the productivity difference between inside the industry and outside of it is small at the bottom pistons of the firm hierarchy.

Wickelgren [2018], and Johnson and Lipsitz [2020] consider how constraints on wages, or more broadly the non-transferability of utility, can result in the inclusion of a noncompete agreement in the optimal contract, even for low wage workers. Wickelgren [2018] uses a dynamic setup to show that firms invest more when the employee is subject to a stronger noncompete. My model is similar in that the firm has a larger size if the noncompete is more restrictive. However, noncompete also influences the effort decision of the employee and thus the impact on production is ambiguous. Johnson and Lipsitz [2020] builds a general equilibrium model where the marginal firm's participation constraint is only met via the inclusion of noncompete. By the law of one price, other firms also include noncompete, despite noncompete reduces the employee-employer surplus. In the partial equilibrium model of this paper, however, the firm includes noncompete solely based on the tradeoff between decreasing the probability of competing and decreasing the employee incentives.

A growing body of empirical literature estimates the relation and impact noncompete clauses have on wages, training, and mobility. Standard economic theory suggests that since the inclusion of noncompete is endogenous, employees must receive a higher wage or other compensation if they are subject to it, keeping everything else constant. Empirical evidence, however, is less clear on the subject. Marx et al. [2009] show that enforcement of noncompete attenuates mobility. Starr et al. [2019] find that increasing enforceability of noncompete

agreements increases the training firms provide to their employees. Balasubramanian et al. [2020] show that both wages and mobility increased after a ban on noncompete in Hawaii. The majority of the empirical research focuses on whether the wage increases [Johnson et al., 2021, Lipsitz and Starr, 2021, Starr et al., 2019] or decreases [Kini et al., 2021, Lavetti et al., 2019, Guimaraes et al., 2021] if the enforceability of noncompetes decreases.

An experimental study by Amir and Lobel [2013] finds employees restricted by post-employment covenants underperform those without restrictions. Barnett and Sichelman [2016, 2020] argue that the firm has an interest in restoring its employees' incentives that are distorted by imposing the noncompete. My model combines the two arguments. Employees have less incentives to provide effort when they are subject to a noncompete, however, they may receive compensation for agreeing to the covenant. At bottom positions, the firm does not provide enough incentives for the employee to exert effort, independent of the noncompete. At top positions, however, the firm promises a high enough wage such that the employee exerts effort.

The paper also relates to the literature on firm and industry specific training and investment. Starting from Becker [1962], a central question of specific and generic human capital literature is which party bears the costs. Several authors have challenged Becker's conclusion that the firm only subsidizes specific investment in a frictionless world [Acemoglu and Pischke, 1998, 1999]. This paper's model uses a framework where the firm sponsors the industry-specific training, that is the training increases the employee's human capital in the industry, but not outside of it. Moreover, the training increases the productivity the most at the firm providing it. The approach is similar to the idea of Lazear [2009].

The employee's effort decision is also modeled similar to a human capital decision. The employee may specialize her human capital or keep it generic. Therefore, the model is related to Rajan and Zingales [1998, 2001]. The difference is that the employee specializes to the industry, meaning the expected value of the outside option inside the industry increases, and only the outside option in other industries decreases.

The model setup also connects to the behavioral contract theory literature on reference points [Hart and Moore, 2008, Hart and Holmström, 2010, Hart, 2009], with the reference point being the contract without noncompete. If the employee is asked to sign the noncom-

pete she may feel aggrieved and thus shades on performance, that is choosing the shirk.

2.3 Model

2.3.1 Description

At $t = 0$ a risk neutral firm hires a risk neutral agent (she). The labor market consists of ex ante identical agents, and there are no other firms in the market at $t = 0$. The contract the firm offers specifies the position the employee is hired for, θ, and the wage, w. Moreover, the contract includes the covenants whether the employee is subject to a noncompete, $NCC = 1$, or not, $NCC = 0$.[12] After an agent is hired, she receives training from the firm to become qualified for her position. The training cost is $c\theta$ where c is the marginal cost of training for the firm.[13] An agent receiving more training has a higher position in the firm.

The employee makes her effort choice at $t = 1$. She has a unit of time that she can spend either improving her skills to succeed in the industry or she can improve skills that are profitable outside the industry. From the firm's perspective, only industry specific skills are beneficial, while working on other skills is considered shirking. Therefore, I denote the choice of industry skills as exerting effort, $e = 1$, and the choice of other skills with $e = 0$, consistently with the existing literature.[14]

The firm can observe the employee's effort choice. The competitor and other firms outside the industry can also observe the employee's effort choice, for example through interviews and tests during the hiring process.[15] Following the literature on incomplete contracting [Hart and Moore, 1990], the court cannot verify whether the employee exerted effort. Hence, the firm cannot make the contract contingent on effort.

The employee is either productive or unproductive with the firm. Her effort choice

[12] Appendix A.2.1 shows that the binary choice is without loss of generality.

[13] The firm paying for the training is the relevant case for noncompetes.

[14] The effort choice impacts future employment options. It is an investment into the employee's own human capital. However, previous literature on noncompete [Barnett and Sichelman, 2020, 2016, Lobel, 2014] labels the notion as effort choice, therefore I follow this convention. The notion of industry specific and generic human capital is also suitable for the model.

[15] If the employee's outside option is starting her own firm, such as for hairdressers, physicians, or lawyers, her effort choice need not be observed by another firm.

influences the ex ante probability of being productive. The expected production of the employee, $E(F(\theta))$, if she shirks is

$$E(F(\theta)) = p\theta, \tag{2.1}$$

and it becomes

$$E(F(\theta)) = (p + e\Delta)\theta, \tag{2.2}$$

if she exerts effort.

The default probability of the employee's productivity, or the quality of labor, is denoted as $p > \frac{1}{2}$. This probability increases by Δ when the employee exerts effort. The variable e represents this effort, taking a value of 1 when effort is exerted and 0 otherwise. If the employee is unproductive, her production level is set to 0

At $t = 2$, the firm observes the employee's productivity and makes a decision regarding dismissal based on this observation. The observation could be linked to a test or a project that the employee completes, allowing the firm to directly observe the outcome. Depending on whether the employee is deemed productive or unproductive, the firm will make a decision on whether to retain or dismiss the employee.

The main friction in the model arises from the employee's inability to commit to staying with the firm despite receiving training from it. At $t = 3$, the employee receives outside options that are endogenous to the contract and her effort decision. The expected value of the offer made by a competitor to an employee who is not subject to a noncompete is given by:

$$E(O(\theta)) = (q + e\Delta)\gamma\theta. \tag{2.3}$$

Here, $\gamma \leq 1$ represents the degree of similarity between the firm and other competing firms within the industry (referred to as "competitor"). It indicates the extent to which the training provided by the firm is firm-specific versus industry-specific. A higher value of γ implies more industry-specific training. The outside option arises with a baseline probability of q, but the employee can increase this probability by exerting effort, with the magnitude of increase denoted by $\Delta < 1 - p$. Additionally, the employee's production and the event of

	Employee	Firm
Stay	$w(\theta)$	$\theta - w(\theta)$
Compete	$\gamma\theta$	$-a\theta$
Other Industry	1	0

Table 2.1: The employee's and the firm's payoff as a function of the employee's decision

a competitor making an offer occur independently from each other.[16]

Noncompete is introduced as a choice variable that influences the probability of the outside option. When an employee is subject to a noncompete, the probability of receiving the outside option is reduced to $\bar{\lambda}(q + e\Delta)$, where $\bar{\lambda} \in [0, 1]$ represents the level of stringency of the noncompete clause. A lower value of $\bar{\lambda}$ indicates a more restrictive noncompete. It is important to note that the employee can only receive an offer from outside the industry if she chooses not to exert effort ($e = 0$). For simplicity, the arrival rate of the outside option is assumed to be 1, and the value of the offer is normalized to be 1. It is crucial to highlight that while a noncompete restricts the employee's options within the industry, it does not affect the arrival rate of offers from outside the industry.

The employee privately observes whether the competitor makes her an offer, and based on this information, the firm makes a decision regarding dismissal. Subsequently, the employee makes a decision to either stay with the firm or leave for one of her outside options. In the case of the employee leaving for the competitor, the firm incurs damages due to the potential loss of valuable knowledge, information, clients, or other intangible assets [Lipsitz and Tremblay, 2021, Krakel and Sliwka, 2009]. The magnitude of these damages increases with the amount of training the employee has received. Specifically, the damage function is given by $A(\theta) = a\theta$, where $0 \leq a < p - c$.[17]

Table 2.1 provides a summary of the payoffs for both the employee and the firm, depending on the employee's decision regarding whether to stay or leave.

2.3.2 Timeline

The timeline of the model is summarized below.

[16]The assumption of independence is relaxed in Section A.2.5 of the Appendix.

[17]The parameter a is chosen to be low to reflect the applicability of the model to the lower positions in the firm's hierarchy, as the damage is determined by the employee's position θ.

- t=0

  A) The firm and employee contracts on wage, noncompete for a certain position. The position is taken as given by both parties.

  B) The employee receives the training according to her position.

- t=1

  The employee chooses e=1 or e=0.

- t=2

  The firm observes whether the employee is productive.

- t=3

  A) Employee privately learns outside options.

  B) The firm decides on dismissal

  C) Employee decides to stay or leave

- t=4 Payoffs are realized. If the employee stayed, production takes place and the wage is paid.

Figure 2.1 shows the decision of the game after the contract is signed by the employee.

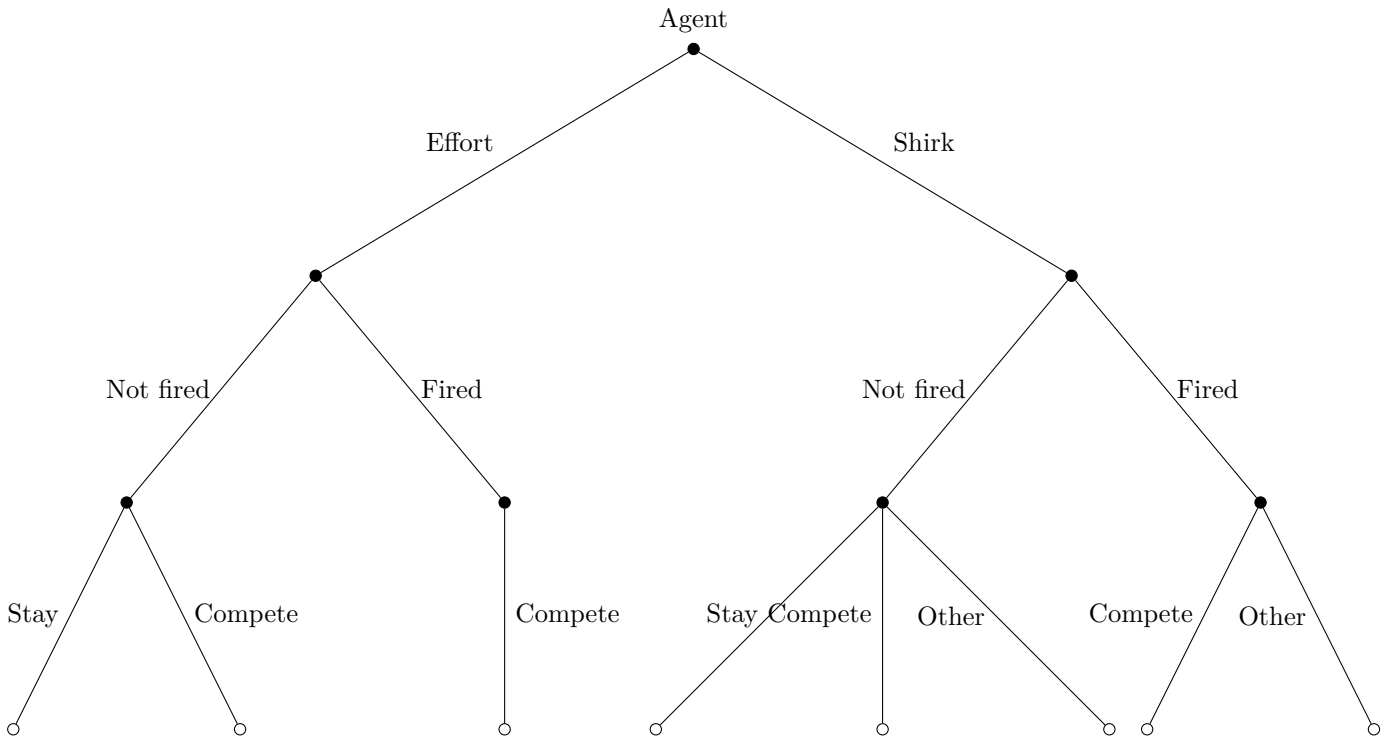


Figure 2.1: Decisions of the game

2.3.3 Objectives

The firm's objective is to maximize its expected profit, while the employee aims to maximize her expected utility. The expected profit of the firm is calculated as the difference between the expected production and the expected costs, including wages, damages, and training expenses. The firm bears the cost of training. On the other hand, the employee's expected utility consists of the expected wage and the expected value of the outside option.

The general functional forms for the firm and employee can be expressed as follows:

$$\pi = \text{expected production} - \text{expected wage} - \text{expected damage} - \text{training cost} \tag{2.4}$$

$$U = \text{expected wage} + \text{expected outside option} \tag{2.5}$$

I elaborate on the functions in detail in section 2.4.1.

To ensure that the employee achieves the highest output in the industry, two conditions must be met: $\theta > 1$ and $\gamma\theta > 1$. The parameter θ represents the output when the employee

produces with the firm, while $\gamma\theta$ denotes the output when the employee competes in the industry, with '1' being the baseline output if the employee leaves the industry. To fulfill these conditions, I make the parameter assumption of $\theta > \frac{1}{\gamma}$.

The main question of the model is how the optimal contract changes with varying positions. I break ties in favor of the firm if a slight increase in the pay would provide incentives to the employee to take the firm's preferred action.

2.4 Contracts

This section discusses the contract with and without noncompete, together with the employee's best response. I solve the problem with backward induction within each contract. Subsequently, I derive the optimal contract.

2.4.1 Possible Contracts

2.4.1.1 Noncompete

I solve the model by backward induction starting from the employee's decision on whether to remain with the firm, compete, or depart from the industry. To begin, I examine positions situated towards the lower end of the firm's hierarchical structure. In the model, these lower-level positions correspond to smaller values of θ. Consequently, the offer extended by a competitor to the employee, denoted as $\gamma\theta$, is also relatively small. Hence, this offer does not provide a substantial incentive for the employee to exert effort. If the firm offers a wage below 1, the employee could shirk and leave for the other industry. It results in no production and negative profit for the firm due to the costly training.

As a result, the wage for low θ's must be set to be least 1. Since the firm could marginally increase the wage over 1 to dominate the outside industry option, I break the tie in favor of the firm. Therefore, I analyze the contract where $w(\theta) = 1$. Therefore, the employee opts to stay with the firm when comparing the outside industry option to staying with the firm. With θ close to $\frac{1}{\gamma}$, the payoff form competing is close to 1 too. Consequently, the employee lacks sufficient incentives to exert effort, as she is unwilling to forgo the opportunity of

working in the other industry. Next, I write down the utility and profit function under this contract. The order of arguments are position (θ), noncompete (NCC=0 or NCC=1), wage ($w(\theta)$), and effort ($e = 1$ or $e = 0$). For example, $U(\frac{1}{\gamma}, 0, 1, 0)$ means the utility at position $\frac{1}{\gamma}$, without the noncompete restriction, the wage offered is 1, and the employee chooses to shirk. The arguments of the wage function, if necessary, are $w(\theta, \text{NCC})$.

$$U(\theta, 1, 1, 0) = \bar{\lambda} q \gamma \theta + (1 - \bar{\lambda} q) \tag{2.6}$$

$$U(\theta, 1, 1, 1) = (p + \Delta)(1 - \bar{\lambda}(q + \Delta)) + \bar{\lambda}(q + \Delta)\gamma\theta \tag{2.7}$$

Comparing (2.6) to (2.7) at $\theta = \frac{1}{\gamma}$ yields that the employee's best response is to shirk, even if Δ is the largest possible, that is $\Delta = 1 - p$. The firm's profit when the employee shirks is

$$\pi(\theta, 1, 1, 0) = p(1 - \bar{\lambda} q)(\theta - 1) - \bar{\lambda} q a \theta - c\theta. \tag{2.8}$$

Further increasing the wage without changing the behavior of the agent only increases the costs of the firm. Thus the next wage to analyse is the one that induces effort from the agent. The employee exerts effort if the utility under effort is at least as high as under shirking.

$$U(\theta, 1, w(\theta), 0) = p(1 - \bar{\lambda} q) w(\theta) + \bar{\lambda} q \gamma \theta + (1 - p)(1 - \bar{\lambda} q) \tag{2.9}$$

$$U(\theta, 1, w(\theta), 1) = (p + \Delta)(1 - \bar{\lambda}(q + \Delta)) w(\theta) + \bar{\lambda}(q + \Delta)\gamma\theta \tag{2.10}$$

The employee chooses $e = 1$ if

$$w(\theta) \geq \frac{(1 - p)(1 - \bar{\lambda} q) - \bar{\lambda} \Delta \gamma \theta}{\Delta(1 - \bar{\lambda}(q + \Delta + p))} = w(\theta, 1) \tag{2.11}$$

The wage is decreasing in Δ. In the limit $\Delta \to 0$ the wage to induce effort becomes infinitely high. As Δ increases the employee's benefit of effort in the industry increases, as both the probability of receiving the wage from the firm and having an offer from the com-

petitor becomes larger. A less stringent noncompete decreases the wage since the employee can take advantage of the industry outside option with a higher probability. The firm's profit becomes.

$$\pi(\theta, 1, w(\theta, 1), 1) = (p + \Delta)(1 - \bar{\lambda}(q + \Delta))(\theta - w(\theta, 1)) - \bar{\lambda}(q + \Delta)a\theta - c\theta \tag{2.12}$$

Note that the firm always prefers to dismiss unproductive employees. The reason is that if the employee has the industry outside option, she leaves voluntarily. Therefore, if firm dismisses the employee she either leaves for the other industry or she will be without an offer. Therefore, the firm can fire the unproductive employee without increasing the probability of damages.

In summary, under the contract with noncompete, 2 different wages are candidates for equilibrium. The firm can offer $w = 1$ for low values of θ that triggers shirking from the employee. For larger θ's, the firm may offer $w = w(\theta, 1)$ that induces effort.

2.4.1.2 Without noncompete

The employee has more incentives to exert effort without noncompete, as she can freely exit to the competitor. In other words, noncompete does not decrease the arrival rate of the competitor's offer. Consider wages that satisfy $w(\theta, 0) < 1 < \gamma\theta$. The employee may exert effort with a lower wage than 1, as the free exit to the competitor increases her incentives. The utility of the employee with choosing $e = 1$ is

$$U(\theta, 0, w(\theta, 0), 1) = (p + \Delta)(1 - q - \Delta)w(\theta, 0, 1) + (q + \Delta)\gamma\theta \tag{2.13}$$

If the employee shirks, she always leaves the firm since her wage is lower than her outside industry option.

$$U(\theta, 0, w(\theta, 0), 0) = q\gamma\theta + 1 - q \tag{2.14}$$

The solution for $w(\theta, 0)$ from the given equations to incentivize effort is:

$$w(\theta, 0) = \frac{1 - q - \Delta\gamma\theta}{(p + \Delta)(1 - q - \Delta)} \tag{2.15}$$

The firm's profit is

$$\pi(\theta, 0, w(\theta, 0), 1) = (p + \Delta)(1 - q - \Delta)(\theta - w(\theta, 0)) - (q + \Delta)a\theta - c\theta \tag{2.16}$$

2.4.2 Optimal contract

Define the following thresholds

$$\theta_1 = \frac{p(1 - \bar{\lambda}q)}{p(1 - \bar{\lambda}q) - \bar{\lambda}qa - c} \tag{2.17}$$

$$\theta_2 = \frac{1 + p\bar{\lambda}q - q - p}{\Delta(1 + \gamma - a - p - q) - (1 - \bar{\lambda})(a + p)q - \Delta^2} \tag{2.18}$$

$$\theta_3 = \frac{q}{(p + \Delta)(q + \Delta) + (q + \Delta)a - \Delta\gamma} \tag{2.19}$$

Lemma 2.1. *For sufficiently low cost of training, $\theta_2 > \theta_1$.*

Proofs are in Appendix C.

The thresholds θ_1 is the participation constraint for the firm, which determines the minimum threshold for the firm to employ agents. The threshold decreases as the training cost, $c\theta$, decreases.

Lemma 2.2. *For a sufficiently stringent noncompete regulation, $\theta_3 > \theta_2$.*

If the regulator permits a stringent noncompete policy, characterized by a small value of $\bar{\lambda}$, the firm experiences greater advantages from incorporating noncompete clauses into the contracts of its employees. Denote the threshold with $\bar{\lambda}^t$.

Proposition 2.1. *Consider sufficiently low training costs ($c < \bar{c}$) and that the regulator permits a sufficiently stringent noncompete ($\bar{\lambda} < \bar{\lambda}^T$). The optimal contract is the following:*

0)$\theta < \theta_1$ *positions do not exist inside the firm.*

1)$\theta_1 < \theta < \theta_2$ *the optimal contract is noncompete, dismissal,* $w(\theta) = 1$.

2)$\theta_2 < \theta < \theta_3$ *the optimal contract is free leave, dismissal,* $w(\theta, 0) = \frac{1-q-\Delta\gamma\theta}{(p+\Delta)(1-q-\Delta)}$.

3)$\theta_3 < \theta$ *the optimal contract includes noncompete with wage* $w(\theta, 1) = \frac{1-\bar{\lambda}q-\bar{\lambda}\Delta\gamma\theta}{1-\bar{\lambda}(q+\Delta)}$.

Denote the above 3 contracts by C_i with $i \in \{1, 2, 3\}$, where the subscript aligns with the numbering in Proposition 2.1. Specifically, C_1 refers to the contract offered at the bottom of the firm's hierarchy, C_2 in the middle, and C_3 at the top

Proof. The proof follows from the derivations of section 4 and by substituting the thresholds into the respective profit functions. All three profit functions are linear in θ, with the linear coefficient increasing from C_1 to C_2 to C_3. ■

Positions with values of θ below θ_1 are not offered by the firm. The reason is that as the firm cannot guarantee that the employee stays and produces, investing in the agent's training does not have a high enough expected return. Under contract C_1 of Proposition 2.1, the firm offers the minimum wage necessary to prevent the employee from leaving for another industry if she can also contribute to the firm's production. However, offering a high enough wage to induce effort is too expensive for the firm given the employees have low productivity. Hence, the wage level offered does not provide sufficient incentives for the employee to exert effort. The firm anticipates shirking, and noncompete decreases the probability that the employee joins the competitor. The firm terminates the employee if she turns out to be unproductive to save on her wage.

As the position, θ, increases, the production becomes more valuable for the firm and thus the marginal product of the effort is also higher. Therefore, the firm uses contract C_2 of Proposition 2.1 to provide the most incentives for the employee to exert effort at a lower wage. Anticipating that the contract induces effort, the firm can offer a wage below 1.

Contract C_3 of Proposition 2.1 reintroduces noncompete. In exchange, however, the firm offers a high enough wage $w(\theta, 1)$. This wage incentivizes the employee to exert effort. The employee leaves for the competitor with probability $\lambda(q + \Delta)$. This equilibrium is reached because the marginal productivity of effort is highest at the top positions, while the potential

damage caused by the employee leaving is also significant. Figure A.2 graphically depicts the profit of the firm.

Remark 1. *The firm only pays a compensating differential for the noncompete for top employees.*

The remark follows from the proposition. An employee at the bottom of the firm's hierarchy receives a wage equal to 1, even if she does not have a noncompete. The firm cannot lower her wage below 1 since she would leave the industry. However, the firm aims to incentivize effort among top employees. Consequently, it offers a higher wage when accompanied by a noncompete agreement compared to when the agreement is absent. This ensures that employees in top positions exert effort.

The model's empirical prediction regarding the compensating differential suggests that firms offer a higher wage to top employees with noncompete agreements, but not to those at the bottom. Testing this prediction requires a dataset encompassing multiple firms' hierarchies, along with information on wages and noncompete agreements. Unfortunately, the available data from the National Longitudinal Survey of Youth only allows for an empirical analysis within a single firm. The motivating evidence presented in this paper relies on data from the same firm.

To examine the compensating differential, Table A.9 in the appendix presents a regression analysis. The coefficient for the compensating differential is statistically insignificant and close to zero in magnitude for positions at the lower end of the firm's hierarchy. Conversely, for top positions, although the coefficient remains insignificant, it is approximately ten times larger in magnitude compared to the bottom positions. The lack of statistical significance may be attributed to the limited number of observations available for analysis.

Several additional comments should be made regarding the model setup and results. Firstly, there is empirical evidence from Prescott and Starr [2021] indicating that noncompete agreements may not be initially included in contracts. The model's results, however, remain unchanged if the noncompete agreement is signed after the rest of the contract but before the effort choice.

Secondly, exerting effort leads to more favorable labor market outcomes for higher positions, as it enables the accumulation of human capital and the potential for positive references, among other factors. However, for lower positions such as fast food restaurant workers and cleaning personnel, the relationship between effort exertion and improved labor market outcomes is less straightforward. The equilibrium of the model demonstrates that individuals in these positions choose to shirk, offering an explanation for why we do not observe the aforementioned phenomenon in the real world.

Thirdly, the interpretation of the parameter θ can be expanded to encompass additional dimensions. While the training cost is solely dependent on θ and independent of the rest of the contract, it is possible to attribute meaning to θ in the absence of cost while preserving the transition points between contracts, θ_2 and θ_3. For instance, θ can represent the degree of access granted by the employer to its valuable assets, where providing access may incur no cost while simultaneously increasing the employee's payoff in the event of competition. Alternatively, θ can be understood as a characteristic specific to the employee, such as education level or experience. An employee with a higher θ would contribute more to production and possess a stronger inside industry outside option, thereby influencing their incentives and choices within the model.[18]

Fourthly, it is important to consider the possibility for renegotiation between the firm and the employee, wherein the firm matches the employee's outside option. In this scenario, the employee's utility remains unaffected as their compensation remains the same, albeit sourced from the firm and not from the competitor. Consequently, the employee's actions and choices within the model remain unchanged. However, the profit of the firm changes in this renegotiation scenario.

$$\pi(\theta, 1, 1, 1) = p(1 - \bar{\lambda}q)(\theta - 1) + p\bar{\lambda}q(\theta - \gamma\theta) - (1 - p)\bar{\lambda}qa\theta - c\theta \tag{2.20}$$

$$\pi(\theta, 0, w(\theta, 0), 1) = (p + \Delta)(1 - q - \Delta)(\theta - w(\theta, 0)) + p(q + \Delta)(\theta - \gamma\theta) - (1 - p)(q + \Delta)a\theta - c\theta \tag{2.21}$$

[18]However, the reservation utility is not a function of θ.

$$\pi(\theta,1,w(\theta,1),1) = (p+\Delta)(1-\bar{\lambda}(q+\Delta))\theta-(1-\bar{\lambda}(q+\Delta))w(\theta,1))+p(q+\Delta)(\theta-\gamma\theta)-(1-p)\bar{\lambda}(q+\Delta)a\theta-c\theta \tag{2.22}$$

The firm only matches the employee's outside option if the employee is productive within the firm. Consequently, the profit of the firm increases more under C_2 compared to C_1. This change in profit causes the threshold θ_2 to shift downwards. Essentially, the relevance of noncompete agreements diminishes when the firm has the ability to match the outside option, as the probability of losing a productive employee decreases. On the other hand, the threshold θ_3 remains unchanged since the corresponding profits for C_3 increase by the same magnitude.

2.4.3 Comparative statics

Lemma 2.3. *The comparative statics of the transition points with respect to noncompete are*

$$\frac{\partial\theta_1}{\partial\bar{\lambda}} > 0, \frac{\partial\theta_2}{\partial\bar{\lambda}} < 0, \frac{\partial\theta_3}{\partial\bar{\lambda}} = 0$$

Proof. The proof directly follows from calculating the respective derivatives. ■

An increase in $\bar{\lambda}$ corresponds to a decrease in the stringency of the noncompete agreement. The firm's profit under contract C_1 of Propostion 2.1 is negatively affected when the noncompete agreement becomes less stringent, as $\frac{\partial\pi(C_1)}{\partial\bar{\lambda}} < 0$. When the mobility of employees is higher, the firm is less likely to recover its training costs, resulting in an increase in the minimum position within the firm, i.e., $\frac{\partial\pi(C_1)}{\partial\bar{\lambda}} < 0$. A more stringent noncompete agreement restricts the employee's ability to leave the firm, leading to a lower probability of the firm incurring damages. This, in turn, facilitates employment opportunities for individuals with lower θ values. These findings align with previous research, such as Rauch [2015].

Under contract C_2, which allows for free exit, the firm's profit remains unchanged regardless of the stringency of the noncompete agreement. However, for C_1, an increase in $\bar{\lambda}$ leads to lower profit, as the firm becomes less likely to recoup its training costs due to increased employee mobility. Moreover, as the stringency of the noncompete agreement decreases, the threshold θ_2 for transitioning from C_1 to C_2 also decreases. Similarly, the threshold θ_3 for transitioning from C_2 to C_3 also decreases.

2.4.4 Expected probability to stay with the firm

Under C_3, the expected probability of the employee staying with the firm is the highest. The employee will only leave the firm if she receives an industry outside option despite the presence of a noncompete agreement, which occurs with a probability of $(1 - \bar{\lambda}q)$. The expected stay with the firm under C_1 is given by $p(1 - \bar{\lambda}q)$, while under C_2 it is expressed as $(p + \Delta)(1 - q - \Delta)$.

To compare the effects of C_1 and C_2, it is necessary to determine which effect dominates. This can be captured by the inequality $p(1 - \bar{\lambda}q) < (p + \Delta)(1 - q - \Delta)$, which simplifies to:

$$pq(1 - \bar{\lambda}) < \Delta(1 - \Delta - p - g) \tag{2.23}$$

This inequality isolates the competing effects at play. If Δ is large, the employee is more likely to receive an offer from a competitor, leading to a higher probability of separation. Conversely, if the noncompete agreement is more restrictive, the employee is more likely to remain with the firm under C_1.

In summary, the expected probability of the employee staying with the firm depends on the interplay between the effects of effort exertion and noncompete stringency. If Δ is large, the employee is more likely to receive competitive offers, leading to a higher probability of separation. On the other hand, a more stringent noncompete increases the likelihood of the employee staying with the firm under C_1.

2.4.5 Employee's utility

Denote the employee's utility under the different contracts by $U(C_i)$, $i \in \{1, 2, 3\}$

$$U(C_1) = 1 - \bar{\lambda}q + \bar{\lambda}q\gamma\theta \tag{2.24}$$

$$U(C_2) = 1 - q + q\gamma\theta \tag{2.25}$$

$$U(C_3) = 1 - \bar{\lambda}q + \bar{\lambda}q\gamma\theta \tag{2.26}$$

$U(C_1)$ and $U(C_3)$ have the same functional form. The utility of the employee is a decreas-

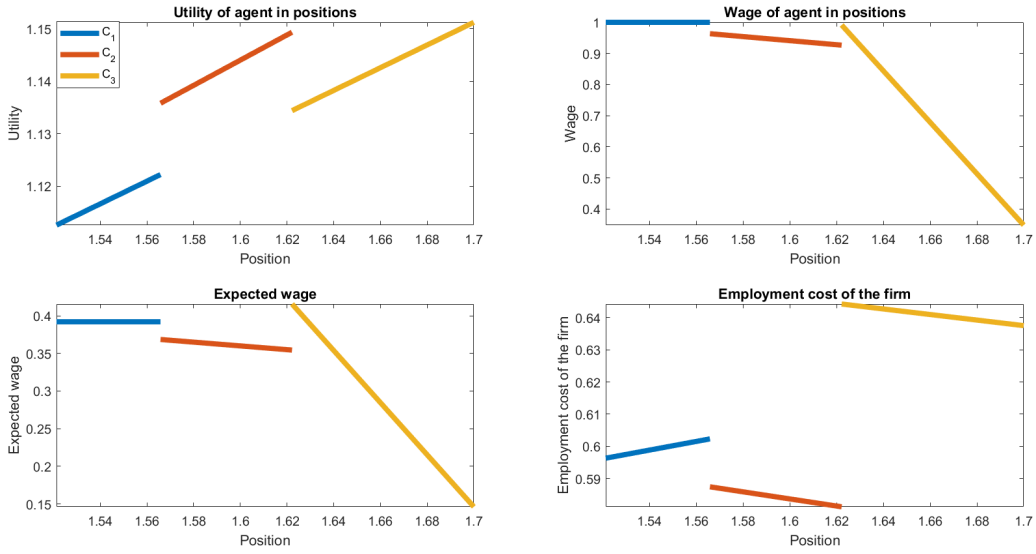


Figure 2.2: Utility, wage, expected wage and employment costs of the firm

The top left panel of graph shows an employee has a larger utility under C_2 than under C_1 and C_3. The rest of the subgraphs show the wage and related costs of the firm. Employment costs include wage, training, and damage.

ing function of the stringency of the noncompete, and an increasing function of the training, θ, when everything else is kept constant. Consequently, for a fixed θ, the employee is better off under C_2 compared to both C_1 and C_3, as $\gamma\theta_1 > 1$. Figure 2.2 visually represents the employee's utility.

2.4.6 Cost of employment

In the model setup, the cost of employment is defined as the sum of the training cost, wage, and damage. The employee is compensated through both wages and training, and all employees have the same outside option from the other industry. Under the first contract (C_1), the employee is offered a wage of $w(\theta) = 1$. Although the degree of training increase as the position within the firm increases, the wage cannot be reduced to prevent the employee from leaving for the other industry.

Under the other two contracts (C_2 and C_3), the employee's wage decreases as the level of training increases. This is because the employee can leverage their training elsewhere in the industry. However, it is important to note that these wages are paid with different

probabilities.

The bottom right subgraph of Figure 2.2 visually shows that the employment cost of the firm are increasing in position for C_1. Denote the employment cost by $ec(C_i)$. For C_2,

$$ec(C_2) = q + \Delta\gamma\theta - (q + \Delta)a\theta - c\theta - 1 \tag{2.27}$$

Therefore, if $\Delta\gamma > (q+\Delta)a+c$, the firm's employment cost decreases with an increase in the employee's position, θ. This is because the employee's increased outside option enables the firm to reduce the wage in return for the training the firm provides.

The employment cost under C_3 is

$$ec(C_3) = (p + \Delta)(1 - \bar{\lambda}(q + \Delta)) \left(-\frac{(1 - p)(1 - \bar{\lambda}q) - \bar{\lambda}\Delta\gamma\theta}{\Delta(1 - \bar{\lambda}(q + \Delta + p))} \right) - \bar{\lambda}(q + \Delta)a\theta - c\theta \tag{2.28}$$

Differentiating it with respect to θ gives

$$\frac{\partial ec(C_3)}{\partial \theta} = -c - \bar{\lambda}(q + \Delta)a + \left(\frac{\bar{\lambda}\Delta\gamma(p + \Delta)(1 - (q + \Delta)\bar{\lambda})}{\Delta - \bar{\lambda}\Delta(p + q + \Delta)} \right) \tag{2.29}$$

Equation 2.29 isolates the threefold impact of a position increase on employment cost. As the position increases, the firm incurs larger training costs and faces a heightened potential for damage caused by the employee. Conversely, the promotion provides the employee with superior outside options, thereby allowing for a potential decrease in her wage. Which effect dominates depends on the size of the parameters of the training cost, c, the damage, a, and the stringency of the noncompete $\bar{\lambda}$. In particular, if a,c and $\bar{\lambda}$ are low, the firm's cost decreases as the position increases.

2.5 Regulation of noncompete

This section focuses on deriving the optimal regulation concerning the stringency of noncompete agreements. The need for such regulation arises from the underlying inefficiencies: the firm does not take into account that the noncompete hurts the employee's future outside

options, while the employee does not consider how departing from the firm causes damages to the firm. Hence, a policymaker, by taking both into account, can balance these effects by setting the maximum stringency of the noncompete. The welfare function is defined as the sum of the firm's profit and the employee's utility, denoted by ϕ. Since the functional form differs depending on whether the employee exerts effort and the type of contract the firm offers, I will present the exact equations case by case in the next subsection. First, I consider regulation dependent on the position, $\bar{\lambda}(\theta)$, and subsequently, I analyze a uniform regulation of noncompetes.

I show that under position-dependent regulation of the noncompete, it is optimal for the policymaker to prohibit noncompete agreements for bottom positions under certain conditions. Specifically, this applies if the training provided by the firm holds a large value outside the firm and the firm expects a medium quality of labor, represented by the paramter p. However, the conditions for banning noncompetes for top positions are more stringent, making it less likely to be deemed optimal. Later in this section, I highlight the trade-offs faced by the policymaker in establishing a uniform regulation governing the stringency of noncompete agreements, and run a simulation of the optimal policy. The simulation shows that a uniform ban is likely to be optimal.

2.5.1 Position dependent regulation

The regulator observes the position, θ, and sets the policy as a function θ, $\bar{\lambda}(\theta)$. I go through each contract, denoted

Proposition 2.2. *Under position dependent regulation, the regulator bans noncompete for bottom positions if*
i) $\gamma > p + a$
ii) $p > \frac{qa\theta - c\theta}{(1-q)(\theta-1)}$.
Condition i) becomes $\gamma > p + a + \Delta$ *for top positions.*

The two conditions can be rewritten as

$$\gamma - a > p > \frac{qa\theta - c\theta}{(1-q)(\theta-1)}. \tag{2.30}$$

That is, if p is neither too high, nor too low, it is optimal to ban noncompetes.

Proof. I set up the problem of the regulator for each contract and subsequently derive the optimal regulation $\theta(\bar{\lambda})$. The contracts are denoted with C_i with $i \in \{1, 2, 3\}$, with C_1 being the optimal contract for bottom, C_2 for middle, and C_3 for top positions.

2.5.1.1 Bottom positions

The social welfare function takes the following form.

$$\phi(\theta, C_1) = \pi_1(\theta, C_1) + U_1(\theta, C_1) = p(\theta - 1) + \bar{\lambda} q(\theta\gamma - a\theta - p\theta) - c\theta + 1 \tag{2.31}$$

Hence the problem of the regulator is

$$\begin{aligned} &\max_{\bar{\lambda}(\theta)} \phi(\theta, C_1) \\ &\text{s.t.} \quad \pi_1(\theta, C_1) \geq 0, \quad U_1(\theta, C_1) \geq 1, \quad C = C_1 \end{aligned} \tag{2.32}$$

The optimal regulation takes into account the firm's and agent's participation constraint. The change in the stringency of noncompete can also alter the optimal contract. The optimal policy is

$$\bar{\lambda}(\theta, C_1) = \begin{cases} \min\left\{\frac{p(\theta-1)-c\theta}{q(p(\theta-1)+a\theta)}, 1\right\} & \gamma > p + a \\ 0 & \gamma \leq p + a \end{cases} \tag{2.33}$$

The optimal regulation is banning noncompete if the training the firm provides has a sufficiently high industry specific component and the firm's participation constraint is met. Substituting in $\bar{\lambda} = 1$, the complete ban, to the firm's participation constraint yields the condition

$$p > \frac{qa\theta - c\theta}{(1 - q)(\theta - 1)} = \hat{p}(\theta). \tag{2.34}$$

Intuitively, the firm's investment in training must pay off to facilitate participation. This condition is satisfied if p, the probability of success inside the firm, is high. In other words,

if the expected match between the firm and the employee is sufficiently high.

2.5.1.2 Middle positions

For middle positions, Under C_2, the regulator's objective is

$$\phi_2(C_2, \theta) = (p + \Delta)(1 - q - \Delta)\theta + (q + \Delta)(\gamma\theta - a\theta) - c\theta. \tag{2.35}$$

This objective, however, is independent of the specific value of $\bar{\lambda}$ since the firm does not include the noncompete in the contract. As a result, any $\bar{\lambda}$ value within the range of $[0, 1]$ can be considered an equilibrium. It is important to note, however, that this equilibrium outcome may lead to inefficiency if the employee chooses to leave the firm when she could have been productive more inside of it.

2.5.1.3 Top positions

For top positions, under C_3, the objective looks as

$$\phi_3(C_3, \theta) = (p + \Delta)\theta - c\theta + \bar{\lambda}(q + \Delta)\theta(\gamma - p - \Delta - a). \tag{2.36}$$

The optimal policy is

$$\bar{\lambda}(C_3, \theta) = \begin{cases} 1 & \gamma > p + a + \Delta \\ 0 & \gamma \leq p + a + \Delta \end{cases} \tag{2.37}$$

The condition to ban noncompete is stricter for top positions within the firm compared to the lowest positions. If an employee exerts effort, it leads to increased expected production within the firm. As a result, the difference in expected production between the firm and the competitor becomes larger. This makes it less likely that a complete ban on noncompete agreements is optimal, as the firm's advantage in terms of expected production is more pronounced at higher positions. ■

2.5.2 Uniform regulation

Under a uniform regulation framework, the regulator sets a fixed value for $\bar{\lambda}$ that does not depend on the employee's position, θ. The complete ban on noncompete agreements proposed by the FTC is an example of such a regulation, where the ban applies uniformly across positions [Federal Trade Commission, 2023]. This approach may be adopted due to the unavailability or high cost of accurately observing the position θ for each individual, making it impractical to establish a position-dependent boundary for the stringency of noncompetes.

Consider that the regulator assigns a weight, denoted by $f(\cdot)$, to each position. For ease of notation, the subscript in ϕ_i matches the contract number $(1, 2, 3)$, indicating the hierarchy from bottom to top positions The regulator's problem can be formulated as follows:

$$\begin{aligned}\max_{\bar{\lambda}} \Phi = &\int_{\theta_1(\bar{\lambda})}^{\theta_2(\bar{\lambda})} \phi_1(\bar{\lambda}, \theta) f(\cdot) d\theta \\ &+ \int_{\theta_2(\bar{\lambda})}^{\theta_3(\bar{\lambda})} \phi_2(\bar{\lambda}, \theta) f(\cdot) d\theta + \int_{\theta_3(\bar{\lambda})}^{\bar{\theta}} \phi_3(\bar{\lambda}, \theta) f(\cdot) d\theta\end{aligned} \tag{2.38}$$

The first derivative with respect to $\bar{\lambda}$ using the Leibniz rule becomes

$$\begin{aligned}\frac{\partial \Phi}{\partial \bar{\lambda}} = &+ \frac{\partial \theta_2(\bar{\lambda})}{\partial \bar{\lambda}} \phi_1(\bar{\lambda}, \theta_2) f(\cdot) - \frac{\partial \theta_1(\bar{\lambda})}{\partial \bar{\lambda}} \phi_1(\bar{\lambda}, \theta_1) f(\cdot) + \int_{\theta_1(\bar{\lambda})}^{\theta_2(\bar{\lambda})} \frac{\partial \phi_1}{\partial \bar{\lambda}} f(\cdot) d\theta \\ &+ \frac{\partial \theta_3(\bar{\lambda})}{\partial \bar{\lambda}} \phi_2(\bar{\lambda}, \theta_3) f(\cdot) - \frac{\partial \theta_2(\bar{\lambda})}{\partial \bar{\lambda}} \phi_2(\bar{\lambda}, \theta_2) f(\cdot) + \int_{\theta_2(\bar{\lambda})}^{\theta_3(\bar{\lambda})} \frac{\partial \phi_2}{\partial \bar{\lambda}} f(\cdot) d\theta \\ &- \frac{\partial \theta_3(\bar{\lambda})}{\partial \bar{\lambda}} \phi_3(\bar{\lambda}, \theta_3) f(\cdot) + \int_{\theta_3(\bar{\lambda})}^{\bar{\theta}} \frac{\partial \phi_3}{\partial \bar{\lambda}} f(\cdot) d\theta\end{aligned} \tag{2.39}$$

Next, I break down the above equation by terms and establish their sign.

$$\frac{\partial \theta_1(\bar{\lambda})}{\partial \bar{\lambda}} \phi_1(\bar{\lambda}, \theta_1) f(\cdot) < 0 \tag{i}$$

As $\frac{\partial \theta_1(\bar{\lambda})}{\partial \bar{\lambda}} < 0$. Since a decrease in the stringency of the noncompete decreases the size of the firm, and thus yields less production, shrinking the overall surplus.

$$\frac{\partial \theta_2(\bar{\lambda})}{\partial \bar{\lambda}}(\phi_1(\bar{\lambda}, \theta_2) - \phi_2(\bar{\lambda}, \theta_2))f(\cdot) > 0 \tag{ii}$$

$\frac{\partial \theta_2(\bar{\lambda})}{\partial \bar{\lambda}} < 0$ and $(\phi_1(\bar{\lambda}, \theta_1) - \phi_2(\bar{\lambda}, \theta_1)) < 0$ is established before. [19] Thus, an increase in $\bar{\lambda}$ increases welfare since it extends the range where the sum of the firm's profit and employee's utility is higher.

$$\frac{\partial \theta_3(\bar{\lambda})}{\partial \bar{\lambda}}(\phi_2(\bar{\lambda}, \theta_3) - \phi_3(\bar{\lambda}, \theta_3))f(\cdot) = 0 \tag{2.40}$$

because of $\frac{\partial \theta_3(\bar{\lambda})}{\partial \bar{\lambda}} = 0$.

The sign of the remaining terms depend whether $\gamma > a + p$ and $\gamma > a + p + \Delta$

$$\frac{\partial \phi_1(\bar{\lambda})}{\partial \bar{\lambda}} = q\theta(\gamma - a - p) \tag{iii}$$

$$\frac{\partial \phi_2(\bar{\lambda})}{\partial \bar{\lambda}} = 0 \tag{2.41}$$

$$\frac{\partial \phi_3(\bar{\lambda})}{\partial \bar{\lambda}} = \theta(\gamma - p - a - \Delta) \tag{iii}$$

The regulator faces a tradeoff involving three key effects. Firstly, a stringent noncompete agreement can encourage firm participation by safeguarding the training investment made in employees (effect marked by equation (i)), thereby leading to greater social welfare. Secondly, a less restrictive noncompete reduces the firm's incentive to impose the agreement, allowing for a broader range of positions where the firm does not require noncompete agreements (contract C_2, effect (ii)). As this range is associated with higher welfare, overall welfare is enhanced. Thirdly, noncompete agreements prevent employees from engaging in ex post competition. While it is socially efficient for unproductive employees to compete, it is inefficient if they are productive within the firm. Effect (iii) captures this ex ante perspective. Thus, a crucial model parameter is γ, which represents the employee's productivity within the industry at a competitor. A higher level of productivity leads to a weaker restriction

[19] The utility of the employee increases at the transition point.

on noncompete imposed by the regulator.[20] Furthermore, the parameter γ is likely to vary across industries, indicating that the optimal stringency of noncompetes may differ among different industries.

2.5.2.1 Simulation

To simulate the impact of noncompete policies on social welfare, it's necessary first to establish the parameter values for p, q, Δ, a, and γ. This is achieved by reviewing existing empirical and experimental evidence. In a study by Mueller (2015), it was found that high-skilled apprenticeship graduates have a 50% probability of staying with their firms, a 43% probability of competing, and a remaining likelihood of leaving the industry post-training. Assuming noncompetes are absent, the model is calibrated to mirror these probabilities for top employees. A feasible set of parameter values could be $p = 0.67$, $q = 0.2$, and $\Delta = 0.23$. Another study by Amir (2014) investigated the effects of post-employment restrictions on motivation and performance, particularly relevant for low and middle-skilled workers. Adopting a similar method to Mueller's study, parameter values of $p = 0.4$ and $q = 0.2$ are derived. As the model does not permit variation in these parameters by position, the values presented in Table 2.2 are used.[21]

Numerous studies have evaluated the extent of firm-specific training, represented by $1-\gamma$ in our model. For instance, studies like Mueller (2015) and Dustmann and Glitz (2005) conclude that the degree of firm-specific training is typically less than 5%. In contrast, Geel and Backes-Gellner (2011) indicate significantly higher values across most industries. Consequently, the parameter γ is adjusted to reflect a range from high ($\gamma = 1$) to low ($\gamma = 0.8$) firm-specific training. As for the parameter a, which quantifies the potential damage when an employee competes with the firm, there is no direct measure available in existing literature. Therefore, a is varied in the model, taking on small ($a = 0.02$) to large ($a = 0.08$) values. Lastly, the weight function $f(\cdot)$ is constant, 1.

[20] Meaning a higher $\bar{\lambda}$ in the language of the model.

[21] Minor variations in these percentages do not significantly alter the results.

	Definition	Value
p	Probability of success inside the firm	0.55
q	Probability the competitor makes an offer	0.2
Δ	Increase in above probabilities if the employee exerts effort	0.23
a	Size of firm damage if employee leaves	[0.02,0.08]
γ	Degree of industry-specific training	[0.8,1]

Table 2.2: Parameter values for simulation

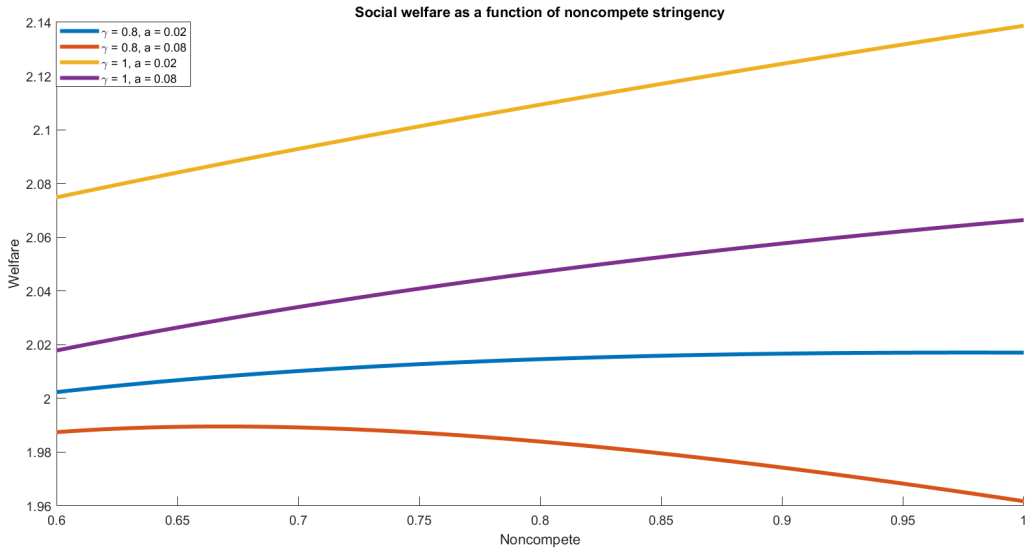


Figure 2.3: Social welfare

The figure illustrates the relationship between social welfare and the stringency of noncompete agreements. If the degree of industry-specific training (γ) is high or the damages incurred by the firm if the employee competes (a) are low, then the optimal policy is to completely ban noncompete agreements.

Figure 2.3 shows that a uniform ban on noncompete agreements is optimal when the level of industry-specific training (γ) is high, or when it is low but accompanied by minimal damage to the firm from competition (low a). These insights support the Federal Trade Commission's (FTC) proposal for a universal ban on noncompetes [Federal Trade Commission, 2023]. This suggests that the benefits of allowing employees to compete outweigh the advantages of increased training and larger firm size. In contrast, if γ is low and the firm experiences significant damages from employee competition (as indicated by the red line in the figure), a total ban on noncompete clauses may not be the most suitable strategy. In such cases, the optimal regulation likely involves a more nuanced approach, with $\bar{\lambda}$ falling within the range

of (0,1).

2.6 Multiple periods

A natural question arises whether a longer time horizon changes the optimal contract or employee's decision, and whether the regulator's objective shifts. The motivation for this extension comes from a real-world incident: a class action lawsuit against the fast-food franchise Jimmy John's. In this case, the plaintiffs allege that the company systematically reduced their work hours, exploiting their noncompete agreements. Consequently, these employees were constrained to accept entry-level positions in other industries if they chose to leave Jimmy John's.[22]

This section broadens the model by incorporating an additional period to explore the increasing holdup power of the firm over time. First, the extension explores how noncompete agreements can be used to suppress wages for employees in bottom positions, linking back to the aforementioned lawsuit. Then, I discuss top positions where choosing to exert effort in the one-period game is optimal. However, in the context of a two-period game, the firm might reduce the employee's wage in the second period. Anticipating this potential holdup, an employee at a top position may opt not to exert maximum effort. To prevent this, the firm can address the holdup issue by either committing to a predetermined wage for the second period or by offering a higher wage upfront. Moreover, regulating the stringency of noncompete agreements can also aid in mitigating these holdup issues

In the extended model, the second period is characterized by static employee human capital. No additional training is provided by the firm, and the employee's effort level remains unchanged. [23] Thus, the employee's effort decision in the first period serves as a human capital decision. The employee can keep her human capital generic (G), or she can specialize to the industry (S). In the second period, the employee receives outside options based on the initial contract and her human capital choice. If the employee remains with the firm in the second period, she engages in production at the end of the period.

[22]The case, identified as Case Number: 18-cv-0133-MJR-RJ, was filed in 2018.

[23]If the employee takes a new effort decision, the stage game results are repeated. Therefore, the interesting case is when the employee's decision carries over to the second period.

The main focus of the extension is on the wage the firm offers in the second period, which is determined by the employee's outside options during that period. The wage offered by the competitor is determined by the employee's training, denoted as $w_M = \gamma\theta$. Since the firm learns about the employee's productivity by the end of the first period, only productive employees continue working for the firm in the second period, while others are dismissed. The arrival rates in the second period are denoted as $q_2 = q$ and $\Delta_2 = \Delta$.

The firm's profit if it offers the wage w_M is given by:

$$\pi_2(w = \gamma\theta) = \theta - \gamma\theta \tag{2.42}$$

The profit is nonnegative because $\gamma \leq 1$. In light of the lawsuit, I consider γ to be close to 1, indicating that the training provided by the firm is valuable in the industry. This assumption is particularly relevant in industries such as fast food restaurants, where skills are highly transferable to competing firms.

2.6.1 Unanticipated second period

First, consider the scenario where neither party anticipates the second period. In this case, the choices and the contract made in the first period remain unchanged. The employee's effort choice and the firm's noncompete decision are determined based on the expectations of a one-period interaction, as detailed in Proposition 2.1.

2.6.1.1 Bottom positions

Lemma 2.4. *If the training the firm provides to the employee is valuable in the industry, the firm does not increase the wage of employees at the bottom of the firm's hierarchy for the second period.*

The intuition behind the result is as follows. Suppose the firm sets a wage of $w = 1$. In this scenario, the employee, who opted for a generic investment in the first period, stay with the firm with a high probability, $1 - \bar{\lambda}q$. The firm cannot decrease the wage below 1 because the employee would then have an incentive to leave for a better opportunity outside the industry. However, the market wage increases with θ. Therefore, the firm establishes an

upper bound on θ below which the firm matches the market wage, above it offers $w = 1$. For high degree of competition (high γ), this θ threshold is lower than the employment threshold. Hence, all employees at the bottom receive $w = 1$.

Even in the absence of friction on the arrival rate of the outside option ($q_2 = 1$), the firm does not offer the market wage for all levels of θ due to the reintroduction of the friction caused by the noncompete. This situation gives rise to a scenario similar to the Jimmy John's lawsuit, where the employee's value increases to θ in the second period, but the firm does not raise the wage because the employee is subject to the noncompete and does not have a better outside option in the industry.

Moreover, the result indicates that even if the parties anticipate a second period renegotiation, the equilibrium described above largely prevails. In this case, the employee expects that the firm will not increase her wage in the second period, which diminishes the incentive for her to specialize in the industry. The only remaining incentive for specialization is the opportunity to compete in the future. However, the likelihood of competing is reduced by the presence of a noncompete agreement, which restricts the employee's ability to pursue alternative opportunities. Consequently, the employee does not have enough incentives to specialize and chooses the generic investment option.

2.6.1.2 Middle positions

For middle positions, that is under contract C_2 in propositoin 2.1, the optimal contract does not include a noncompete. However, the employee may still face a holdup problem in the second period. After specializing in the industry, her only outside option in the second period is from a competitor within the same industry. If the arrival rate of the outside offer is low, the firm's expected loss from letting the employee go is lower than the wage cost it can save by decreasing her wage. For simplicity, I assume that the firm has the option to offer a wage of 0.

The firm offers a wage of $w = \gamma\theta$ if it satisfies the condition:

$$\theta - \gamma\theta > (1 - q - \Delta)\theta - (q + \Delta)a\theta \tag{2.43}$$

Simplifying the equation, we have:

$$(q + \Delta)(1 + a) > \gamma \tag{2.44}$$

If γ is small enough or the probability of receiving an outside offer is high $(q + \Delta)$, the firm offers the market wage. In other words, if the firm perceives a higher risk of losing the employee to a competitor, it is more likely to offer the market wage. Furthermore, if $q + \Delta = 1$, indicating a certain outside offer, the firm offers the market wage regardless of the value of γ.

Therefore, the holdup problem arises as a consequence of employee specialization in the industry. However, the severity of the holdup is lower if the employee does not face a noncompete agreement, as the probability of receiving an outside offer is not diminished.

2.6.1.3 Top positions

Employees in the one period game exert effort, as shown in proposition 2.1. Therefore, they forego the option to work in a different. In the extension, the wage renegotiation occurs at the beginning of the second period, after the firm has already learned that the employee is productive inside the firm. I allow the firm to offer any wage in the second period. This relaxation aids the analysis, however, somewhat unrealistic since wages are known to be sticky. Therefore, decreasing the wage can be also associated with decreasing the non-contractual benefits of a certain position inside the firm's hierarchy which are not modeled here.

In equilibrium the firm either offers the market wage, $w(\theta) = \gamma\theta$, or $w(\theta) = 0$ for the second period. If the firm offers the market wage, the employee stays with certainty. Any wage below the market wage means the employee leaves for the competitor if the opportunity arises. Hence the other candidate for optimal wage is $w(\theta) = 0$ in which case the employee leaves for the competitor upon receiving an offer. Offering the market wage yields a higher profit if

$$\theta - \gamma\theta > (1 - \bar{\lambda}(q + \Delta)\theta) - \bar{\lambda}(q + \Delta)a\theta \tag{2.45}$$

The cost of the employee leaving is the sum of the foregone production and the damage she causes as shown by the above inequality. It simplifies to

$$\bar{\lambda} > \frac{\gamma}{(q+\Delta)(1+a)} = \bar{\lambda}^T \tag{2.46}$$

Thus if noncompete is lax enough, the firm offers the market wage in the second period. However, even the contract without noncompete yields to a holdup problem in the second period if $\gamma > (q+\Delta)(1+a)$. Otherwise, the firm decreases the wage of employees at the top.

2.6.2 Optimal contract for the two period model

Consider that both the firm and the employee anticipates the second period and makes decisions at the beginning of the game, such as contractual terms and effort choice, accordingly. Since the interesting question arises whether employees are willing to exert effort, or in other words choose industry specific skills, I focus on top positions.

This larger section addresses the holdup problem between the firm and an employee in a top position. I derive the optimal contract that is crucially driven by the parameter γ that is the value of the training outside the firm but inside the industry. The firm has more incentive to include noncompete in the contract if γ is high. A high γ means the market wage of the employee in the second period is high.

Consider the wage $\gamma\theta > w(\theta) > 1$. The employee's utility under choosing S and G respectively are

$$\begin{aligned} U(\theta, 1, w(\theta), S) = (p+\Delta)(1-\bar{\lambda}(q+\Delta)w(\theta)) + \bar{\lambda}(q+\Delta)\gamma\theta \\ +\bar{\lambda}(q+\Delta)\gamma\theta + (p+\Delta)\bar{\lambda}(q+\Delta)\gamma\theta \end{aligned} \tag{2.47}$$

$$\begin{aligned} U(\theta, 1, w(\theta), G) = p(1-\bar{\lambda}q)w(\theta) + \bar{\lambda}q\gamma\theta + (1-p)(1-\bar{\lambda}q) \\ +\bar{\lambda}q\gamma\theta + (1-\bar{\lambda}q) + p(\bar{\lambda}q)\gamma\theta \end{aligned} \tag{2.48}$$

The wage becomes

$$w(\theta) = \frac{(1-p)(1-\bar{\lambda}q) + (1-\bar{\lambda}q) - 2\bar{\lambda}\Delta\gamma\theta}{\Delta(1-\bar{\lambda}(q+\Delta+p))} \tag{2.49}$$

Thus if the firm has enough resources to pay the wage for two periods upfront to the agent, it can avoid the holdup. I continue the analysis looking for further solutions.

Proposition 2.3. *If γ is large, the firm offers the contract with $w(\theta) = 1$ and $\lambda = \bar{\lambda}$, and the employee does not specialize. Otherwise, the firm offers a contract that induces specialization.*

The full proof is in Appendix A.4. I set up the profit function to provide intuition for the result.

I divide the problem into two cases with respect to noncompete, $\lambda \geq \lambda^T$ and $\lambda < \lambda^T$, where λ^T is defined from equation (2.46). Note that the firm's problem may not yield a corner solution of λ, hence I allow the firm to set the noncompete variable continuously, $\lambda \in [\bar{\lambda}, 1]$.

2.6.2.1 Lax noncompete

First, consider the case when noncompete is lax with $\lambda \geq \lambda^T = \frac{\gamma}{(q+\Delta)(1+a)}$. I focus on wages such that $\gamma\theta > 1 > w$ as in the baseline model. The first line of the firm's profit is identical to the one period case. In the second period, the productive employee always stays.

$$\begin{aligned}\pi(\theta, 1, 0, w(\theta, S) =& (p+\Delta)(1-\lambda(q+\Delta)(\theta - w(\theta)) - \lambda(q+\Delta)a\theta - t\theta \\ &+ (p+\Delta)(1-\lambda(q+\Delta))(\theta - \gamma\theta)\end{aligned} \tag{2.50}$$

The first period employee utility is identical to the one period case. In the second period the employee receives a wage $\gamma\theta$ from the firm if stayed for the second period, or receives $\gamma\theta$ if competed in the first period.

$$\begin{aligned}U(\theta, 1, 0, w(\theta), S) =& (p+\Delta)(1-\lambda(q+\Delta))w(\theta) + \lambda(q+\Delta)\gamma\theta \\ &+ (p+\Delta)(1-\lambda(q+\Delta))\gamma\theta + \lambda(q+\Delta)\gamma\theta\end{aligned} \tag{2.51}$$

If the employee leaves the industry in the first period, she will not receive a competitor outside offer from the industry. Thus the utility of the agent investing in generic capital takes the following form and the employee never stays with the firm.

$$U(\theta, 1, 0, 1, G) = \lambda q\gamma\theta + 1 - \bar{\lambda}q + \lambda q\gamma\theta + 1 - \bar{\lambda}q \tag{2.52}$$

The problem of the firm is then

$$\max_{\lambda, w(\theta)} \pi(\theta, 1, 0, w(\theta, S)) \tag{2.53}$$

s.t.

$$U(\theta, 1, 0, w(\theta), S) \geq U(\theta, 1, 0, w(\theta), G) \tag{2.54}$$

For large enough θ's, the optimal contract features $\lambda = \lambda^T$, as shown in the appendix. Since the profit is a decreasing function of λ^T, it also decreases in γ.

2.6.2.2 Stringent noncompete

If $\lambda < \lambda^T$ noncompete is so restrictive that the employee anticipates to be held up in the second period if she specializes.

The profit of the firm is

$$\pi(\theta, 1, 0, 1, G) = p(1 - \bar{\lambda}q)(\theta - 1)) - \bar{\lambda}qa\theta + p(1 - \bar{\lambda}q)^2(\theta - 1) - p(1 - \bar{\lambda}q)\bar{\lambda}qa\theta - c\theta \tag{2.55}$$

The profit of the firm under this contract does not depend on γ.

In summary, the firm offers the contract that incentivizes specialization ($\lambda = \bar{\lambda}^T$) if the parameter γ is low. The firm does not hold up the employee in the second period but offers her the market wage, $w(\theta) = \gamma\theta$, as the market wage is low enough. If γ is high, however, the firm would hold up the employee. Hence the employee, who correctly anticipates the holdup, does not specialize in equilibrium.

2.6.2.3 Regulator's problem

The regulator's and firm's incentives are diverging with respect to γ. A higher value of γ implies that the training provided by the firm has more industry-specific value. This, in turn, increases the value of the noncompete, as the employee's outside option in the industry becomes more valuable. Hence, it is more costly for the firm to pay the market wage and the firm would rather prefer to hold up the employee in the second period. Consequently, the employee is less likely to specialize.

From a social perspective, a larger value of γ indicates a higher social value of training and specialization. As a result, there is a greater social loss from restricting the employee from competing. Therefore, the regulator prefers to step in to constrain how restrictive the noncompete may be.

Lemma 2.5. *The regulator can shift the firm's incentives to offer the contract with a laxer noncompete ($\lambda = \lambda^T$) by regulating the stringency of noncompete, $\bar{\lambda}$.*

Proof. The lemma directly follows from the observation that the firm's profit is only dependent on $\bar{\lambda}$ under the second contract. ■

Regulating and disallowing stringent noncompetes gives the regulator the ability to influence the firm's profit under the contract $w = 1$ and $\lambda = \bar{\lambda}$. By implementing this regulation, the regulator can improve efficiency by encouraging the firm to adopt a contract with a less restrictive noncompete clause ($\lambda = \lambda^T$). This incentivizes the employee to specialize leading to a larger overall welfare.

2.6.2.4 Summary of two period model

The firm may have incentives to reduce wages of specialized employees in the second period. However, employees, anticipating this may not specialise in the first period, giving rise to a holdup problem. However, there are several solutions to address this problem. Firstly, the firm can commit to the wage of the employee (tenure) and not reduce it in the second period. Secondly, if the firm is unable to make commitments, it can pay the wage upfront for the second period. By providing the wage upfront, the firm eliminates the holdup problem

from the employee's perspective, as they have already received their full compensation. This solution requires deep enough pockets from the firm. Lastly, regulatory intervention can also play a role in mitigating the holdup problem. If the regulator sets a maximum limit on the stringency of noncompete, ensuring they are not overly restrictive, the firm offers the market wage in the second period. This, in turn, provides employees incentives to specialize, as they are not overly constrained by the noncompete.

Overall, these solutions address the holdup problem in different ways, either through firm commitment, upfront payment, or regulatory constraints on noncompetes. Each approach aims to align the interests of the firm and the employee, encouraging specialization and maximizing overall efficiency in the labor market.

2.7 Extensions

The subsequent extensions relax the assumption of agent rationality, introduces agent heterogeneity, and expands the model to include multiple firms at the beginning of the game. Together, these extensions demonstrate the robustness of the model's main results against these variations. Detailed formulations and mathematical expositions of these extensions are presented in Appendix A.2, while the upcoming sections offer concise summaries.

2.7.1 Relaxing rationality of the agents

In this extension of the model, I introduce the scenario where the employee holds an incorrect belief about the stringency of her noncompete agreement. Specifically, I explore how the optimal contract changes when the firm has the ability to influence the employee's belief. This analysis reveals that the firm can manipulate the employee's belief in a way that makes her worse off. This highlights the asymmetry in information between the firm and the employee, and the potential for strategic behavior on the part of the firm.

Next, I relax the assumption of ex ante identical agents and introduce heterogeneity in their their perception of noncompete agreement stringency. In equilibrium, agents who underestimate the stringency of their noncompete agreement mistakenly exert effort, and are employed in lower positions within the firm's hierarchy. Hence, a regulator may want

to intervene and ban noncompetes. However, the downside of the ban is that some low ability agents are employed with noncompete and receive a positive rent would not be hired if noncompete is banned. The reason is that misunderstanding the contract mitigates the commitment problem of the employee regarding effort. Thus, the regulator needs to weigh the above costs and benefits.

2.7.2 Multiple firms

By introducing a second firm into the model, a competitive dynamic emerges between the two firms. This new setup may lead to an asymmetric equilibrium. Specifically, it is possible for one firm to find it more profitable to act as the competitor, offering a different contract than derived in 2.1. To delve deeper into this two-firm competition scenario, I analyze the game with two firms and two employees. This analysis not only confirms the previous section's findings, but also highlights the potential emergence of a prisoner's dilemma situation, where both firms face incentives to deviate from the cooperative outcome and compete for the employee.

2.8 Conclusion

This paper studies how the optimal stringency of a noncompete varies with the employee's position inside a firm's hierarchy. The analysis reveals that in equilibrium, employees at the top and bottom positions of the firm are subject to noncompete agreements, while those in the middle are not. At the top, where employees are highly productive, the firm uses noncompetes to reduce the likelihood of competition while still incentivizing effort. In the middle, where productivity is moderate, allowing employees to compete maximizes effort incentives. At the bottom, where productivity is lowest, noncompetes are reintroduced and the firm does not provide sufficient incentives for effort exertion due to the agents' low productivity.

In addition, the paper examines the regulatory aspect of noncompetes and shows that a ban on noncompetes can be if the employee's expected productivity inside the is expected to be moderately productive. With a moderate match, allowing the employee the opportunity

to compete can enhance productivity and increase social welfare, while still ensuring the firm maintains sufficient expected profit to employ the agent. Since at top positions employees exert effort to increase their expected productivity, the condition for banning noncompete is stricter, because the difference in expected production between the firm and its competitor is larger.

Appendix A

Appendix

A.1 Motivating evidence

This section extends the discussion of the motivating evidence.

A.1.1 Data

The National Longitudinal Survey of Youth 1997 offers valuable data on noncompete agreements, starting from the round conducted in 2017. Building on the findings of previous empirical studies and media reports that highlight industries where noncompetes are commonly observed for employees at the bottom of the firm hierarchy, this paper delves into an analysis of a firm based on data from the survey. The firm consists of 261 respondents included in the census, with 34 respondents engaged in food preparation and serving occupations, and 19 respondents involved in cleaning and building service occupations. The census data also provides information on the respondents' education levels, measured on a scale of 0-7, as well as their length of employment, which is converted to the same scale for analysis purposes.

A.1.2 Hierarchy measure

Hierarchy is the internal organization of the firm [Smeets and Warzynski, 2008]. A direct hierarchy measure is not available in the NLS database. I construct a measure of hierarchy as

a weighted average of education and length of tenure at the firm. Previous empirical papers show that these variables correlate with the firm's hierarchy. [1] Smeets and Warzynski [2008], Smeets and Warzynski [2011], Smeets et al. [2019] use a confidential database with access to a 5 layer hierarchy (worker to corporate vice president). In table 1 they show that the average firm tenure, experience, and education all increase as the hierarchy measure increases. Previous studies are also consistent with the above patterns [Baker et al., 1994a,b].

A.1.3 Statistical test

Figure A.1 exhibits the U-shaped relationship between hierarchy and noncompete incidence, as suggested by the model.

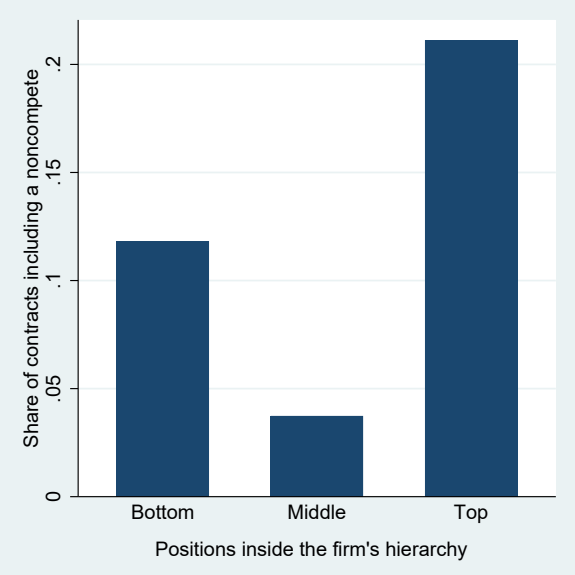


Figure A.1: Noncompete incidence by positions in the firm's hierarchy

Employees at the bottom and at the top of the hierarchy are more frequently subject to a noncompete. The graph shows a firm's hierarchy and noncompete incidence from the data source the National Longitudinal Survey of Youth 1997. The hierachy measure is based on Baker et al. [1994a] and Smeets and Warzynski [2008].

Table A.1 summarizes the regression results, with the first two columns displaying the linear probability model (LPM), the second two the logistic regression. Columns one and three exclude the quadratic term. In both the LPM and the logit model, the linear coefficients

[1] Age is another relevant variable for hierarchy, however, the respondents of the census are the same age

are insignificant without the quadratic term. Including the quadratic term yields significant linear and quadratic coefficients. The last column of table A.1 estimates the probability of having noncompete for the lowest positions in the hierarchy is 10%, for middle positions it is only 4%, while at the top of the firm it is 18%.

	(1) LPM	(2) LPM	(3) Logit	(4) Logit
Hierarchy	0.033	-0.373*	0.363	-5.034*
	(0.170)	(0.014)	(0.172)	
Hierarchy sq		0.103**		1.343*
		(0.007)		(0.017)
Constant	0.038	0.373**	-2.915	1.527
	(0.433)	(0.005)	(0.000)	(0.411)
Observations	261	261	261	261

p values in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table A.1: Hierarchy estimation table

The table shows the estimates for regressing noncompete incidence on the hierarchy measure. The regressions highlight the quadratic relationship between noncompete and hierarchy.

A.1.4 Robustness checks

A.1.4.1 Hierarchy measure

I extend the set of variables used for the hierarchy measure and carry out principal component and principal factor analysis for robustness. The variables are in table A.2.

Variable name	**Description**
Employment lenght	Length of tenure of the employye at the firm
Education	Highest degree received
Supervise	Frequency of supervising other employees
Short and rep	Frequency of short and repetitive task
Physical	Frequency of physical task
Problem solving	Frequency of problem solving
Docs read	Longest document employees have read

Table A.2: Variables included in the construction of the hierarchy measure

Principal component analysis (PCA) is a technique to reduce the dimensionality of a

large set of correlated variables to components that are linear combinations of the original variables. The first principal component maintains the largest possible variance of the data [James et al., 2013]. Figure 4 shows that the first component loadings are all positive, as the variables correlate positively correlated with one other. The first component explains 27 % of the total variance.

Principal components/correlation	Number of observation= 207
	Number of comp. = 7
	Trace=7
Rotation: (unrotated = principal)	Rho= 1.

Component	Eigenvalue	Difference	Proportion
Comp1	1.9376	.669678	0.2768
Comp2	1.26793	.312636	0.1811
Comp3	.95529	.0989063	0.1365
Comp4	.856384	.0948599	0.1223
Comp5	.761524	.124909	0.1088
Comp6	.636615	.0519596	0.0909
Comp7	.584656	.	0.0835

Table A.3: PCA output with Componenets

The output shows that the first component explains 27.68% of the variance of the variables.

Table A.4 shows that all loadings are positive in the first component.

	Comp1	Comp2	Comp3	Unexplained
Employment lenght	.2699984	.4253433	-.3201179	0
Education	.4719358	-.3389817	-.1991325	0
Supervise	.1971271	.582004	.5214084	0
Short and rep	.2752353	-.3015385	.7114025	0
Physical	.4349763	-.4120884	-.0195224	0
Problem Solving	.4199458	.2840947	.0514484	0
Docs Read	.473503	.1548991	-.2772769	0

Table A.4: PCA output with loadings

The table shows that the first component has all positive loadings as anticipated.

I also run factor analysis for robustness. Factor analysis is a method to uncover whether a larger set of observable variables is linearly related to a smaller set of latent variables

[Tryfos, 2001]. In particular, whether the above 7 variables can give information about the unobservable hierarchy. From figure A.5, only the first factor uses positive loadings on all variables, hence I focus on this factor. The principal component and the factor analysis yield similar loadings on the variables.

	Factor 1	Factor 2	Factor 3
Employment lenght	.2564065	.2507784	-.0663934
Education	.5202047	-.2215546	-.041111
Supervise	.1853165	.3629879	.1063376
Short and rep	.2673364	-.154774	.1495327
Physical	.4691728	-.2616933	.0133566
Problem Solving	.4298277	.201043	.0239833
Docs Read	.5015999	.1224624	-.0754527

Table A.5: Factors

The first factor has positive, and very similar loadings to the PCA result.

Next, I regress these newly created measures of hierarchy on noncompete incidence. The results are in table A.6, both confirm that noncompete incidence exhibits a U-shaped relationship to hierarchy. Noncompete is most frequent at the bottom and top of a firm. Note that the measures created are standardized, hence the smallest values are negative.

A.1.4.2 Second firm

Table A.7 and A.8 summarizes the result of a similar analysis for a different firm. The firm's healthcare workers have a high incidence of noncompete (36%). The analysis confirms the quadratic relationship. [2]

[2]There is a bias regarding employment length in the data of this firm since the rounds of the survey occur every two years. Hence, only employees who worked for this firm for at least two years are included in the data. Thus, I only report the results with the PCA and factor analysis and subsequent regressions with the hierarchy measures. The small loadings on the employment length can be due to the bias.

	(1) PCA	(2) PCA	(3) Factor	(4) Factor
PCA Hierarchy	0.027			
	(0.126)			
PCA Hierarchy sq.	0.024*	0.029**		
	(0.011)	(0.001)		
Factor Hierarchy			0.050	
			(0.124)	
Factor Hierarchy sq			0.085**	0.103***
			(0.008)	(0.001)
Constant	0.084**	0.074**	0.082**	0.072*
	(0.004)	(0.010)	(0.005)	(0.011)
Observations	207	207	207	207
R^2	0.061	0.050	0.067	0.056

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.6: Regression with PCA and Factor based hierarchy

The first two columns show that the first principal component based hierarchy measure exhibits a quadratic relationship with noncompete incidence. Column 3 and 4 do the same with the first factor.

Variable	PCA	Factor
emp17	0.0825	0.0886
education	0.4736	0.6092
superv17	0.0965	0.1054
shortrep17	0.3667	0.4307
physical17	0.4796	0.6178
probsolv17	0.3765	0.4428
docread17	0.5034	0.6669

Table A.7: The loadings from PCA and factor analysis

	(1) PCA	(2) Factor
PCA Hierarchy sq.	0.036***	
	(0.001)	
Factor Hierarchy sq		0.123***
		(0.000)
Constant	0.086*	0.085*
	(0.027)	(0.028)
Observations	136	136
R^2	0.087	0.092

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.8: Regression with PCA and Factor based hierarchy

The first column shows that the first principal component based hierarchy measure exhibits a quadratic relationship to noncompete incidence. The second column is similar just with the first factor.

A.1.5 Wage premium

The wage premium paid for signing a noncompete at different levels of the firm's hierarchy may be different. Below table shows that the wage premium is larger at the top of the hierarchy than at the bottom, however the relationship is insignificant. The number of observations are low and can cause the statistically insignificant result.

	(1) Bottom	(2) Top
Noncompete	-35.736	449.392
	(0.878)	(0.580)
Education	184.012*	10.162
	(0.045)	(0.932)
Supervise	-3.766	-268.977
	(0.961)	(0.138)
Short and rep	147.078	295.276
	(0.178)	(0.245)
Physical	944.904*	170.266
	(0.013)	(0.273)
Problem Solving	34.741	-508.145
	(0.737)	(0.160)
Docs Read	76.749	-215.612
	(0.503)	(0.185)
Gender	-183.964	-1224.492*
	(0.431)	(0.010)
Race	67.223	57.943
	(0.429)	(0.667)
Constant	-246.995	5448.605
	(0.713)	(0.060)
Observations	57	54
R^2	0.429	0.290

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.9: Regression for wage premium at the bottom and top of firm hierarchy

The first column displays the regression for the wage premium at the bottom of the hierarchy. There is an insignificant, but negative relationship between the wage and noncompete. The relationship is positive, but still insignificant at the top of the firm.

A.2 Extension

A.2.1 Continuous noncompete

This section shows that the solution of the model is identical with a continuous noncompete, $\lambda \in [\bar{\lambda}, 1]$, ie.: the firm chooses one of them corners for the stringency of the noncompete.

A.2.1.1 C_1 and C_2

Consider the profit under C_1.

$$\pi(C_1) = p(1 - \lambda q)(\theta - 1) - \lambda q a\theta - c\theta \tag{A.1}$$

The firm profit is decreasing in λ, thus sets it to the minimum $\bar{\lambda}$ which is the most restrictive. Therefore, if the employee chooses to shirk, the firm prefers to set noncompete as restrictive as possible.

The Lagrangian for the problem when the employee exerts effort is

$$\begin{aligned}\mathcal{L}(\lambda, w) &= p(+\Delta)(1 - \lambda(q + \Delta))(\theta - w) - \lambda(q + \Delta)a\theta - t\theta \\ &- \mu(\lambda q\gamma\theta + 1 - \lambda q - (p + \Delta)(1 - \lambda(q + \Delta))w - (q + \Delta)\lambda\gamma\theta)\end{aligned} \tag{A.2}$$

The first order conditions are

$$\frac{\partial \mathcal{L}}{\lambda} = -(p+\Delta)(q+\Delta)(\theta-w)-(q+\Delta)a\theta-\mu(p+\Delta)(q+\Delta)w-(q+\Delta\gamma\theta+q\gamma\theta-q) = 0 \tag{A.3}$$

$$\frac{\partial \mathcal{L}}{\partial w} = -(p + \Delta)(1 - \lambda(q + \Delta)) - \mu(-(p + \Delta)(1 - \lambda(q + \Delta)) = 0 \tag{A.4}$$

Note that it follows that $\mu = 1$ and $\frac{\partial \mathcal{L}}{\lambda} = 0$ simplifies to

$$-(p + \Delta)(q + \Delta)\theta - (q + \Delta)a\theta + \Delta\gamma\theta + q = 0 \tag{A.5}$$

Note that the expression has no variables in it and it is satisfied if $\theta = \theta_3$

If $\theta < \theta_3$, the expression is positive yielding $\lambda = \bar{\lambda}$ as solution.

A.2.1.2 C_3

The Lagrangian becomes

$$\begin{aligned}\mathcal{L} &= (p+\Delta)(1-\lambda(q+\Delta))\theta - (1-\lambda(q+\Delta)w - \lambda(q+\Delta)a\theta - t\theta \\ &- \mu(\lambda q\gamma\theta + (1-\lambda q) - (1-\lambda(q+\Delta))w - \lambda(q+\Delta)\gamma\theta\end{aligned} \tag{A.6}$$

the first order conditons are

$$\begin{aligned}\frac{\partial\mathcal{L}}{\partial\lambda} &= -(p+\Delta)(q+\Delta)\theta + (q+\Delta)w - (q+\Delta)a\theta \\ &- \mu(q\gamma\theta - q + (q+\Delta)w - (q+\Delta)\gamma\theta = 0\end{aligned} \tag{A.7}$$

$$\frac{\partial\mathcal{L}}{\partial w} = -(1-\lambda(q+\Delta)) - \mu(-(1-\lambda(q+\Delta)w)) = 0 \tag{A.8}$$

Therefore $\mu = 1$ and $\lambda = \bar{\lambda}$ for $\theta \geq \theta_3$. The reason for the corner solution is that the problem is linear and the constraint $(U(e=1) \geq U(e=0))$ binds.

A.2.2 Relaxing rationality of agents

A.2.2.1 Firm's influence

Consider a modified version of the baseline model where the employee holds an incorrect belief about the stringency of her noncompete agreement. In this scenario, the firm has the ability to intentionally misinform the employee regarding the true extent of the noncompete. This behavior, referred to as exploitative contracting, is documented as a common practice in the literature [Prescott and Starr, 2021]. Furthermore, the employee may face cognitive limitations that prevent her from fully comprehending the intricacies of the contract, particularly when it involves multiple post-employment restrictions [Tirole, 2009, Lobel, 2021, Balasubramanian et al., 2021].

This section examines the optimality of strategically including unenforceable noncompetes ($\tilde{\lambda} = 0$) in the contract, and explores the implications of the employee mistakenly be-

lieving that she is subject to a stringent noncompete clause. To illustrate this phenomenon, we can consider the case of noncompete agreements in California, where such agreements are void and unenforceable by law. However, empirical evidence suggests that despite their unenforceability, noncompete agreements are still often included in employment contracts in California [Colvin and Shierholz, 2019, Sanga, 2018].

Denote with $\tilde{\lambda}$ the employee's belief about the stringency of the noncompete. Under contract C_1, where the firm offers wage $w = 1$, the resulting utility and profit are

$$U(\theta, C_1, 0) = \tilde{\lambda} q \gamma \theta + (1 - \tilde{\lambda} q) \tag{A.9}$$

$$\pi(\theta, C_1, 0) = p(1 - \tilde{\lambda} q)(\theta - 1) - \tilde{\lambda} q a \theta - c\theta \tag{A.10}$$

Thus, knowing that the employee shirks, the firm prefers to set $\tilde{\lambda} = 0$. In equilibrium, the firm can induce investment by offering the wage $w = \frac{1}{p+\Delta}$, and as a result, the employee never leaves the firm. This leads to the profit:

$$\pi(\theta, C_1, 1, \tilde{\lambda} = 0) = (p + \Delta)(\theta - \frac{1}{p + \Delta}) - c\theta \tag{A.11}$$

The firm offers $w = 1$ if $\theta < \frac{1-p}{\Delta}$ and $w = \frac{1-p}{\Delta}$ otherwise.

Under C_3, the firm also prefers $\tilde{\lambda} = 0$, and both the profit and utility take the same form as under C_1. As a result, the employee always has a utility of 1 if the firm can influence her belief about the enforceability of noncompete, while the firm pays $w = 1$. However, in this case, the employee is worse off compared to the baseline case. The reason is that the firm compensates the employee by only the minimum amount needed ($w = 1$), while the noncompete eliminates the employee's larger outside option ($\gamma\theta > 1$). This leads to a lower utility for the employee under C_3 compared to the baseline case.

A.2.2.2 Sophistication

In this extension of the model, I introduce a distinction between sophisticated agents (high ability) and naïve agents (low ability) to capture heterogeneity in their beliefs about noncom-

pete agreements. Empirical evidence suggests that employees vary in their understanding and awareness of the restrictions imposed by noncompete agreements. For example, a study by Prescott et al. [2021] found that 8.8% of employees admitted to signing noncompete agreements unknowingly. Furthermore, the complexity of noncompete agreements, often coupled with other post-employment restrictive covenants, can further hinder employees' comprehension [Balasubramanian et al., 2021, Lobel, 2021]. These additional covenants may include non-disclosure agreements (NDAs), nonsolicitation agreements (NSAs), and nonrecruitment agreements (NRAs), which restrict various post-employment activities.

Sophisticated agents, being more productive, can generate an additional output denoted by A within the industry. Consequently, their production inside the firm is given by $F(\theta, A) = \theta + A$, and the competitor's offer is $O(\theta, A) = \gamma\theta + A$. The rest of the model remains unchanged for high-ability agents.

On the other hand, naïve agents do not fully understand the terms of their contract and mistakenly believe that they are not subject to any restrictions. Consequently, they act as if they have no limitations on their post-employment activities.

As an example, under C_1, the naïve agent believes his payoff if choosing to exert effort is

$$U(\theta, C_1, 1)_L = (p + \Delta)(1 - q - \Delta) + (q + \Delta)\gamma\theta \tag{A.12}$$

while the correct function is

$$U(\theta, C_1, 1) = (p + \Delta)(1 - \bar{\lambda}(q - \Delta)) + \bar{\lambda}(q + \Delta)\gamma\theta \tag{A.13}$$

The L subscript stands for the naïve/low ability agent.

The following proposition summarizes the results. If the high ability agents' additional productivity is not too large, the lowest positions are filled up by low ability agents.

Define the thresholds

$$\theta_{1,L} = \frac{(p + \Delta)(1 - \bar{\lambda}(q - \Delta))}{(p + \Delta)(1 - \bar{\lambda}(q + \Delta)) - \bar{\lambda}(q + \Delta)a - c} \tag{A.14}$$

$$\tilde{\theta} = \frac{(p+\Delta)(1-q-\Delta)A - 1 + q + (q+\Delta)A + (p+\Delta)(1-\bar{\lambda}(q+\Delta))}{(1-\bar{\lambda})(q+\Delta)a - \Delta\gamma + (p+\Delta)(1-\bar{\lambda})(q+\Delta)} \tag{A.15}$$

Proposition A.1. *If $A < \hat{A}$, the optimal contract for $\theta_{1,L} < \theta < \tilde{\theta}$ employs the low ability agent.*

From the firm's perspective, the inclusion of noncompete agreements is beneficial if the expected increase in production resulting from effort outweighs the productivity advantage of the high-ability agent. Thus the parameter A must be constrained. Under this extension, the firm employs naïve agents for low values of θ, who choose to exert effort. As θ increases, high-ability agents also exert effort, eliminating the comparative advantage of the naïve agents and leading to their employment.

Graphs A.3, A.4, and A.5 provide a visual summary of the results. These graphs demonstrate that the true utility of low-ability employees is lower than their ex-ante belief. In fact, for smaller values of θ, their true utility may fall below their reservation utility of 1. This raises the question of whether a complete ban on noncompete agreements would be socially beneficial.

Proof.

$$U(C_1, 1)_L = (p+\Delta)(1-q-\Delta) + (q+\Delta)(\gamma\theta) > U(C_1, 0)_L = q\gamma\theta + 1 - q \tag{A.16}$$

Leading to the condition

$$\theta > \frac{(1-p-\Delta)(1-q)}{\Delta\gamma} = \theta_{L,1} \tag{A.17}$$

The firm, on the other hand, knows that the employee is subject to the noncompete, thus its profit is

$$\pi_L(\theta) = (p+\Delta)(1-\bar{\lambda}(q+\Delta)(\theta-1) - \bar{\lambda}(q+\Delta)a\theta - c\theta \tag{A.18}$$

The minimum θ that the firm's participation constraint is satisfied is

$$\theta_{1,L} = \frac{(p+\Delta)(1-\bar{\lambda}(q-\Delta))}{(p+\Delta)(1-\bar{\lambda}(q+\Delta)) - \bar{\lambda}(q+\Delta)a - c} \tag{A.19}$$

A sophisticated agent follows the behavior similar to the baseline model since the payoff of the agent is only changed by a constant in the competitor offer.

Taking again C_1, the payoff of the high ability agent when choosing G and S respectively gives

$$U(C_1, 0)_H = \bar{\lambda}q(\gamma\theta + A) + 1 - \bar{\lambda}q \tag{A.20}$$

$$U(C_1, 1)_H = (p+\Delta)(1-\bar{\lambda}(q+\Delta)) + \bar{\lambda}(q+\Delta)(\gamma\theta + A) \tag{A.21}$$

The high ability agent does not exert effort as long as θ is below the following threshold,

$$\theta(C_1) > \frac{(1-\bar{\lambda}q) - (p+\Delta)(1-\bar{\lambda}(q+\Delta)) - \bar{\lambda}\Delta A}{\bar{\lambda}\Delta\gamma} = \theta(C_1)_H \tag{A.22}$$

Consider the most interesting case when the low ability employee exerts effort but the high ability does not, $\theta(C_1)_L < \theta < \theta(C_1)_L$. The firm then chooses a low ability agent if

$$\pi(C_1, S)_L = (p+\Delta)(1-\bar{\lambda}(q+\Delta))(\theta-1) - \bar{\lambda}(q+\Delta)a\theta - t\theta > \pi(C_1, G)_H = p(1-\bar{\lambda}q)(A+\theta-1) - \bar{\lambda}qa\theta - c\theta \tag{A.23}$$

This yields the following condition on θ

$$\theta > \frac{p(1-\bar{\lambda}q)A + \Delta(1-\bar{\lambda}(q+\Delta+p))}{\Delta(1-\bar{\lambda}(q+\Delta+p)) - \bar{\lambda}\Delta a} = \theta_{H0,L1} \tag{A.24}$$

The threshold shows the firm's tradeoff. If the high ability agent is more productive (high A), the threshold becomes higher meaning employing a high ability agent for larger θ's. On the other hand, if Δ increases, the importance of effort becomes higher and thus the threshold is lowered. Note that having a lower threshold on employing a low ability agent is also intuitive. The higher θ, the training is, the more dangerous the employee is to leave, and thus the relevance of noncompete increases. In this section I want to focus on the equilibrium in which all agents exert effort, thus I restrict the range of A to be small enough

such that high ability agents who do not exert effort are not hired. The minimum training such that firm's participation constraint is satisfied is $\theta_1(A) = \frac{p(1-\bar{\lambda}q)(1-A)}{p(1-\bar{\lambda}q)-\bar{\lambda}qa-c}$. Combining it with $\theta_{H0,L1}$ leads to the following restriction on A

$$\frac{p(1-\bar{\lambda}q)\Delta(1-\bar{\lambda}(q+\Delta+p+a)-p(1-\bar{\lambda}q)-\bar{\lambda}qa-t)\Delta(1-\bar{\lambda}(q+\Delta+p)}{p(1-\bar{\lambda}q)[1+p(1-\bar{\lambda}q)-\bar{\lambda}qa-t]} > A_{HG,LS} \tag{A.25}$$

The wage that incentivizes the high ability agent to exert effort [3]

$$w(\theta)_H = \frac{(1-\bar{\lambda}q)-\bar{\lambda}\Delta(\gamma\theta+A)}{(p+\Delta)(1-\bar{\lambda}(q+\Delta)} \tag{A.26}$$

The firm chooses the low ability agent if the wage required to induce effort from a high ability employee is too high, i.e.

$$A+1 < w(\theta)_H \tag{A.27}$$

or

$$\theta < \frac{(1-p)(1-\bar{\lambda}q)-\bar{\lambda}\Delta A-(A+1)\Delta(1-\bar{\lambda}(q+\Delta+p))}{\bar{\lambda}\Delta\gamma} = \theta_{H1,L1} \tag{A.28}$$

The contract C_1 with a low ability agent is optimal, if $\exists\theta$ such that

$$\theta_{1,L} \leq \theta \leq \theta_{H1,L1} \tag{A.29}$$

Above condition yields to another lower bound on A.

$$A_{HS,LS} < \left[\frac{\bar{\lambda}\Delta\gamma(p+\Delta)(1-\bar{\lambda}(q+\Delta)}{(p+\Delta)(1-\bar{\lambda}(q+\Delta)-\bar{\lambda}(q+\Delta)a-t} - (1-p)(1-\bar{\lambda}q)+\Delta(1-\bar{\lambda}(q+\Delta+p))\right]\frac{1}{\Delta(1-\bar{\lambda}(q+\Delta+p-1)} \tag{A.30}$$

C_2

[3]Note that I focus on the case with $w(\theta)_H < 1$ because the high ability employee is now more productive inside the industry, making it cheaper to keep her.

Note that this contract cannot be equilibrium with a low ability agent since the firm can impose noncompete costlessly.

The wage that induces effort from a high ability agent is

$$w(C_2,\theta)_H = \frac{1-q-\Delta\gamma\theta-(q+\Delta)A}{(p+\Delta)(1-q-\Delta)} \tag{A.31}$$

The threshold on θ above which employing a low ability agent is better than employing a high ability one without noncompete is

$$\theta > \frac{(p+\Delta)(1-q-\Delta)A-1+q+(q+\Delta)A+(p+\Delta)(1-\bar{\lambda}(q+\Delta))}{(1-\bar{\lambda})(q+\Delta)a-\Delta\gamma+(p+\Delta)(1-\bar{\lambda})(q+\Delta)} = \tilde{\theta} \tag{A.32}$$

The condition $\theta_{1,L} < \tilde{\theta}$ imposes a lower bound on A

$$\left[\frac{(p+\Delta)(1-\bar{\lambda}(q-\Delta))}{(p+\Delta)(1-\bar{\lambda}(q+\Delta))-\bar{\lambda}(q+\Delta)a-t}(1-\bar{\lambda})(q+\Delta)a-\Delta\gamma+(p+\Delta)(1-\bar{\lambda})(q+\Delta)-(1+q+(p+\Delta)(1-\bar{\lambda}(q+\Delta))\right]$$
$$\times\frac{1}{(p+\Delta)(1-q-\Delta)+q+\Delta} = \tilde{A} > A \tag{A.33}$$

The lower bound on A is $\hat{A} = \min\{A_{H0,L1}, A_{H1,L1}, \tilde{A}\}$. The lower bound on A exists as A goes to 0 the low ability agent would dominate the high ability one because he exerts effort. ■

A.2.2.3 Banning noncompete

This section examines the optimal policy of banning noncompete agreements from the perspective of a regulator, considering the prevalence of noncompetes among low-paid jobs [Shubber, 2018, Neil, 2014]. In the case where the regulator can observe θ, noncompetes are banned for θ values that result in a utility below 1 for the employee. However, in a more realistic scenario where the regulator cannot observe θ, additional considerations come into play. The tradeoff arises from the decision to prohibit noncompete agreements for low θ values, where the employees' utility would fall below their reservation utility of 1, while still allowing the hiring of low ability agents for higher θ values, where they mistakenly exert effort. Without the provision of effort, low ability agents would not be employed, and due

to the lack of credible commitment, the misunderstanding of the contract leads to effort ecertion.

The objective function of the planner can be formulated as follows:

$$\max_{\bar{\lambda}} \int_{\theta_{1,L}}^{\tilde{\theta}} (U_L(\theta) - 1) f(\cdot) d\theta \tag{A.34}$$

The underlying assumption of the objective function is that the supply of high ability agents is abundant, allowing the firm to hire more high ability agents if there is a change in the regulation of noncompete. The regulator's objective solely focuses on the utility of naïve agents and does not consider the utility of high ability agents or the firm's profit.

In the objective function, $U_L(\theta)$ represents the true utility of low ability agents, and the distribution function $f(\cdot) > 0$ captures the distribution of the population of low ability types. The planner assigns equal weights to all agents, and these weights are independent of the decision variables.

The derivative of the objective function with respect to the decision variable is:

$$\frac{\partial \tilde{\theta}}{\partial \bar{\lambda}}(U_L(\tilde{\theta}) - 1) - \frac{\partial \theta_{1,L}}{\partial \bar{\lambda}}(U_L(\theta_{1,L}) - 1) + \int_{\theta_{1,L}}^{\tilde{\theta}} \frac{\partial U_L(\theta)}{\partial \bar{\lambda}} d\theta \tag{A.35}$$

The breakdown of the signs of the derivatives is as follows:

$$\frac{\partial \tilde{\theta}}{\partial \bar{\lambda}}(U_L(\tilde{\theta}) - 1) < 0 \tag{i}$$

Here, $\frac{\partial \tilde{\theta}}{\partial \bar{\lambda}} < 0$ and $(U_L(\tilde{\theta}) - 1 > 0)$. If $(U_L(\tilde{\theta}) - 1)$ were negative, there would be no low ability agents benefiting from noncompete. Therefore, increasing $\bar{\lambda}$ (decreasing the stringency of noncompete) reduces the range of θ for which low ability agents are employed with an expected utility higher than their reservation utility.

$$-\frac{\partial \theta_{1,L}}{\partial \bar{\lambda}}(U_L(\theta_{1,L}) - 1) > 0 \tag{ii}$$

Here, $\frac{\partial \theta_{1,L}}{\partial \bar{\lambda}} > 0$ and $(U_L(\theta_{1,L}) - 1) < 0$, resulting in a positive value for the second term (due to the minus sign). Increasing $\bar{\lambda}$ reduces the range of θ where the low ability employee's

utility falls below their reservation utility.

$$\int_{\theta_{1,L}}^{\tilde{\theta}} \frac{\partial U_L(\theta)}{\partial \bar{\lambda}} d\theta > 0 \tag{iii}$$

Here, $\frac{\partial U_L(\theta)}{\partial \bar{\lambda}} > 0$. Equation (iii) indicates that the ex post utility is always higher when noncompete is less intense.

In conclusion, a regulator focusing only on low ability agents may choose to ban noncompete if $iii + ii > i$. Banning noncompete ensures that no agent misinterprets the covenant and has a utility lower than their reservation utility. However, the downside is that low ability agents who are employed with noncompete and receive a positive rent would not be hired if noncompete is banned. Additionally, when $\bar{\lambda} = 1$, the term iii becomes zero, meaning that misunderstanding the contract mitigates the commitment problem faced by the employee regarding effort.

A.2.3 Multiple firms

In this extension, the game involves two firms competing for the employee at the beginning. Once one firm successfully hires the employee, it becomes the incumbent firm, while the other firm becomes the competitor, where the employee may choose to leave for. The competitor's payoff is denoted as $\varepsilon\theta$, where ε is chosen to be small enough such that $\varepsilon + \gamma < 1$, ensuring that the training provided by the incumbent firm yields the highest return inside the firm.

The competitor's payoff can be expressed as follows:

$$\pi_C = \Pr(\text{join of the employee})\varepsilon\theta \tag{A.36}$$

The competitor has a lower payoff if the employee is subject to a noncompete. The incumbent's payoff (π_I) , however, remains independent from the competitor's payoff, that is the damage function ($a\theta$) is not a function of ε. I distinguish two cases. The first case is when it is more profitable to be the competitor under the optimal contract derived in Section 4. In this case, the competitor has a higher payoff than the incumbent. The second case is when it is equally or more profitable to be the incumbent compared to being the competitor. In this situation, the incumbent firm's payoff is at least as high as the competitor's payoff.

A.2.3.1 $\pi_C > \pi_I > 0$

If it is more profitable to be the competitor, the game does not have a symmetric equilibrium. The reasoning behind this is as follows. First, consider that neither firm offers employment to the agent initially. In this case, both firms have an incentive to deviate from this strategy and offer a contract to the agent. However, it is not possible for both firms to offer the contract simultaneously as an equilibrium, because each firm would have an incentive to deviate and become the competitor instead. As a result, there is no symmetric equilibrium where both firms offer employment to the agent. Instead, the asymmetric equilibrium emerges, where one firm offers the contract to the agent, following the strategy outlined in the baseline model, while the other firm does not offer employment.

A.2.3.2 $\pi_C \leq \pi_I$

The firms have incentives to be the incumbent. Thus, there is a symmetric equilibrium of the game, where both firms offer to contract to the employee such that $\pi_C = \pi_I$.

A.2.3.3 2 firms and 2 employees

The setup involves two firms, each hiring one agent. The net payoff from poaching an employee is denoted as $\varepsilon\theta$, where ε is a small parameter representing the relative value of poaching.[4] In this scenario, the most common assumption is that firms engage in simultaneous poaching of each other's employees [Bar-Isaac and Leaver, 2021, Bar-Isaac and Levy, 2022]. Therefore, from the perspective of the agents, the model remains unchanged.

The payoffs for the firms are below. The first argument denotes whether the firm's agent is subject to a noncompete, and the second argument is whether the competitor firm's agent is.

$$\pi(FREE, FREE) = p(1 - (q + \Delta))(\theta - w(\theta)) - (q + \Delta)a\theta - t\theta + (q + \Delta)\varepsilon\theta \qquad \text{(A.37)}$$

[4]The employee still receives $\gamma\theta$

$$\pi(NCC, FREE) = p(1 - \bar{\lambda}q)(\theta - 1) - \bar{\lambda}qa\theta - t\theta + (q + \Delta)\varepsilon\theta \tag{A.38}$$

$$\pi(FREE, NCC) = p(1 - (q + \Delta))(\theta - w(\theta)) - (q + \Delta)a\theta - t\theta + \bar{\lambda}q\varepsilon\theta \tag{A.39}$$

$$\pi(NCC, NCC) = p(1 - \bar{\lambda}q)(\theta - 1) - \bar{\lambda}qa\theta - t\theta + \bar{\lambda}q\varepsilon\theta \tag{A.40}$$

In the baseline case with one active firm, θ_2 was the threshold such that $\theta > \theta_2$ the firm preferred the contract with free exit. Now, I focus on θ's slightly lower than θ_2. In this range, the equilibrium unfolds as follows. Starting from both firms choosing the free exit contract, firms have the incentive to deviate to subject their employee to a noncompete. The benefit from poaching the other employee remains, while the loss from the employee choosing to shirk is smaller than the benefit of noncompete, since $\theta < \theta_2$. As a result, the competitor firm also chooses to sign a noncompete with the employee, with similar reasoning. Therefore, both firms constrain their employees.

However, denote the threshold where $\pi(FREE, FREE) = \pi(NCC, NCC)$ with θ^{FF}. The threshold is less than θ_2 since $q + \Delta > \bar{\lambda}q$. Therefore, for $\theta^{FF} < \theta < \theta_2$ there is a prisoner's dilemma. While $\pi(FREE, FREE) > \pi(NCC, NCC)$, the firms cannot commit not to bind their own employees and end up constraining them, while every player would be better off without noncompetes.

A.2.4 Effort

This section compares the threshold θ_2 on the equilibrium path, from which the employee exerts effort to the socially optimal value. The friction exists in a setup without a noncompete.

The increased expected production in the industry if the employee exerts effort is $\Delta\theta + (1-p)\bar{\lambda}\Delta\gamma\theta$. If the employee chooses to shirk, the expected production in the other industry, taking the contracts as given, is $(1-p)(1-\bar{\lambda}q)$. Hence, it is socially beneficial if the employee

chooses S if

$$\theta > \frac{(1-p)(1-\bar{\lambda}q)}{\Delta(1+(1-p)\bar{\lambda}\gamma)} = \theta^e \tag{A.41}$$

$\theta^e < \theta_2$, that is the employee chooses S at a higher threshold of θ than it is socially optimal since the employee does not endogenize all the benefits of exerting effort.

A.2.5 Correlated production

This section relaxes the independence assumption on p and q, that is the employee is a good fit with the firm and receives the offer from the competitor, respectively.

Denote the arrival of the competitor's offer conditional on being a good fit with the firm with α, i.e.

$$\Pr(\text{Production at the firm}|\ \text{No production at the competitor}) = \alpha \tag{A.42}$$

Consider first the profit under C_1. If the value of α is close to p, the optimal contract is similar to the independent probabilities case. The firm's profit and the firm's lower bound on positions are

$$\pi(\theta, C_1, \alpha, 0) = p(\theta - \gamma\theta) - \frac{\bar{\lambda}q + \alpha(1-\bar{\lambda}q) - p}{1-p} a\theta - c\theta \tag{A.43}$$

$$\theta_1(\alpha) = \frac{\alpha(1-\bar{\lambda}q)}{\alpha(1-\bar{\lambda}) - \bar{\lambda}qa - t} \tag{A.44}$$

Under C_2, the employee exerts effort. I define the new conditional probability as

$$\Pr(\text{Production at the firm}|\ \text{No production at the competitor})_{|S=1} = \alpha + \Delta \tag{A.45}$$

Solving the model requires the same steps as with independent probabilities. The respective functions are

$$U(\theta, C_2, \alpha, 1) = (\alpha+\Delta)(1-q-\Delta)w(\theta,\alpha) + (q+\Delta)\gamma\theta \tag{A.46}$$

$$U(\theta, C_2, \alpha, 0) = q\gamma\theta + 1 - q \tag{A.47}$$

$$w(\theta, C_2, \alpha) = \frac{(1 - q - \Delta\gamma\theta)}{(\alpha + \Delta)(1 - q - \Delta)} \tag{A.48}$$

$$\pi(\theta, C_2, \alpha, 1) = (\alpha + \Delta)(1 - q - \Delta)(\theta - w(\theta, \alpha)) - (q + \Delta)a\theta - t\theta \tag{A.49}$$

$$U(\theta, C_3, \alpha, 1) = (1 - \bar{\lambda}(q + \Delta))w(\theta, \alpha) + \bar{\lambda}(q + \Delta)\gamma\theta \tag{A.50}$$

$$U(\theta, C_3, \alpha, 0) = \bar{\lambda}q\gamma\theta + 1 - \bar{\lambda}q \tag{A.51}$$

$$w(C_3, \theta, \alpha) = \frac{1 - \bar{\lambda}q - \bar{\lambda}\Delta\gamma\theta}{(1 - \bar{\lambda}(q + \Delta))} \tag{A.52}$$

$$\pi(\theta, C_3, \alpha, 1) = (\alpha + \Delta)(1 - \bar{\lambda}(q - \Delta))\theta - (1 - \bar{\lambda}(q + \Delta))w(\theta, \alpha) - \bar{\lambda}(q + \Delta)a\theta - t\theta \tag{A.53}$$

$$\theta_2(\alpha) = \frac{1 + \alpha\bar{\lambda}q - q - \alpha}{\Delta(1 + \gamma - a - \alpha - q) - (1 - \bar{\lambda})(a + p)q - \Delta^2} \tag{A.54}$$

$$\theta_3(\alpha) = \frac{q}{(\alpha + \Delta)(q + \Delta) + (q + \Delta)a - \Delta\gamma} \tag{A.55}$$

The interesting case is when α is small such that there is a high correlation between production at the firm and at the competitor.

A.2.5.1 Small α

The optimal contract changes if there is a high correlation between production at the firm and the occurrence of the competitor's offer, that is, if α becomes small. A high wage, $w(\theta) = \gamma\theta$, keeps the employee from leaving if he is a good fit. Denote the contract with noncompete, dismissal, and $w(\theta) = \gamma\theta$ by C_0. Without investment, the firm's profit takes the form of

$$\pi(\theta, C_0, , \alpha) = p(\theta - \gamma\theta) - \frac{\bar{\lambda}q + \alpha(1 - \bar{\lambda}q) - p}{1 - p}a\theta - c\theta \tag{A.56}$$

where by the law of total probability

$$\Pr(\text{Production at competitor}|\ \text{No Production at firm})_{|G=1} = \frac{\bar{\lambda}q + \alpha(1 - \bar{\lambda}q) - p}{1 - p} \tag{A.57}$$

$$\begin{aligned}&\Pr(\text{Production at competitor}|\text{ No Production at firm})_{|G=1} = \\ &= \frac{\bar{\lambda}(q+\Delta)+(\alpha+\Delta)(1-\bar{\lambda}(q+\Delta))-(p+\Delta)}{1-p-\Delta}\end{aligned} \tag{A.58}$$

The higher α is, the lower the profit of the firm is under the above contract. The firm prefers a high correlation (low α) between the productions so that the employee rarely leaves to the competitor.

Remark 2. $\exists \alpha^T(\theta)$ *such that* $\forall \alpha < \alpha^T(\theta)$, C_0 *is part of the optimal contract.*

Proof. By equating the profits under C_0 and C_1 the following threshold, α^T, arises

$$\pi(C_0) \geq \pi(C_1) \iff \alpha \leq \frac{p\theta[a(1-\bar{\lambda}q)+(1-\gamma)(1-p)]}{(1-\bar{\lambda}q)[(1+a)\theta+p(1-\theta)-1]} \tag{A.59}$$

■

A.3 Figures from simulations of the model

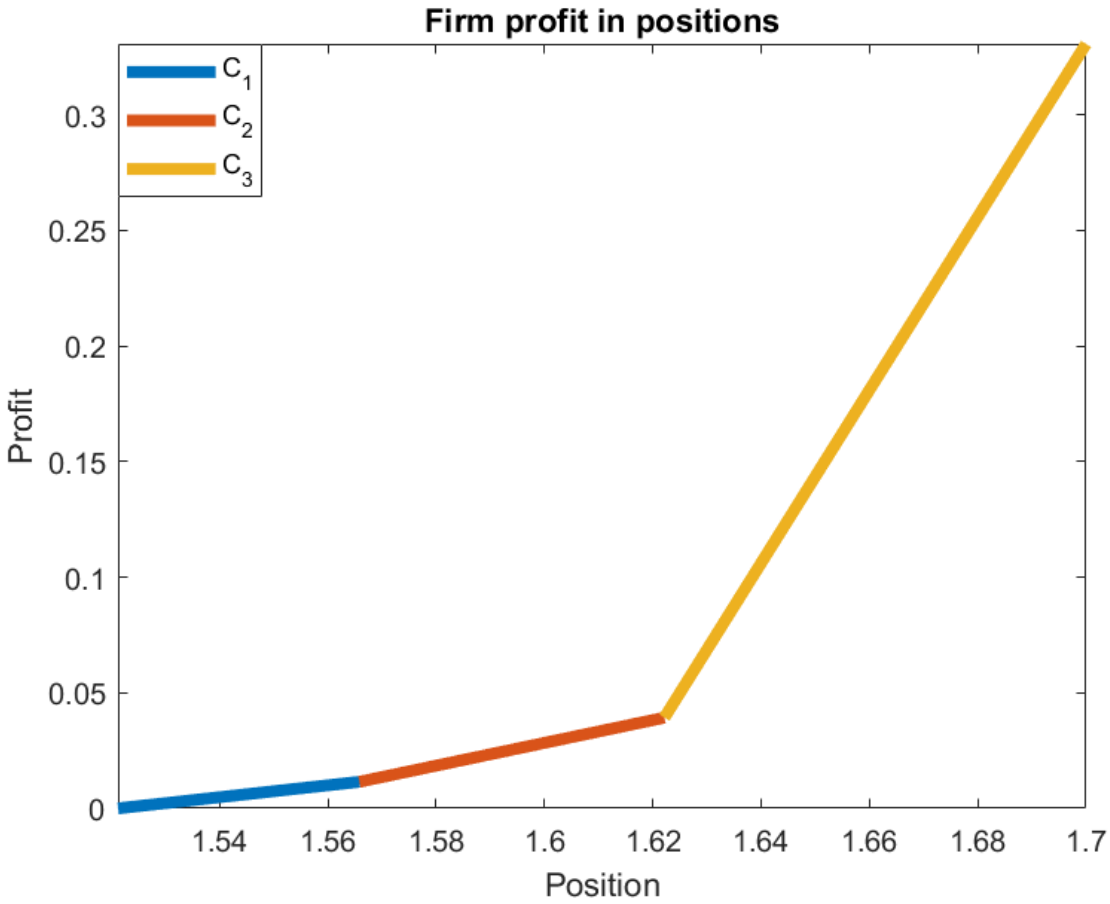


Figure A.2: The firm profit under the optimal contract

A.3.1 Sophistication

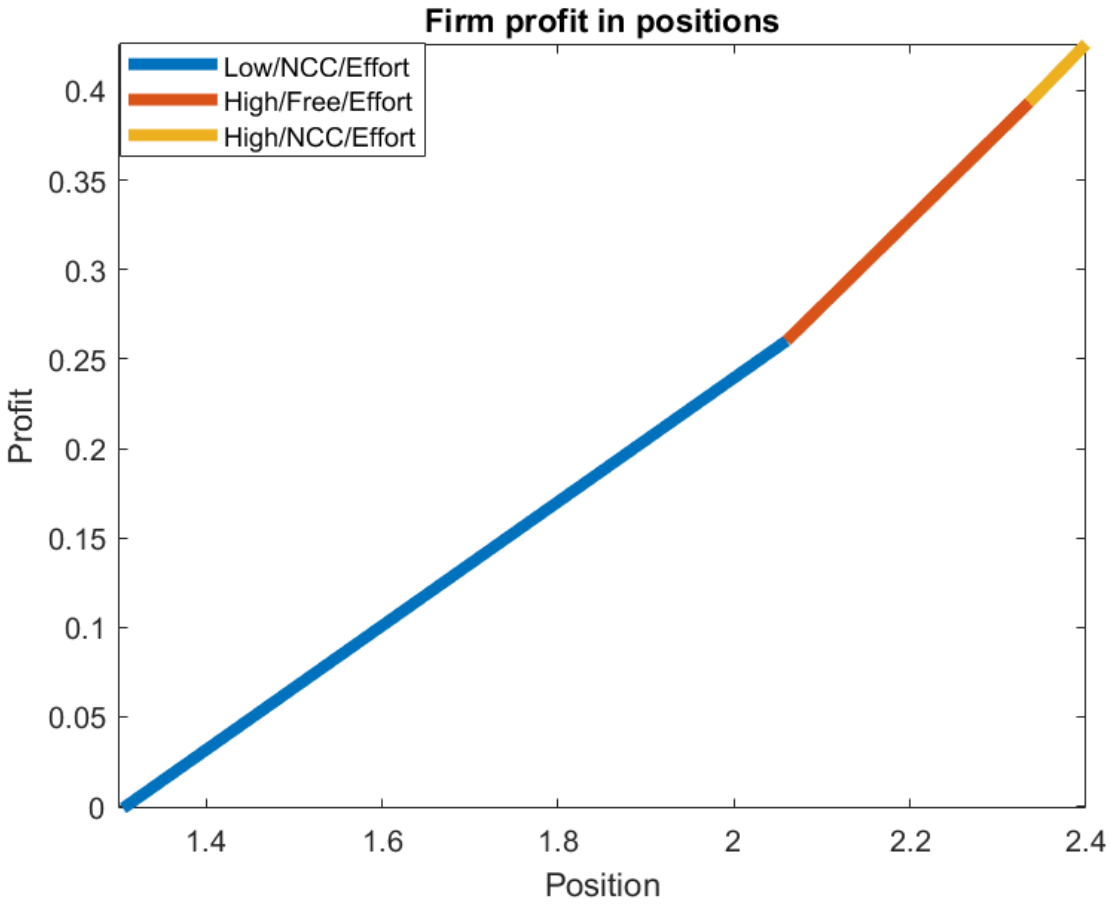


Figure A.3: Profit of the firm under the different contracts

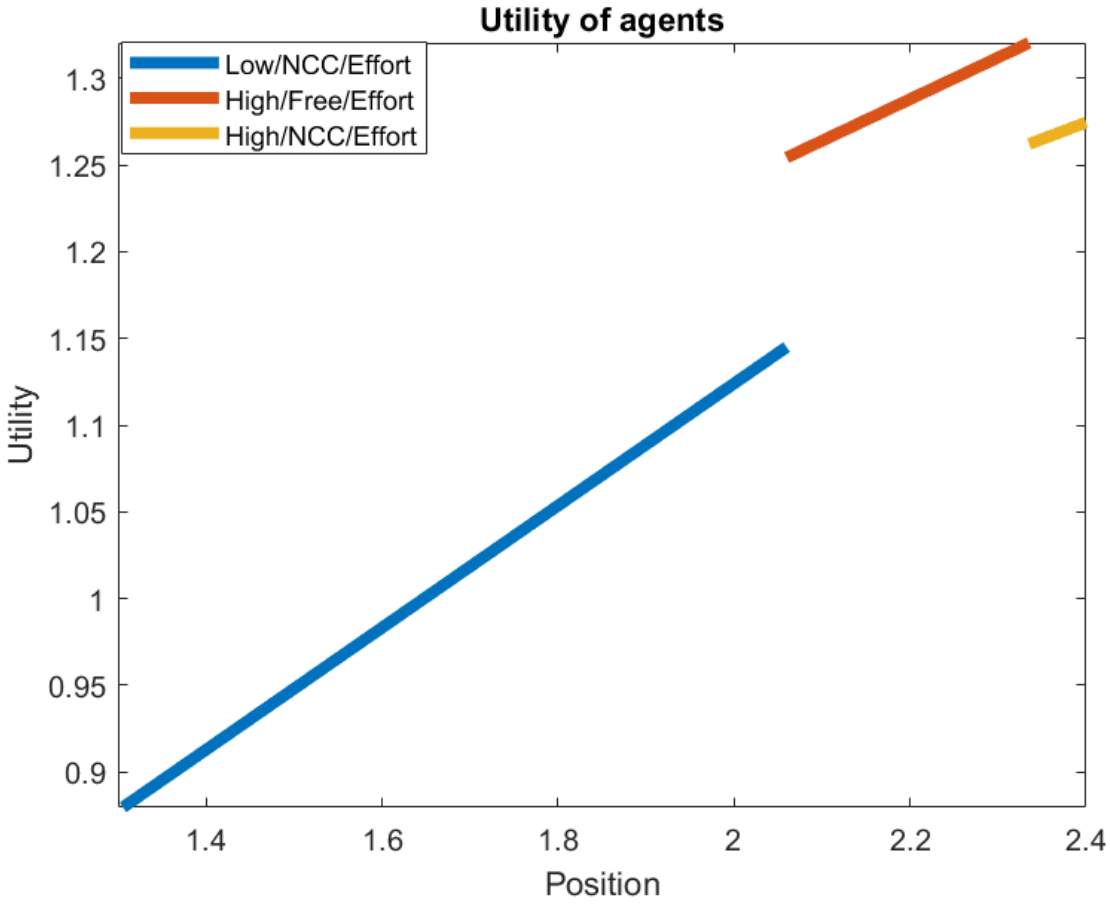


Figure A.4: Utility of the agent under the different contracts

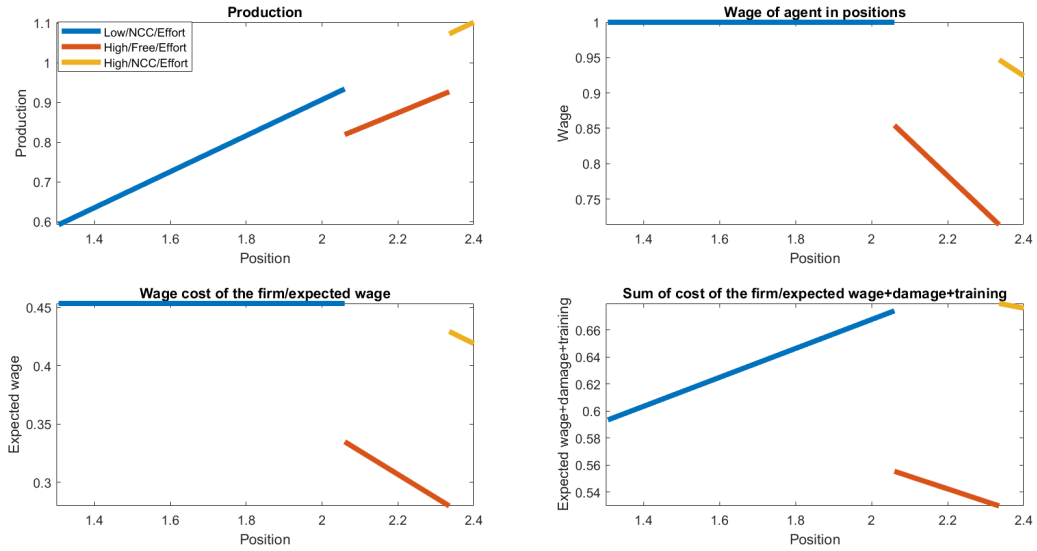


Figure A.5: Production and wage costs

A.4 Proofs

A.4.1 Proof of Lemma 1

Proof. The lemma is proven by comparing θ_1 and θ_2. $\theta_2 > \theta_1$ if

$$c < \frac{a(-1+q)q\lambda - p^2(-1+q+\Delta)(-1+q\lambda) - p(1+(-1+a-\gamma)\Delta+\Delta^2+q(-1+a+\Delta))(-1+q\lambda)}{1-q+p(-1+q\lambda)} = \bar{c} \tag{A.60}$$

■

A.4.2 Proof of Lemma 2

Proof.

$$\bar{\lambda} > \frac{pq(-1+\Delta)+(\gamma-\Delta)\Delta+a(-1+p)(q+\Delta)+p^2(q+\Delta)+p\Delta(-1-\gamma+\Delta)}{q(a(-1+p)q+ap\Delta+pq(-1+p+\Delta)+p\Delta(p-\gamma+\Delta))} = \lambda^t \tag{A.61}$$

■

The expressions show the upper bound on $\bar{\lambda}$, that is the least stringent noncompete under which the inequality of $\theta_3 > \theta_2$ holds.

A.4.3 Proof of Lemma 2.4

Proof. Under C_1 the firm offers $w_2 = \gamma\theta$ if

$$\theta - \gamma\theta > (1-\bar{\lambda}q_2)(\theta-1) - \bar{\lambda}q_2 a\theta \tag{A.62}$$

Above leads to the condition on θ

$$\theta < \frac{1-\bar{\lambda}q_2}{\gamma-\bar{\lambda}q_2-\bar{\lambda}q_2 a} = \theta(C_1)_2 \tag{A.63}$$

Since γ is assumed to be close to one, the denominator is positive. However, $\theta_1 > \theta(C_1)_2$ [5], where θ_1 is the threshold for employment. Hence, the firm does not offer the market wage, but $w = 1$. ■

A.4.4 Proof of Proposition 2.3

Proof. I divide the problem into two cases with respect to noncompete, $\lambda \geq \lambda^T$ and $\lambda < \lambda^T$. Note that the firm's problem may not yield a corner solution of λ, hence I allow the firm to set the noncompete variable continuously, $\lambda \in [\bar{\lambda}, 1]$.

A.4.4.1 $\lambda \geq \lambda^T$

First, consider the case when noncompete is mild with $\lambda \geq \lambda^T = \frac{\gamma}{(q+\Delta)(1+a)}$. I focus on wages such that $\gamma\theta > 1 > w$ as in the baseline case. The first line of the firm's profit is identical to the one period case. In the second period, the productive employee always stays.

$$\begin{aligned}\pi(\theta, 1, w(\theta), S) =&(p+\Delta)(1-\lambda(q+\Delta)(\theta - w(\theta)) - \lambda(q+\Delta)a\theta - t\theta \\ &+ (p+\Delta)(1-\lambda(q+\Delta))(\theta - \gamma\theta)\end{aligned} \tag{A.64}$$

The first period employee utility is identical to the one period case. In the second period the employee receives a wage $\gamma\theta$ from the firm if stayed for the second period, or receives $\gamma\theta$ if competed in the first period.

$$\begin{aligned}U(\theta, 1, w(\theta), S) =&(p+\Delta)(1-\lambda(q+\Delta))w(\theta) + \lambda(q+\Delta)\gamma\theta \\ &+ (p+\Delta)(1-\lambda(q+\Delta))\gamma\theta + \lambda(q+\Delta)\gamma\theta\end{aligned} \tag{A.65}$$

If the employee leaves the industry in the first period, she will not receive a competitor outside offer from the industry. Thus the utility of the agent investing in generic capital takes the following form and the employee never stays with the firm.

[5] The condition boils down to $c + \bar{\lambda}qa > p(1 + \bar{\lambda}qa - \gamma$, the inequality holds since γ is close to 1.

$$U(\theta, 1, 1, G) = \lambda q\gamma\theta + 1 - \bar{\lambda}q + \lambda q\gamma\theta + 1 - \bar{\lambda}q \tag{A.66}$$

The problem of the firm is then

$$\max_{\lambda, w(\theta)} \pi(\theta, 1, w(\theta, S), S) \tag{A.67}$$

s.t.

$$U(\theta, 1, w(\theta), S) \geq U(\theta, 1, w(\theta), G) \tag{A.68}$$

The Lagrangian takes the form of

$$L = \pi(\theta, 1, w(\theta), S - \mu(U(\theta, 1, w(\theta), G) - U(\theta, 1, w(\theta), S)) \tag{A.69}$$

with first order conditions.

$$\frac{\partial L}{\partial w} = -(p + \Delta)(1 - \lambda(q + \Delta) - \mu(-(p + \Delta)(1 - \lambda(q + \Delta)) = 0 \tag{A.70}$$

$$\begin{aligned}\frac{\partial L}{\partial \lambda} &= -(p + \Delta)(q + \Delta)(\theta - w(\theta) - (q + \Delta)a\theta - (p + \Delta)(q + \Delta)(\theta - \gamma\theta) \\ &- \mu(2q\gamma\theta - 2q(-((p + \Delta)(q + \Delta)w(\theta) + (q + \Delta)\gamma\theta - (p + \Delta)(q + \Delta)\gamma\theta + (q + \Delta)\gamma\theta) = 0\end{aligned} \tag{A.71}$$

From (A.70) it follows that $\mu = 1$ and thus the corresponding constraint binds. It follows that the problem is convex in λ yielding a corner solution. The sign of the derivative of the profit function determines whether $\lambda = 1$ or $\lambda = \lambda^T$ is the optimal choice. Note that $\lambda = 1$ means the noncompete is not imposed, hence the interesting case for the analysis is when $\lambda = \lambda^T$. $\lambda = \lambda^T$ if

$$\theta > \frac{2q}{2\Delta\gamma - 2(p + \Delta)(q + \Delta) - a(q + \Delta)} = \theta_2^T \tag{A.72}$$

The corresponding wage and profit function respectively are

$$w(\theta) = \frac{2(1-\lambda^T q - \lambda^T \Delta\gamma\theta) - (p+\Delta)(1-\lambda^T(q+\Delta))\gamma\theta}{(p+\Delta)(1-\lambda^T(q+\Delta))} = w(\theta, \lambda^T) \tag{A.73}$$

$$\begin{aligned}\pi(\theta, 1, 0, w(\theta), S, \lambda = \lambda^T) = (p+\Delta)(1-\lambda^T(q+\Delta))\theta - [2(1-\lambda^T q - \lambda^T\Delta)\gamma\theta) - (p+\Delta)(1-\lambda^T(q+\Delta)\gamma\theta] - \lambda^T(q+\Delta)a\theta \\ + (p+\Delta)(1-\lambda^T(q+\Delta)(\theta-\gamma\theta) - c\theta\end{aligned} \tag{A.74}$$

Importantly, the profit is a decreasing function of λ^T, hence it also decreases in γ.

A.4.4.2 $\lambda < \lambda^T$

If $\lambda < \lambda^T$ noncompete is so restrictive that the employee anticipates to be held up in the second period if she specializes. The firm has two strategies that may be optimal. First, the firm may offer the employee $w = 1$ and imposes the most restrictive noncompete, $\lambda = \bar{\lambda}$. The employee in turn chooses G.

The profit of the firm is

$$\pi(\theta, 1, 1, G) = p(1-\bar{\lambda}q)(\theta-1)) - \bar{\lambda}qa\theta + p(1-\bar{\lambda}q)^2(\theta-1) - p(1-\bar{\lambda}q)\bar{\lambda}qa\theta - c\theta \tag{A.75}$$

The last term is the damage if the employee leaves in the second period. The utility of the employee is

$$U(\theta, 1, 1, G) = \lambda q\gamma\theta + 1 - \bar{\lambda}q + (\lambda q + p(1-\lambda q)\lambda q)\gamma\theta + p(1-\lambda q)^2 + 1 - \lambda q - p(1-\lambda q) \tag{A.76}$$

Second, the firm may offer the wage that incentivizes the employee to choose S despite knowing the firm holds up the employee in the second period. In other words, the firm can add the second period wage to the first period wage and offer it to the employee up front. Consider a contract with $\gamma\theta > w_1(\theta) > 1$ and $w_2(\theta) = 0$ where the subscripts denote the time period. Moreover, the firm imposes the strictest noncompete, $\lambda = \bar{\lambda}$.

The utility of the employee if choosing S is

$$U(\theta,1,w_1(\theta),S) = (p+\Delta)(1-\bar{\lambda}(q+\Delta))w_1(\theta)+\bar{\lambda}(q+\Delta)+\bar{\lambda}(q+\Delta)+(p+\Delta)(1-\bar{\lambda}(q+\Delta))\bar{\lambda}(q+\Delta) \tag{A.77}$$

In the second period, the employee only receives an income if she competes. She either already starts the period working for the competitor or she receives the offer in the second period.

If the employee chooses G her utility is

$$U(\theta,1,w_1(\theta),G) = p(1-\bar{\lambda}q)w_1(\theta)+\bar{\lambda}q\gamma\theta+(1-p)(1-\bar{\lambda}q)+\bar{\lambda}q\gamma\theta+p(1-\bar{\lambda}q)\bar{\lambda}q\gamma\theta+(1-\bar{\lambda}q-p(1-\bar{\lambda}q)\bar{\lambda}q) \tag{A.78}$$

The wage to induce S is then

$$w_1(\theta) > \frac{\left(2\bar{\lambda}\Delta+\bar{\lambda}(q+\Delta)\Delta(1-\bar{\lambda}(q+\Delta+p)+p\bar{\lambda}(q+\Delta)+p(1-\bar{\lambda}q)\bar{\lambda}\Delta)\right)\gamma\theta-(1-p)(1-\bar{\lambda}q)-1+\bar{\lambda}q+p(1-\bar{\lambda}q)\bar{\lambda}q}{\Delta(1-\bar{\lambda}(p+q+\Delta))} \tag{A.79}$$

Hence, offering a high wage in the first period can solve the holdup problem. I continue the analysis when offering a high wage is not possible, for example, because the firm cannot credibly commit to it since the firm's revenue is too low. Therefore, I compare the contracts when the firm offers $\lambda = \bar{\lambda}$ and $w = 1$ to $\lambda = \lambda^T$ with $w = w(\theta)$ at $\lambda = \lambda^T$

A.4.4.3 Optimal contract

The firm offers the contract that incentivizes specialization if the parameter γ is low. The firm does not hold up the employee in the second period but offers her the market wage, $w(\theta) = \gamma\theta$ as the market wage is low enough. If γ is high, however, the firm would hold up the employee. Hence the employee, who correctly anticipates the holdup, does not specialize in equilibrium.

Formally, $\pi(\theta,1,w(\theta),S,\lambda=\lambda^T)$ is decreasing in γ, while $\pi(\theta,1,w(\theta),G,\lambda=\bar{\lambda})$ is not a function of γ. Hence if γ is large enough, the firm prefers the contract with $w = 1$ and the strictest noncompte $\bar{\lambda}$. $\pi(\theta,1,w(\theta),S,\lambda=\lambda^T) \geq \pi(\theta,1,w(\theta),G,\lambda=\bar{\lambda})$ yields the condition on θ

$$\theta \geq \frac{2 - \frac{2\gamma q}{1+a} - p(1-\bar{\lambda}q)(2-\bar{\lambda}q)}{2(p+\Delta)(1-\frac{\gamma}{1+a}(1-\gamma)) - \frac{\gamma}{1+a}a + \frac{2\gamma^2\Delta}{1+a} - p(1-\bar{\lambda}q)(2-\bar{\lambda}q) + \bar{\lambda}qa + p(1-\bar{\lambda}q)\bar{\lambda}qa} = \theta_2^S \tag{A.80}$$

■

Chapter 3

Guarding Expertise and Assets: Non-competition Agreements and Their Implications

3.1 Introduction

Successful firms possess unique critical assets that enable them to generate economic surplus [Rajan and Zingales, 2001]. These assets can range from innovative technology and robust customer relationships to novel tools. A crucial organizational decision involves determining how much access to the critical asset to provide to employees, as they may replicate the technology, walk away with customers, or steal crucial information. On the one hand, the greater the degree of access provided to employees, the more they understand the operations of the firm, and the more effectively they can contribute to the firm's profitability. On the other hand, extensive knowledge about the firm's critical asset enables employees to become fierce rivals, either by setting up their own startups or by joining existing competitor firms. To mitigate this risk, firms frequently employ non-competition clauses (commonly referred to as noncompetes).[1] Economic theory suggests that noncompetes can help alleviate the hold-up problem [Williamson, 1979] by aligning the incentives of employers and employees

[1] "[N]on-compete agreements are contracts between workers and firms that delay employees' ability to work for competing firms." ([US-Treasury, 2016], p.3)

[Lipsitz, 2017]. Noncompete agreements have become increasingly common in recent years, with almost 20% of US employees currently subject to such clauses [Prescott et al., 2021]. The use of noncompetes is also prevalent in Europe, with similar ratios reported [Boeri et al., 2022].

This paper explores the optimal compensation package for employees, encompassing access, wage, and noncompete, and how these elements vary with the employee's level of ability. The higher an employee's ability, the greater the compensation they demand. The main friction of the model is the inability of employees to commit ex post to staying with the firm, potentially leaving after gaining access to the firm's critical asset and causing damage. Despite the risk of ex post departure, the firm prioritizes access as compensation mechanism because it boosts both the employee's utility and the firm's productivity. Hence, the first key result of this paper is that access to the firm's assets is non-decreasing with respect to the employee's ability. That is, if it is optimal to employ an agent with a certain degree of access, it is also always optimal to employ an agent who has greater ability, with at least as high degree of access as the lower ability colleague.

Another key finding of the paper specifically concerns high ability agents, who demand the highest compensation. These employees are provided the maximum access to the firm's assets, while the remaining compensation depends on the extent of damage the employee may cause through competition. With low damages, the firm offers a lax noncompete with smaller wages. Conversely, when the potential damage is high, the firm compensates with increased wages paired with a more stringent noncompete. This compensation dynamic, especially evident in CEO contracts as documented by [Kini et al., 2021], is coherently explained by the model, offering a theoretical framework for these observed real-world practices

In the theoretical model, the firm offers an employment contract to an agent, he, whose primary attribute is his level of ability. The contract specifies both the stringency of the noncompete agreement and the degree of access to the firm's critical asset. The employee's productivity is dependent on both their level of ability and the degree of access provided to the assets. Greater access leads to increased production potential for the employee. However, the employee cannot commit to staying with the firm, and a competing firm may offer them a job before production takes place. The offer from the competitor is proportional to the

degree of access the employee has at the firm, as providing access transfers knowledge and information to the employee, which may benefit the competitor. The firm incurs damages if the employee leaves and takes their knowledge with him. To mitigate this risk, the firm may include a noncompete covenant of varying stringency in the contract, which restricts the employee's potential outside opportunities and reduces the firm's damages if the employee leaves.

One key aspect of the model is that even with the most stringent noncompete clause, the employee still has some outside opportunities available due to legal limits on the stringency of the restriction. For instance, the degree of noncompete could represent the minimum distance that a competitor must be located from the firm in order to make an employment offer to the employee, with a natural boundary such as a state or country. Joining a competitor in a different state causes less harm to the firm, but still impacts its future profitability. The cost of implementing the noncompete clause is implicit in the model, as it reduces the expected payoff of the employee, thereby compelling the firm to increase compensation to meet the participation constraint of the employee's ability level.

In the first part of the paper, I focus on how the optimal contract in terms of noncompete and access is influenced by the prior ability of the agent. Ability is ex ante observable, contractible, and constant over time. The connection between ability and noncompete is particularly interesting as this relationship is non-monotonic shown by the data from the National Longitudinal Survey of Youth. The data suggests that when ability is measured solely by education level, the highest ability agents do not necessarily have a higher likelihood of a noncompete in their contracts than others in the labor market.[2] In alignment with above evidence, recent studies have highlighted the prevalence of noncompete agreements among low and mid-wage workers as well, including physicians [Lavetti et al., 2019], cleaning staff,[3] and sandwich makers.[4]

An important assumption of the model is that a low ability employee learns from high ability colleagues. As a result, competitors value these low ability workers more highly than their initial ability level would suggest. This knowledge transfer significantly increases the

[2]The non-monotonic relationship is illustrated in Figure B.1 in Appendix A.
[3]Financial Times, 10-16-2018
[4]New York Times, 04-14-2014

damage to the incumbent firm if such an employee departs.

The primary findings of the baseline model can be summarized as follows: the firm establishes a minimum threshold of ability, below which the agent's potential harm upon joining a competitor outweighs their expected production, rendering them unemployable. Above this threshold, agents are hired and subjected to the strictest noncompete agreements in their contracts. This is because although their contribution to the firm's profits is minimal, their departure can have an outsized impact due to their propensity for learning. These agents are given only enough access to the firm to incentivize them to accept the employment offer.

In the intermediate range, the agents have abilities closer to, but still below, the average ability of the population. To ensure their participation, the firm offers them a high degree of access and a less stringent noncompete clause. These agents make a significant contribution to the firm's profit, so the firm is willing to offer them employment despite the potential threat of their leaving.

For high-ability agents who have abilities higher than the average of the firm, the firm provides them with a high degree of access to maximize their output potential. However, since these agents pose a greater threat of leaving and causing significant damage, the same stringency of the noncompete is offered as in the previous range. In the subsequent part of the paper, I examine how the relative size of the firm's damage and the employee's outside option affects the optimal contract. Additionally, The model is also expanded to include an initial period where the firm can offer an unconditional monetary transfer (wage) to the employee, which does not incentivize staying with the firm. The findings reveal that when firm damage is smaller, the firm opts for a contract with a lower wage and a less stringent noncompete, reducing the firm's costs. Conversely, in the scenario with larger firm damage, a higher wage coupled with a more stringent noncompete becomes preferable to minimize losses from the employee's potential departure. This result is consistent with the empirical evidence of Kini et al. (2019), where they approach the problem from the employees' side and find that CEO's are less likely to have a noncompete in their contract if it greatly decreases their outside option. This situation occurs when the CEO is not qualified to work in another industry.

I also examine the size of the firm with respect to the maximum stringency of the noncompete permitted. This analysis reveals that more stringent noncompetes enable the firm to hire lower ability agents while mitigating potential damages from their departure. Since the maximum ability of agents remains constant across both regimes, the firm's size is larger when noncompete agreements are more stringent. Additionally, my findings indicate a non-monotonic relationship between firm size and the ratio of the employee's ex post outside option to firm damage. Specifically, when this ratio is small, the employee derives minimal benefit from the outside option, but the cost to the firm is significant. In such scenarios, the firm sets a higher minimum ability requirement, which results in a smaller overall firm size. Conversely, when the employee's gain from external access is substantial, the firm faces higher compensation demands in the bargaining process, necessitating a higher minimum ability threshold. Consequently, the firm size exhibits an inverted U-shaped function in relation to the employee gain to firm damage ratio.

In addition, this paper investigates the optimal regulation of noncompete stringency and examines whether setting an upper limit enhances welfare. Such an upper bound could be linked to the duration or geographic scope of the covenant's enforceability. The regulator's objective is to maximize ex post welfare, factoring in the firm's production, the employee's outside options, and the potential damage to the firm. I find that imposing an upper bound on noncompete stringency is unnecessary when the employee's gain from joining a competitor is smaller than the potential damage to the firm. A more stringent noncompete acts as an incentive for the firm, encouraging it to provide greater access to employees. This is due to the fact that a more stringent noncompete reduces the firm's expected damage if an employee departs, making it profitable to hire agents with lower abilities. Consequently, this approach leads to an increase in the firm's size, as the risk associated with providing access is mitigated. However, as the employee's outside option increasing outweighing the firm damage imposing an upper bound on the stringency of the noncompete may improve welfare. The regulator must trade off the benefit of strict regulation in terms of facilitating access provision and the cost that great outside options are reduced.

My work closely relates to two streams of literature: one focusing on access and the

other on noncompete agreements. The concept of access, as introduced by Rajan and Zingales [1998], is defined as 'the ability to use or work with the critical resource' of a firm, be it physical or an idea (p.388). They compare this with property rights theory and optimal asset ownership [Grossman and Hart, 1986]. In their related work, Rajan and Zingales [2001] explore a tradeoff similar to the one in my study, where granting access enhances a manager's productivity but also poses the risk of them becoming a competitor upon departure. Their focus is on organizational aspects such as the hierarchy and size of the firm. My paper contributes an additional perspective by considering the intangible aspects of access that employees retain upon leaving and introducing noncompete agreements as a direct instrument against competition.

In the work of Garicano and Rayo [2017], the accessible asset is exclusively knowledge. Their dynamic model describes a scenario where an expert imparts divisible knowledge to a novice, which can also be utilized externally. The novice's incentive to stay hinges solely on the additional knowledge they can gain. My paper, in contrast, concentrates on the one-period optimal access in the context of employee ability heterogeneity.

Comparing access to training and investment is important in understanding its nature. The literature on specific and generic human capital investment, initiated by Becker [1962], considers who should bear the costs of investment. In a frictionless world, firms are willing to subsidize specific investment only, since generic investment increases the employee's outside option, making them a tougher bargaining opponent. In the model presented in this paper, access increases an employee's productivity both inside and outside the firm. What distinguishes access from either type of investment is that the firm's future profitability is damaged if the employee moves on to a competitor. The reason is that the employee's knowledge of the critical resource of the firm, when used outside the firm, makes them a more formidable competitor. For instance, they may develop a competing product that reduces the firm's market share and lowers profit. Another difference from training is that giving access has no direct cost. Access assumes that the critical resource is already created, and the employee is not required to put any effort into its creation. In section 3.3.4, I provide an analytical comparison between investment and access.

Economic theory suggests that noncompete agreements can help alleviate the hold-up

problem [Williamson, 1979] by aligning the incentives of the employer and employee [Lipsitz, 2017]. Following the above idea, Garmaise [2009], Ghosh and Shankar [2017] study setups when the firm and worker co-invest into the worker's human capital, taking noncompete exogenous and endogenous respectively. Both papers reach the conclusion that with noncompete in the employment contract firms increase the investment, while when the non-compete is forgone the employee tends to invest more. Wickelgren [2018] uses a dynamic setup to show that firms invest more when the employee is bounded by a stronger noncompete. Noncompete is a continuous variable indicating the time length the covenant applies. In our paper, we have similar dynamics in the sense that the firm gives a higher degree of access if the noncompete is stronger. However, access is given to an already created resource which only has an indirect cost that the employee may use it outside the firm and causes damages. Lipsitz [2017] sets up a similar model to mine in that the employee may spin-off before production and compete. However, the paper emphasizes the difference in effort with centralized and decentralized decision making in the sense of centralized decisions are closer to first best.

While much of the existing literature has focused on how noncompete agreements affect high-skilled employees [April and Matthew, 2008, Krakel and Sliwka, 2009], recent studies have highlighted the prevalence of such agreements among low and mid-wage workers as well, including physicians [Lavetti et al., 2019], cleaning staff,[5] and sandwich makers.[6] Lipsitz and Johnson [2018] also underscore the impact of noncompete agreements on low-wage workers in their theoretical model, where the employer is required to pay a minimum wage but values the employee's contribution less than that wage. As the employee gains experience and their contribution becomes more valuable, noncompete agreements allow the employer to increase wages less steeply, as outside job opportunities are less attractive due to the restrictions imposed by the agreement.

A growing body of empirical literature has examined the relationship between noncompete clauses and various labor market outcomes such as wages, training, and mobility. While

[5] https://app.ft.com/content/bfb69d30-ce44-11e8-b276-b9069bde0956?sectionid=home

[6] https://www.nytimes.com/2014/10/15/upshot/when-the-guy-making-your-sandwich-has-a-noncompete-clause.html#targetText=When%20the%20Guy%20Making%20Your,Sandwich%20Has%20a%20Noncompete%20Clause&targetText=If%20you%20are%20a%20chief,until%20some%20period%20has%20elapsed.

standard economic theory predicts that workers subject to noncompetes should receive higher compensation, the empirical evidence is less clear. For instance, Marx et al. [2009] show that the enforcement of noncompetes attenuates mobility, while Starr et al. [2019] find that increasing enforceability of noncompete agreements increases the training provided by firms. Additionally, Balasubramanian et al. [2020] demonstrate that both wages and mobility increased after a ban on noncompetes in Hawaii. The majority of the empirical research focuses on whether the wage increases [Johnson et al., 2021, Lipsitz and Starr, 2021, Starr et al., 2019] or decreases [Kini et al., 2021, Lavetti et al., 2019, Guimaraes et al., 2021] when the enforceability of noncompetes decreases.

As for the institutional background, the enforceability of noncompete agreements varies across different regions, with variations in regulations and legal frameworks. For instance, noncompete agreements are enforceable in major European countries [Weberndörfer et al., 2017]. However, there is increasing tension around noncompete agreements [Kalse, 2019], with debates surrounding their impact on employee mobility and innovation. In the United States, regulations regarding noncompete agreements vary from state to state, with recent scrutiny from the Federal Trade Commission, which has proposed a complete ban on noncompete agreements in early 2023 [Federal Trade Commission, 2023].

The remainder of the paper is organized as follows: Section 3.2 outlines the model setup, and Section 3.3 presents the optimal contract. Section 3.4 extends the model to include asymmetric employee gain and firm damage. Section 3.5 focuses on the efficiency of noncompete agreements. Finally, Section 3.6 concludes the paper.

3.2 Model

3.2.1 Setup

A risk neutral firm offers a contract to a risk neutral agent (he) in period 0. The agent has an observable type $A \in [1, A^{\max}]$, that is his ability. Ability is exogenous, ex ante observable, and contractible and it can pertain to his educational degree or specific knowledge certification. The contract specifies the degree of access, $\Theta \in [0, 1]$, the employee has to the assets of

the firm, and a non-competition agreement (noncompete), λ. The employee has maximum access to the firm's assets if $\Theta = 1$. The firm's asset may be innovative technology, a client list, or the know-how of a new tool. The noncompete the firm chooses falls in the range of $\lambda \in [0, \bar{\lambda}]$, where the legal upper bound on the stringency of the noncompete is denoted by $\bar{\lambda} \leq 1$.

In period 1, the matching between the firm and the employee is revealed. This match could involve factors such as the employee's fit with the firm's culture, compatibility with other employees, or other personal characteristics. The probability of the employee being a good match with the firm is an exogenous factor, denoted by p. In the case of a good match, the employee's productivity with the firm is given by the equation:

$$F(A, \Theta) = A\Theta \tag{3.1}$$

.

That is, the production increases both in the access provided to the employee and in his ability. Conversely, the employee is a bad match with the firm with $(1 - p)$ probability, in which case he is unproductive with the firm.

At $t = 1.5$, the employee receives an offer from a competing firm. The main friction of the model is the employee's inability to commit to staying with the initial firm, meaning he may choose to accept the competitor's offer. If he decides to join the competitor, he ceases to produce for the original firm. Conversely, if the employee remains, production takes place, and the resulting payoffs are determined through Nash bargaining between the firm and the employee. Figure 3.1 show the game tree, while the timeline is depicted in Figure 3.2. Further details on the bargaining, including the outside options are provided below.

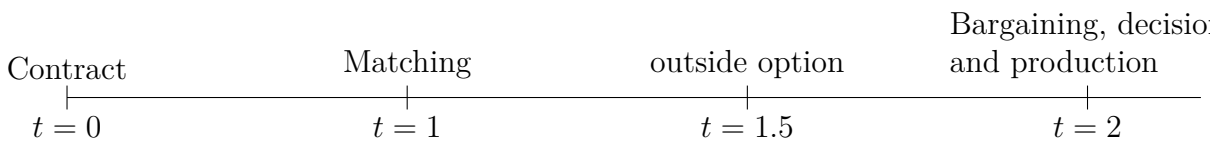


Figure 3.2: Time line

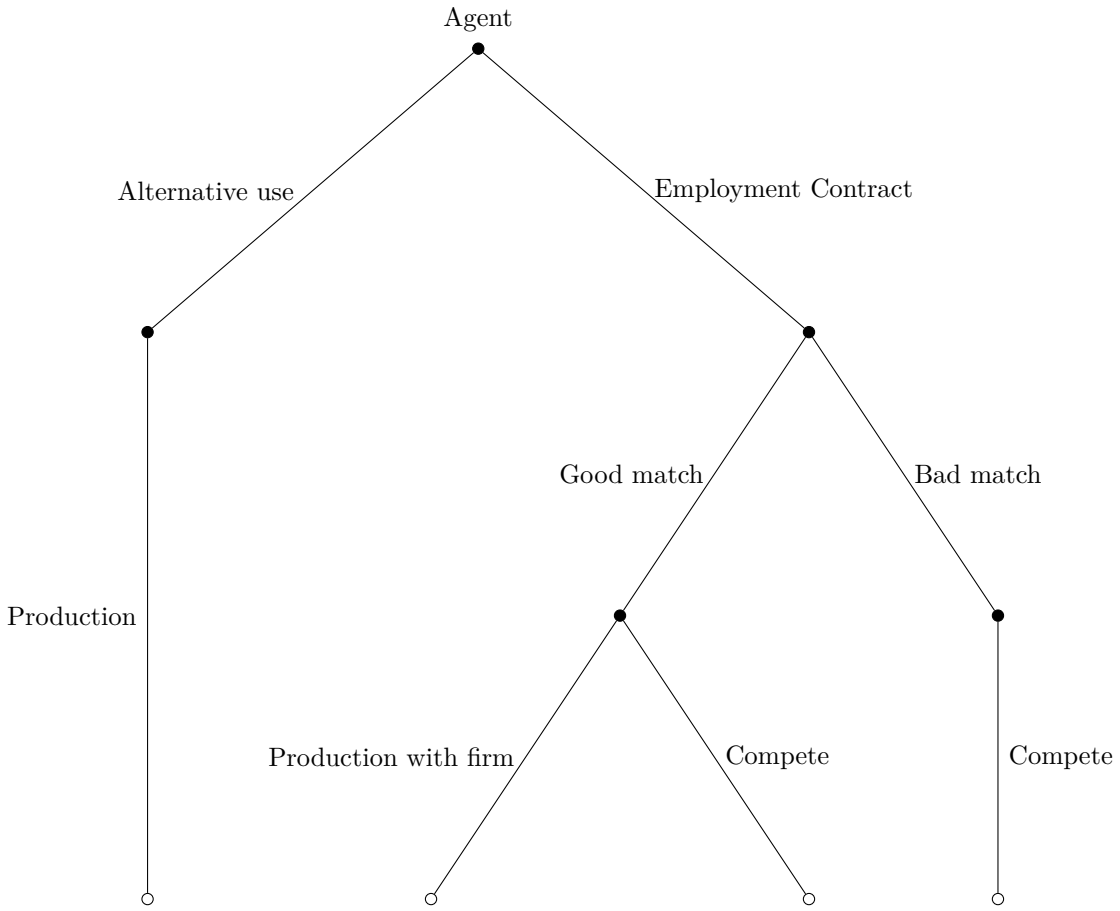


Figure 3.1: Game tree

3.2.2 Outside option

A crucial part of the model is the competitor's employment offer to the employee. This offer is determined by several variables that are broken down in this section. My definition of outside option also involves the possibility that the employee starts his own business.

3.2.2.1 High and low ability agents

I distinguish between high and low ability agents.

$$\begin{cases} A \geq \bar{A} & \text{(high ability)} \\ A < \bar{A} & \text{(low ability)} \end{cases} \tag{3.2}$$

Employees are classified based on their abilities relative to the average ability in the population, denoted as $\bar{A}$. Those with abilities below $\bar{A}$ are considered low ability, while those above it are categorized as high ability. During their tenure, low ability employees learn from their high ability counterparts, acquiring skills and enhancing their networks. Notably, the firm is unable to regulate this transfer of knowledge or access to human capital among employees. As a result, at $t = 1.5$, low ability employees may receive job offers that surpass what their initial abilities would warrant. However, this learning and skill acquisition by low ability employees does not contribute to an increase in the firm's overall productivity, as these skills, connections, and networks were pre-existing assets within the firm.

The assumption of low ability employees learning from high ability colleagues stems from a large macroeconomic literature in which economic growth is fueled by learning from others. Most recently, Jarosch et al. [2021] empirically finds that more higher paid coworkers substantially increase future wage growth. In particular, they suggest that there is significant learning from coworkers that earn more. Nix [2020] also establishes learning spillovers. Coworkers learn general skills from each other that increase future productivity. Theoretically, the most similar modeling assumption to this paper is made by Jovanovic [2014] that a young (less talented) agent's skill depends on his innate talent and on the average skill of the old. Models by Lucas [2009], Lucas and Moll [2014], Perla and Tonetti [2014], and Buera and Oberfield [2020] build growth theories based on random meetings and skill transfer among

agents.

In contrast to their low ability colleagues, high ability employees do not learn during the employment and thus their offer is a function of their initial ability. This is similar to Jovanovic and Rob [1989] in that high ability agents already know the skills of the low ability ones thus there is no more learning. Furthermore, I assume that the firm does not influence the average ability strategically. When the firm hires an individual, they consider the specific agent's ability and do not factor in the marginal change in the average ability.

Cost of access

The employer incurs the following indirect costs of providing access. Firstly, access increases the outside option of the employee. As a result, he will be able to obtain a higher payoff from the Nash-bargaining. I refer to this effect as employee gain. I denote the exact functional form the ex-post outside option of the employee, $g(A, \Theta)$.

$$g(A,\Theta) = \begin{cases} \alpha(1-\lambda)A\Theta^2, & \text{for } A \geq \bar{A} \qquad \text{(high ability)} \\ \alpha(1-\lambda)\bar{A}\Theta^2, & \text{for } A < \bar{A} \qquad \text{(low ability)} \end{cases} \tag{3.3}$$

Consider the first line of equation (3.23) for a high ability employee. The gain is an increasing function of access, Θ. In particular, the quadratic function yields that any level of access leads to at least as high production inside the firm as the employee's outside option may be, since $\Theta^2 \leq \Theta$ for $\Theta \leq 1$. However, the difference becomes smaller as the level of access approaches 1. The intuition is that the more the firm reveals its critical asset, the easier it is to reproduce it outside. The arrival rate of the outside option is $(1-\lambda)$ meaning a more stringent noncompete decreases the probability that the employee receives an outside option. Furthermore, the gain is increasing linearly in ability, similar to production.

For low ability agents, the outside option is the function of the ability at $t = 1.5$, which is $\bar{A}$ due to the learning.[7]

The second source of cost of giving access to the employee is that the firm's future profitability is decreased due to the effect that the employee transfers his knowledge on the

[7]Making it both function of initial ability and the average would not change the results qualitatively but would hinder analytical solutions

critical asset to the competitor. We refer to this effect as the firm's damage. Similar arguments to the employee gain leads to similar functional form, $d(A, \Theta)$.

$$d(A,\Theta) = \begin{cases} (1-\lambda)A\Theta^2, & \text{for } A \geq \bar{A} \qquad \text{(high ability)} \\ (1-\lambda)\bar{A}\Theta^2, & \text{for } A < \bar{A} \qquad \text{(low ability)} \end{cases} \tag{3.4}$$

3.2.3 Payoffs

I normalize the firm's outside option/participation constraint to 0 which is also the output without the employee. Following the literature on organizational economics and contract theory, among others ([Grossman and Hart, 1986],[Rajan and Zingales, 1998], [Rajan and Zingales, 2001] or [Hart, 2009] most recently [Bar-Isaac and Levy, 2022], the output is distributed according to the standard Nash bargaining solution, when the employee is a good match, with the employee having β bargaining power. If the employee is a bad match, both players receive their outside option that depends on the contract (λ, Θ).

3.2.3.1 Low ability

In the case $A < \bar{A}$, the employee learns from high ability colleagues inside the firm, making the gain and damage proportional to $\bar{A}$. Denote with subscript L the functional forms for low ability employees

$$U_L = p(\beta(A\Theta - g(\bar{A},\Theta) + d(\bar{A},\Theta)) + g(\bar{A},\Theta)) + (1-p)g(\bar{A},\Theta) \tag{3.5}$$

The employee is a good match with the firm with probability p, in which case there is $A\Theta$ production inside the firm. The employee's outside option is increasing by $(1-\lambda)\bar{A}\Theta^2$, while the firm's decreasing by the same amount, thus the surplus becomes $p(A\Theta - (1-\lambda)\bar{A}\Theta^2 + (1-\lambda)\bar{A}\Theta^2) = pA\Theta$. The second part of the expression is when the employee is a bad match with the firm. In this case, the employee leaves to the competitor.

The profit of the firm is

$$\pi_L = p((1-\beta)(A\Theta - g(\bar{A},\Theta) + d(\bar{A},\Theta)) - d(\bar{A},\Theta) - (1-p)(1-\lambda)d(\bar{A},\Theta) \tag{3.6}$$

The profit can be broken down similarly to the employee's utility.

3.2.3.2 High ability

In this case the employee's outside option is a function of his own ability, denote the functional forms with subscript H.

$$U_H = p(\beta(A\Theta - g(A,\Theta) + d(A,\Theta)) + g(A,\Theta) + (1-p)g(A,\Theta) \tag{3.7}$$

The interpretation is similar to before.

The profit of the firm

$$\pi(A > \bar{A}) = p((1-\beta)(A\Theta - g(A,\Theta) + d(A,\Theta)) - d(A,\Theta) - (1-p)d(A,\Theta) \tag{3.8}$$

3.2.4 Participation constraint

The agent has an ability dependent outside opportunity, which we call the alternative use of his ability at time 0. It serves as his participation constraint and takes the following form.

$$U^{\mathrm{PC}} = \gamma A \tag{PC}$$

with $\gamma < 1$ as the marginal return of ability at the beginning of the game.

3.2.5 Actions and outcomes

At $t = 0$ the employee chooses between the alternative use of his ability and employment by the firm. If the agent is employed by the firm, with $(1-p)$ probability he is a bad match and is leaving to the competitor. With probability p there is a good match and production may take place with bargaining over the output.

Figure 4.1 summarizes the actions the employee can take.
Equilibrium is defined as the contract under which the firm's profit is maximized.

3.2.6 Parameter assuption

$$\gamma > p\beta, \tag{3.9}$$

introduces the friction that the employee has a higher return on its own than with the firm. In other words, higher ability agents are more expensive for the firm.

3.3 Optimal contract - Baseline model

The firm proposes a contract that specifies the stringency of the noncompete and the degree of access (λ, Θ) to be provided to the employee. The firm maximizes its profit given the participation constraint of the employee, the maximum degree of access the firm has, and the legal constraint on the stringency of noncompete $(\bar{\lambda})$. The firm participation constraint is checked afterward. As the profit and utility functions vary for employees with high and low ability, the problem is solved separately for each case.

3.3.1 Low ability

First consider the case when the employee has low ability. Equation (3.6) and (3.5) can be rewritten in the following way

$$\max_{\Theta,\lambda} \pi_L(\Theta, \lambda) = p(1-\beta)(A\Theta) - (1-\lambda)\bar{A}\Theta^2 \tag{3.10}$$

s.t

$$p\beta(A\Theta) + (1-\lambda)\bar{A}\Theta^2 \geq \gamma A \tag{PC}$$

$$\Theta \leq 1 \tag{Access}$$

$$\lambda \leq \bar{\lambda} \tag{Noncompete}$$

Lemma 3.1. *The lowest ability employees inside the firm are compensated by access, while they are subject to the most stringent noncompete.*

The formal proofs are in the appendix.

Denote the optimal access and noncompete with $\Theta^*(A) = \Theta^* = \Theta_{pc}$ and $\lambda^*(A) = \lambda^*$ to simplify the notation. For the lowest ability employees, the firm offers the most stringest noncompete paired with a degree of access such that the agent accepts the contract and becomes the employee of the firm. Since the firm gives a take it or leave it offer, the utility the employee receives equals the participation constraint. That is

$$U_L = p\beta A\Theta_{pc} + (1-\bar{\lambda})\bar{A}(\Theta_{pc})^2 = A\gamma \tag{3.11}$$

Equation (3.11) highlights that the firm can use two instruments to satisfy the agent's participation constraint: increasing access and decreasing the stringency of the noncompete. Consider a contract characterized by $\lambda', \Theta'\text{pc}$, where $\lambda' < \bar{\lambda}$, and $\Theta' < \Theta\text{pc}(\bar{A})$. In this scenario, Θ'_{pc} is set such that the employee's participation constraint is binding. Increasing λ and Θ such that the participation constraint remains to be binding leads to higher expected production. While the employee's utility remains unchanged, the expected production - and consequently, the firm's profit - increases. To sum up the argument, increasing access yields to higher expected production, while decreasing the stringency of the noncompete only increases the employee's expected utility at the expense of lowering the firm's profit. Formally, this can be represented as

$$\frac{\frac{\partial \pi_L}{\partial \Theta}}{\frac{\partial U_L}{\partial \Theta}} = \frac{p(1-\beta)A - 2(1-\lambda)\bar{A}\Theta}{p\beta A + 2(1-\lambda)\bar{A}\Theta} > \frac{\frac{\partial \pi_L}{\partial \lambda}}{\frac{\partial U}{\partial \lambda_L}} = -1. \tag{3.12}$$

Expression (3.12) shows that marginally increasing access is dominant to marginally decreasing noncompete.

Differentiating both sides of equation (3.11) with respect to A gives

$$p\beta\Theta_{\text{pc}} + A\frac{\partial \Theta_{\text{pc}}}{\partial A} + 2(1-\bar{\lambda})\bar{A}\Theta_{\text{pc}}\frac{\partial \Theta_{\text{pc}}}{\partial A} = \gamma. \tag{3.13}$$

The rationale for focusing on the parameter range $\gamma > p\beta$ in the context of γ is eluci-

dated in equation (3.13). Under this parameter assumption, equation (3.13) can only be met if $\frac{\partial \Theta_{\text{pc}}}{\partial A} > 0$. This translates to higher ability employees being more expensive for the firm to compensate. As ability increases, the firm also has to modify the contract due to the increased participation constraint. Conversely, if $\gamma < p\beta$, the firm could decrease the compensation of the employee as his ability rises, which would be unrealistic.

Define $\tilde{A}$ as the ability level at which the optimal contract involves granting maximum access, denoted as $\Theta = 1$, coupled with the most stringent noncompete, indicated by $\lambda = \bar{\lambda}$

Lemma 3.2. *For all low ability employees with $A > \tilde{A}$, the firm provides the maximum access and compensation is adjusted through a less stringent noncompete agreement*

Since the firm cannot further increase access beyond $\Theta = 1$, the only means to satisfy the participation constraint for the employees $A > \tilde{A}$ is by reducing the stringency of the noncompete. I define the optimal noncompete as $\lambda^* = \lambda_{\text{pc}}$, where the stringency of the noncompete is adjusted to meet the participation constraint at the highest degree of access. Consequently, any contract defined by $\lambda' < \lambda_{\text{pc}}(\bar{A})$ and $\Theta < 1$ is suboptimal, as established previously.

The utility function for the employee is represented by:

$$U_L = p\beta A + (1 - \lambda_{\text{pc}}(\bar{L}))\bar{A}\Theta_{\text{pc}}^2 = A\gamma \tag{3.14}$$

Upon differentiating this equation with respect to ability, A, we obtain:

$$p\beta - \bar{A}\frac{\partial \lambda}{\partial A} = \gamma \tag{3.15}$$

Given that $\gamma > p\beta$, equation (3.15) can only hold true if $\frac{\partial \lambda}{\partial A} < 0$. This implies that as an employee's ability increases, their demand for higher compensation leads the firm to lessen the stringency of the noncompete agreement as a strategy to attract them to the firm.

Lemma 3.3. *The firm sets a minimum ability threshold for employment, denoted as A_{min}. Agents with abilities below this threshold are not employed.*

The firm's requirement of a minimum ability level, $A_{\min}$, for employment arises from the need to satisfy its own participation constraint. Utilizing the optimal values of access and noncompete, Θ^* and λ^*, the firm's participation constraint can be expresse as

$$\pi(\Theta^*, \lambda^*) = p(1-\beta)(A\Theta^*) - (1-\lambda^*)\bar{A}\Theta^{*2} \geq 0 \tag{3.16}$$

This can be rewritten as:

$$p(1-\beta)(A\Theta^*) \geq (1-\lambda^*)\bar{A}\Theta^{*2} \tag{3.17}$$

As established in Proposition 1A, the firm offers the contract $\Theta^* = \Theta_{\text{pc}}$ and $\lambda^* = \bar{\lambda}$ for the lowest ability agents. Hence, (3.18) becomes

$$p(1-\beta)A\Theta_{\text{pc}} \geq (1-\bar{\lambda})\bar{A}\Theta_{\text{pc}}^2 \tag{3.18}$$

The firm must ensure that the expected production not only satisfies the employee's participation constraint but also generates sufficient profit for the firm since the employee might leave the firm causing damages. Increasing the degree of access, Θ, has dual effects: it raises expected production ($pA\Theta$) but also amplifies potential damages $[(1-\bar{\lambda})\bar{A}\Theta^2]$. The damages, being a function of $\bar{A} > A$, highlight the risks associated with providing high degree of access to lower ability agents. The damage is a function of $\bar{A} > A$, that directly points out the costly feature of giving too much access for the lowest ability agents. Their contribution is limited to their ability, yet they are capable of inflicting greater harm. Furthermore, the degree of access required to achieve a certain level of output decreases as ability increases, implying that agents with the lowest ability require higher degrees of access.

The next proposition formally summarizes the optimal contract for low ability agents, putting together Lemma 3.1, 3.2, 3.3.

Proposition 3.1.

1.) The firm requires a minimum ability for employment. That is, below a threshold A_{min} agents are not employed.
2.) The lowest ability agents employed by the firm are compansated via access. That is, $\exists \tilde{A}$ such that for $A_{min} < A < \tilde{A}$, the optimal contract includes the most stringent noncompete ,$\bar{\lambda}$, and degree of access $\Theta_{pc}(A))$ that is high enough to meet the agent's participation constraint.
3.) Agents with ability $\tilde{A} < A \leq \bar{A}$, are provided the maximum access,$\Theta = 1$. To meet their participation constraint, the firm reduces the strictness of the noncompete as their ability increases.

The formal proof is in the Appendix.

3.3.2 High ability

For high ability agents the outside option and damage function changes to $d(\lambda, \Theta, A) = g(\lambda, \Theta, A) = (1-\lambda)A\Theta^2$, which are functions of the agent's own ability that is higher than average. Hence, the profit and utility functions change accordingly to

$$\max_{\Theta,\lambda} \pi_H(\Theta, \lambda) = p(1-\beta)(A\Theta) - (1-\lambda)A\Theta^2 \tag{3.19}$$

$$p\beta(A\Theta) + (1-\lambda)A\Theta^2 \geq \gamma A \tag{PChigh}$$

Proposition 3.2. *The optimal contract for high ability agents involves the maximum degree of access and a constant, not type dependent, noncompete.*

The maximum level of access makes the employee productive inside, while the noncompete agreement restricts their ability to use this access outside the firm. The employee's participation constraint is linearly increasing with ability, and so are the production and the outside option. In equilibrium, these increments are equal when the firm offers the optimal stringency of noncompete. Therefore, even though employees with higher abilities require more compensation, the stringency of noncompete is constant for them.

The following figure graphically represents the optimal contracts and resulting profits, production utility, and the offer from the competitor for both low and high ability employees.

The varying colors in the figure correspond to the different segments of the ability space, as outlined in Propositions 3.1 and 3.2 .[8]

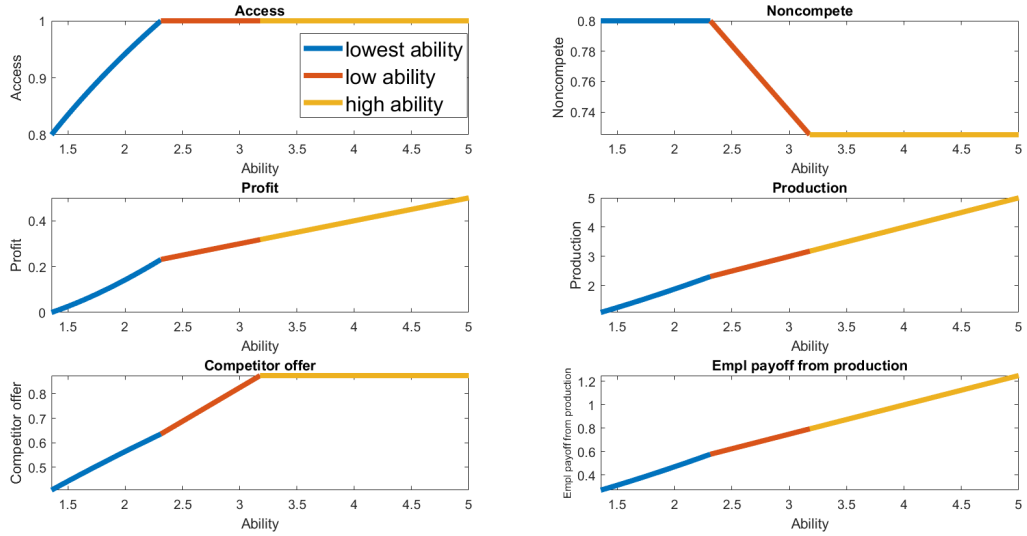


Figure 3 summarizes the optimal contract in the first row, and the outcomes in the second and third row. The figures show that employees are compensated first via access, and if the maximum degree of access is provided via a decreasingly stringent noncompete.

Figure 3.3: Optimal contract

From Proposition 1 and 2, the following corollary directly arises.

Corollary 3.1. *Access is weakly increasing in ability.*

Both the productivity and the outside option depend on the level of access provided to an agent. If it is profitable for the firm to employ one agent, it is also profitable to employ another agent with slightly higher ability, as the latter will produce more within the firm. This conclusion follows mathematically from the linear nature of the production function and the quadratic relationship of the outside option with access.

3.3.3 Firm size

This section examines the size of the firm in terms of the agents' ability levels. Firstly, it is important to note that the firm always hires the highest ability agents in the population, as

[8]Details on the parameter values used in this illustration can be found in the appendix.

they contribute the most to the firm's profits due to the linear relationship between ability and profits.[9]

Next, consider the lowest ability agent employed by the firm, denoted as $A_{\min}$. At this lower bound, both the agent's and the firm's participation constraints are binding. Therefore, $A_{\min}$ can be determined by setting the firm's profit to zero under the contract specified by $(\bar{\lambda}, \Theta_{\text{pc}})$

$$p(1-\beta)(A_{\min}\Theta_{\text{pc}}) - (1-\bar{\lambda})\left(\frac{A_{\max}+A_{\min}}{2}\right)\Theta_{\text{pc}}^2 = 0 \tag{3.20}$$

Above yields

$$A_{\min} = \frac{A_{\max}(1-\bar{\lambda})\gamma}{2p^2(1-\beta)-(1-\bar{\lambda})\gamma} \tag{3.21}$$

The next lemma summarizes the comparative statics of the lower threshold of ability.

Lemma 3.4. $\frac{\partial A_{min}}{\partial A_{max}} > 0, \frac{\partial A_{min}}{\partial \beta} < 0, \frac{\partial A_{min}}{\partial \gamma} > 0, \frac{\partial A_{min}}{\partial p} < 0, \frac{\partial A_{min}}{\partial \lambda} < 0.$

Lemma 3.4 can also summarized in a table.

Parameters	$A_{\min}$
$A_{\max} \uparrow$	$\uparrow$
$\beta \uparrow$	$\downarrow$
$\gamma \uparrow$	$\uparrow$
$p \uparrow$	$\downarrow$
$\bar{\lambda} \uparrow$	$\downarrow$

Table 3.1: Comparative statics of threshold of ability

Proof. By inspection of (3.21). ■

As the maximum ability level of agents in the population rises, the average ability inside the firm also increases. This leads to lower ability agents having more to learn and becoming more costly to retain. As a result, the firm requires a higher minimum level of ability. Similarly, an increase in agents' bargaining power, β, enables them to expropriate more from production, prompting the firm to increase the threshold on ability. If the marginal value

[9] As emphasized in the model description, the firm does not take into account that hiring high ability agents increases the average ability and thus has an implicit cost as well.

of ability in the participation constraint, γ, increases, agents demand higher compensation (higher access). However, as access increases, the damage to the firm also increases. Therefore, the firm ensures that only agents with sufficiently high ability can join by raising the lower bound. Conversely, if the probability of a match, p, is higher, the threshold is lowered as agents produce with a higher likelihood.

Lastly, if regulation permits a more stringent noncompete, then the firm lowers the threshold on ability. The following graphs visually depict this effect, contrasting the scenarios of an unenforceable noncompete agreement ($\bar{\lambda} = 0$) with an enforceable one ($\bar{\lambda} = 0.2$).

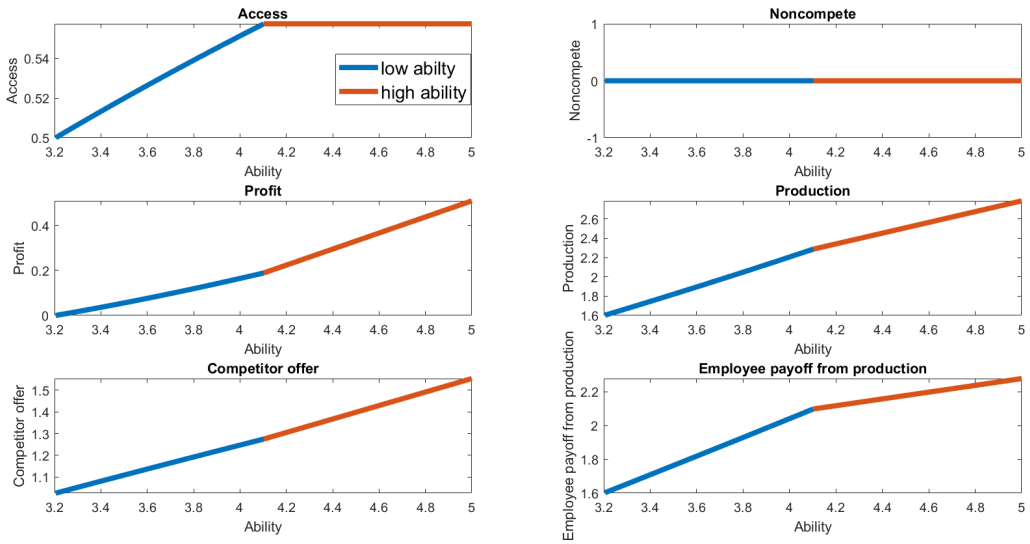
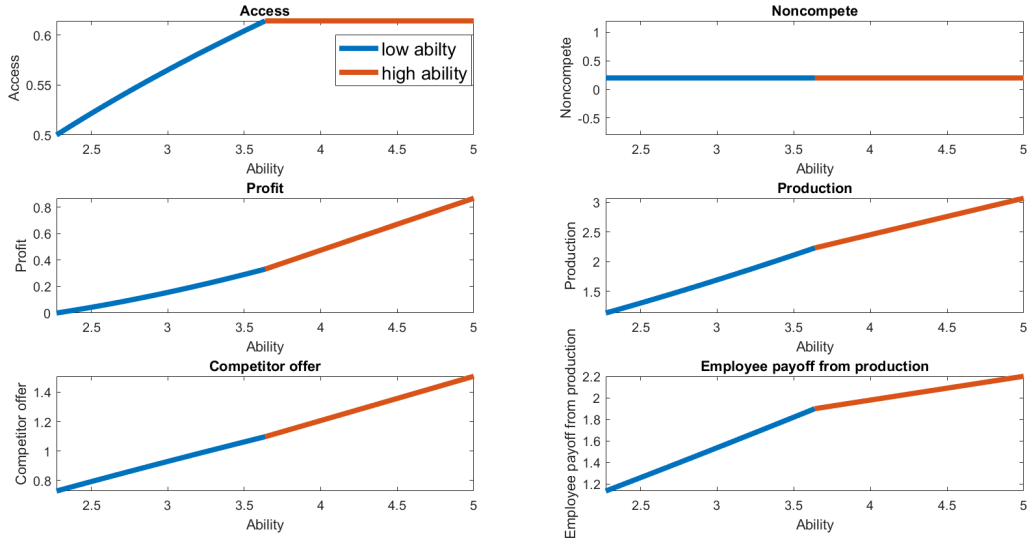


Figure 3.4: Unenforceable noncompete $\bar{\lambda} = 0$



Figures 4 and 5 show the difference in the contract and outcomes when noncompete is unenforceable and enforceable respectively. A more stringent noncompete facilitates access provision resulting in higher production, profit, and employee payoff from production. However, it decreases the offer the employee receives from the competitor.

Figure 3.5: Enforceable noncompete $\bar{\lambda} = 0.2$

Consider a scenario where the lowest ability agent is offered a contract under a regime with $\bar{\lambda} = 0$. If the regime shifts to a more stringent noncompete ($\bar{\lambda} = 0.2$), the same contract would not be acceptable to the agent. This change occurs because a more stringent noncompete diminishes the agent's gains from the outside option, failing to meet their participation constraint with the initial contract terms. However, the firm can still realize a profit under the stricter noncompete regime by increasing the degree of access provided to the agent. Increased access enables the agent to be more productive within the firm, thereby enhancing the firm's profit. Consequently, the firm adjusts by offering greater access to satisfy the agent's participation constraint.

Although the agent's total compensation remains unchanged across both regimes, its composition shifts. Under the regime with the more stringent noncompete, the agent is provided a higher degree of access, resulting in increased earnings from internal production. Conversely, in the regime with a laxer noncompete, the agent benefits more from external opportunities, enhancing their compensation from these outside options. These variations in the outside option and employee compensation from production are depicted in the last

row of the graphs.

As demonstrated in Table 3.1, the implementation of more stringent noncompete clauses reduces the minimum ability threshold set by the firm. Given the reduced probability of employees engaging in competition externally, the firm is inclined to provide a greater degree of access to agents with lower abilities. Consequently, this leads to a lower average ability level within the firm.

3.3.4 Investment

This section draws a comparison between the firm's approach to providing access to its resources and the alternative strategy of directly investing in an employee's human capital. While providing access involves allowing the employee to utilize the firm's existing assets, direct investment focuses on enabling the employee to develop new, intangible assets within the firm. This distinction leads to two key differences: an agent's departure inflicts less damage when investment in human capital is involved, but the initial investment is more expensive. I represent this investment by i, and its associated cost by $c(i)$. For the sake of comparison, I assume that the investment cannot exceed 1, and the cost of investment is borne by the firm. The problem of the firm with low ability agents is as follows:

$$\max_{i,\lambda} \pi(i,\lambda) = p(1-\beta)(Ai - (1-\lambda)\bar{A}i^2) + (1-p)0 - c(i) \tag{3.22}$$

s.t

$$p(1-\beta)(Ai - (1-\lambda)\bar{A}i^2) + (1-p)(1-\lambda)\bar{A}i^2 \geq \gamma A \tag{PC}$$

$$i \leq 1 \tag{Access}$$

$$\lambda \leq \bar{\lambda} \tag{Noncompete}$$

Lemma 3.5. *Given a certain level of ability, the optimal level of investment is higher than the optimal level of access, i.e.,* $i^*(A) > \Theta^*(A)$.[10]

[10] $i^*(A) = \frac{-p\beta A + \sqrt{p^2\beta^2A^2 - 4(1-\bar{\lambda})\bar{A}(1-p\beta)\gamma A}}{(1-\lambda)\bar{A}1(1-p\beta)}$

Proof follows in the text.

The firm has less incentive to retain an employee who can cause no ex post damage. The employee anticipates that he can demand less compensation ex post and thus requires more ex ante compensation, i.e., more investment. Thus, given a certain level of ability, the optimal level of investment is higher than the optimal level of access, i.e., $i^*(A) > \Theta^*(A)$.

Regarding the size of the firm, the comparison between the ex ante cost of investment, denoted as $c(i)$, and the ex post cost of providing access is crucial. The ex post cost of access, labeled as $q(\Theta, A)$, encompasses not only the firm's damages but also the additional compensation owed due to the employee's strengthened bargaining position. Assuming that the ex ante cost of investment for a given level of ability, A, is not higher than the ex post cost for the same degree of access, expressed as $c(i, A) \leq q(\Theta, A) \quad \forall A \quad \text{and} \quad i = \Theta$, the optimal contract includes a higher investment than it would access. Consequently, the minimum level of ability required by the firm (A_{min}) is lower with investment than with access, resulting in a larger firm size with investment. Only if the ex ante cost is significantly higher than the ex post cost, $c(A, i^*) > q(A, \Theta^*)$, can the minimum level of ability be lower under access, resulting in a larger firm size.

3.4 Different outside option than firm damage

In this section, I introduce a scalar α that denotes the ratio between the employee's outside option compared to the firm's damage.

$$g(A, \Theta) = \begin{cases} \alpha(1-\lambda)A\Theta^2, & \text{for } A \geq \bar{A} \qquad \text{(high ability)} \\ \alpha(1-\lambda)\bar{A}\Theta^2, & \text{for } A < \bar{A} \qquad \text{(low ability)} \end{cases} \tag{3.23}$$

Note that $d(A, \Theta) = \frac{g(A,\Theta)}{\alpha}$. Thus if $\alpha > 1$, the employee's outside option is higher than the firm's damage, if $\alpha < 1$ the firm's damage is larger. The parameter α represents the ratio of the employee's outside option to the firm damage if the employee leaves the firm for the competitor. If α is high, the employee can capitalize on access to the firm's crucial asset at the competitor, such as transferring clients or learning about crucial technological inventions,

to a greater extent than the firm is damaged from it. Moreover, empirically, α also reflects labor market conditions: high α implies numerous competitors where the employee could capitalize on his knowledge.

This extension builds on the empirical result in Kini et al. [2019]. They find that CEOs are less likely to have noncompete in their contract when they expect greater personal costs and more likely when firms expect to suffer greater harm if departing CEOs work with competitors. In the language of my model, CEOs have a less stringent noncompete if their gain from leaving is larger than the firm's damage, that is, if the parameter α is high. Note that $\alpha \neq 0$ also changes the bargaining outcome as the outside option of the employee changes.

The utility of a low ability employee becomes

$$U_L(\lambda, \Theta, A, \alpha) = p\beta(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) + \alpha(1-\lambda)\bar{A}\Theta^2 \tag{3.24}$$

and the utility of a high ability agent is

$$U_H(\lambda, \Theta, A, \alpha) = p\beta(A\Theta + (1-\alpha)(1-\lambda)A\Theta^2) + \alpha(1-\lambda)A\Theta^2 \tag{3.25}$$

Similarly, the profit of the firm takes the form

$$\pi_L(\lambda, \Theta, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) - (1-\lambda)\bar{A}\Theta^2 \tag{3.26}$$

and

$$\pi_H(\lambda, \Theta, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)A\Theta^2) - (1-\lambda)A\Theta^2 \tag{3.27}$$

accordingly.

If $\alpha > 1$, the employee's gain from capitalizing on the access the firm provided at the competitor is larger than the damage caused to the firm. On the other hand, if $\alpha < 1$, the damage to the firm is larger than the gain of the employee. The optimal contract in this case is similar to the one with $\alpha = 1$. Therefore, I move on to the question of the minimum ability required by the firm, which also determines the firm size. As before, the minimum

ability required by the firm can be calculated by making both the agent's and the firm's participation constraint binding.

$$U_L(\lambda, \Theta, A, \alpha) = p\beta(A\Theta + (1-\alpha)(1-\bar{\lambda})\bar{A}\Theta^2) + \alpha(1-\bar{\lambda})\bar{A}\Theta^2 = 0 \tag{3.28}$$

$$\pi_L(\lambda, \Theta, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\bar{\lambda})\bar{A}\Theta^2) - (1-\bar{\lambda})\bar{A}\Theta^2 = 0 \tag{3.29}$$

Proposition 3.3. *For high enough p and $(1-\beta)$, the minimum ability required by the firm, $A_{min,\alpha}$, has the following characteristics*
$\frac{\partial A_{min,\alpha}}{\partial \alpha} < 0$ *for* $\alpha < \alpha^T$
$\frac{\partial A_{min,\alpha}}{\partial \alpha} > 0$ *for* $\alpha > \alpha^T$,
with α^T being an endogenous threshold.

The proposition states that the minimum ability inside the firm is a non-monotonic function of α due to two reasons. Firstly, if α is very low, the cost of access for the firm is high, but the agent benefits less from it, hence the firm has to compensate the agent more. As a result, an increase in α on this domain ($\alpha < \alpha^T$) leads to a decrease in the minimum ability and hence a larger firm size. On the other hand, if α is high, agents demand high compensation in the bargaining, making it expensive for the firm to keep them. Therefore, if $\alpha > \alpha^T$, a further increase in α increases the firm's costs and results in a smaller firm size. It is important to note that having a high enough p and $(1-\beta)$ ensures the firm makes a positive profit with some contracts.

Lemma 3.6. *The size of the firm increases if the regulator allows more stringent noncompetes.*

The size of the firm increases as the legally allowed stringency of the noncompete increases, similar to previous results. If the employee has a lower probability of competing, the firm can provide more access to low ability employee's and hence the firm becomes larger. The result follows from implicitly differentiating the profit function with respect to $\bar{\lambda}$.

3.4.1 Wage

This subsection augments the model by introducing a first period in which the employee receives an unconditional wage.[11] The minimum wage, $\underline{w}$, is constrained to be less than γ, $\underline{w} < \gamma$, to ensure that the minimum wage is below the participation constraint for all abilities. It is important to note that the wage has no incentive effects; meaning, increasing the wage of an employee does not lead to a higher level of production. Instead, the wage influences the employee's decision to accept the contract by affecting their participation constraint. The central question emerging from this model extension concerns identifying the most suitable compensation instrument for employees of varying ability levels and for different values of α, which represents the ratio between the employee's outside option and the damage they could potentially cause to the firm. For simplicity, it is assumed that there is no discounting

The utility of low and high ability employees, respectively, are

$$U_L(\lambda, \Theta, w, A, \alpha) = p\beta(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) + \alpha(1-\lambda)\bar{A}\Theta^2 + w \tag{3.30}$$

$$U_H(\lambda, \Theta, w, A, \alpha) = p\beta(A\Theta + (1-\alpha)(1-\lambda)A\Theta^2) + \alpha(1-\lambda)A\Theta^2 + w \tag{3.31}$$

Similarly, the profit of the firm respectively, is

$$\pi_L(\lambda, \Theta, w, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) - (1-\lambda)\bar{A}\Theta^2 - w \tag{3.32}$$

$$\pi_H(\lambda, \Theta, w, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)A\Theta^2) - (1-\lambda)A\Theta^2 - w \tag{3.33}$$

3.4.1.1 Optimal contract

First, I solve the firm's problem for the low ability agents. The firm's problem becomes

[11] This unconditional compensation could also have different interpretations, such as a bonus or even a non-pecuniary benefit.

$$\begin{aligned}\max_{\Theta,\lambda,w} L(\Theta,\lambda,w) = {} & p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) - (1-\lambda)\bar{A}\Theta^2 - w \\ & - \mu_1(-p\beta(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) - \alpha(1-\lambda)\bar{A}\Theta^2 - w + \gamma A) \\ & - \mu_2(\Theta - 1) \\ & - \mu_3(\lambda - \bar{\lambda}) \\ & - \mu_4(\underline{w} - w)\end{aligned} \tag{3.34}$$

The interesting question arising from the setup is how the firm prefers to compensate the employee as there are three different instruments under its disposal. Denote the contract in the form (Θ, λ, w).

Lemma 3.7.

1.) The firm requires a minimum ability for employment, $A_{min}(\underline{w}, \alpha)$.

2.) The lowest ability agents employed by the firm are compensated via access.

Lemma 3.7 provides the familiar results. Increasing access to meet the employee participation constraint has the secondary effect of higher production. Thus it is a better instrument to remunerate employees than wage or noncompete.

Proof. Formally, the proof follows from

$$\frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial w}}{\frac{\partial U(\Theta,w,\lambda)}{\partial w}} = -1 < \frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial \Theta}}{\frac{\partial U(\Theta,w,\lambda)}{\partial \Theta}} = -\frac{p(1-\beta)(A + 2(1-\alpha)(1-\bar{\lambda})\Theta - 2(1-\bar{\lambda})\bar{A}\Theta}{p\beta(A + 2(1-\alpha)(1-\bar{\lambda})\Theta + 2\alpha(1-\bar{\lambda})\bar{A}\Theta} \tag{3.35}$$

■

For the remainder of the domain of ability, I divide the optimal contract into two subcases, whether $\alpha < 1$ or $\alpha > 1$.

Proposition 3.4. *Agents with $A > \tilde{A}(w, \alpha)$ are compensated via wage if $\alpha < 1$, and are compensated via a less stringent noncompete if $\alpha > 1$.*

For $A > \tilde{A}(w, \alpha)$, the firm provides the maximum access 1. Thus, one of the remaining instruments needs to be adjusted, either decreasing the stringency of the noncompete or increasing the wage. Expressing this mathematically yields:

$$\frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial \lambda}}{\frac{\partial U(\Theta,w,\lambda)}{\partial \lambda}} = \frac{p(1-\beta)(-(1-\alpha)\bar{A}) + \bar{A}}{p\beta(-(1-\alpha)\bar{A}) - \alpha\bar{A}} \tag{3.36}$$

If $\alpha < 1$,

$$\frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial \lambda}}{\frac{\partial U(\Theta,w,\lambda)}{\partial \lambda}} < \frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial w}}{\frac{\partial U(\Theta,w,\lambda)}{\partial w}} = -1 \tag{3.37}$$

The rationale for this inequality is that reducing the stringency of the noncompete agreement is more costly for the firm compared to increasing wages. This is because the potential damage to the firm from a less stringent noncompete outweighs the benefits an employee might gain by joining a competitor. In essence, the firm's profit would decrease more by relaxing the noncompete terms than by offering additional monetary compensation through higher wages

If $\alpha > 1$ the opposite is true as the previous argument can be reversed.

$$\frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial \lambda}}{\frac{\partial U(\Theta,w,\lambda)}{\partial \lambda}} > \frac{\frac{\partial \pi(\Theta,w,\lambda)}{\partial w}}{\frac{\partial U(\Theta,w,\lambda)}{\partial w}} = -1 \tag{3.38}$$

The next two graphs summarizes the optimal contracts.

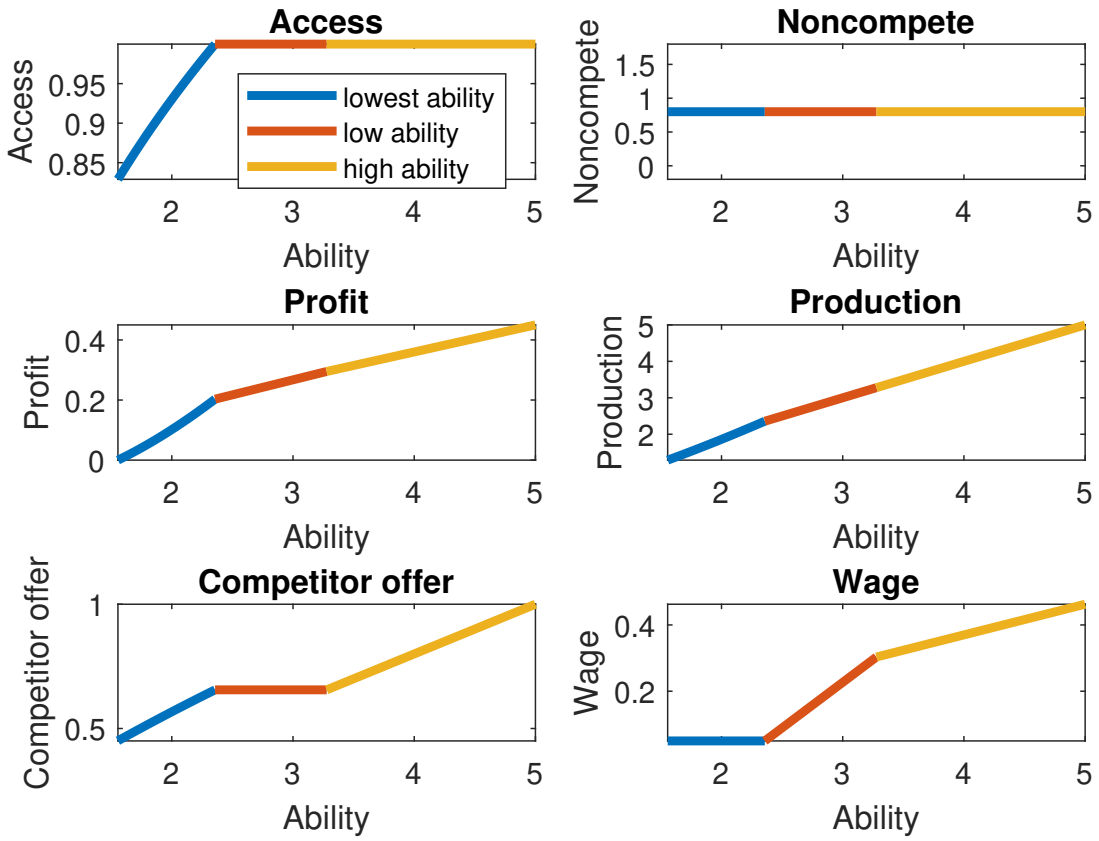


Figure 7 shows that the optimal contract features compensation via increasing wage if $\alpha < 1$ for employees with ability $\tilde{A}(w, \alpha) < A$.

Figure 3.6: Optimal contract with minimum wage with $\alpha < 1$

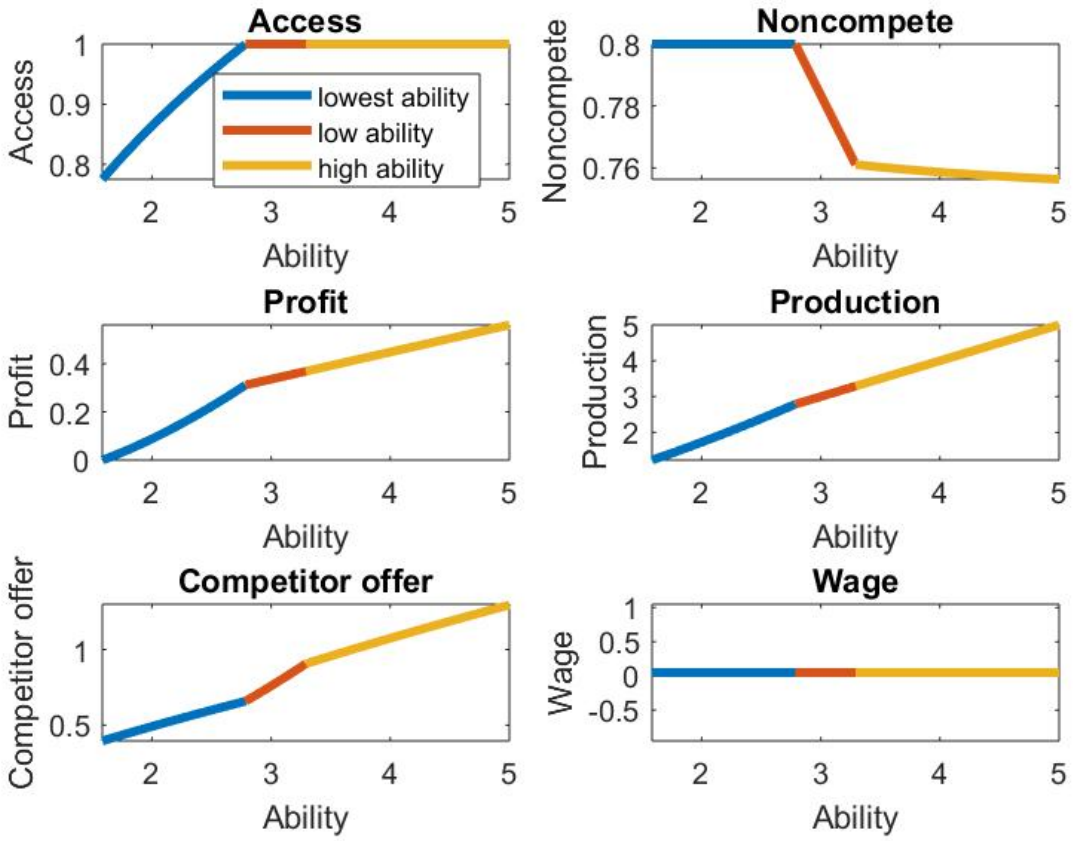


Figure 8 shows that the optimal contract features compensation via a laxer noncompete if $\alpha > 1$ for employees with ability $\tilde{A}(w, \alpha) < A$.

Figure 3.7: Optimal contract with minimum wage with high $\alpha > 1$

In summary, if the value of α is greater than one, indicating that the employee has favorable outside options, the optimal contract includes compensation through a laxer noncompete. Conversely, if α is less than one, the noncompete is set to be as stringent as possible. Specifically, for high ability employees who are given maximum access to the firm's critical assets, the stringency of the noncompete may vary based on their outside option. These findings support the empirical results of Kini et al. [2019], who found that 'CEOs are less likely to have (strict) non-competition agreements if they face a greater personal cost and more likely when the firm expects to suffer greater harm if departing CEOs work with competitors' (p.1).

3.4.2 Wage to induce staying

This section explores the possibility of the firm offering a state-contingent wage dependent on the match quality. The primary focus is on the wage that encourages the employee to stay even in a bad-match state to mitigate potential damages caused to the firm.

For low ability agents, the firm's objective is as follows:

$$\pi_L(\lambda, \Theta, w, A, \alpha) = p(1-\beta)(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) - w \tag{3.39}$$

subject to the constraint that the wage is at least as high as the value of the outside option of the employee in the bad state:

$$w \geq \alpha(1-\lambda)\bar{A}\Theta^2 \tag{3.40}$$

If the wage is lower than the outside option of the employee in the bad state, the employee will leave, reverting to the previously discussed problem. However, if the constraint in equation (3.40) is strictly exceeded, it implies the firm is overpaying the employee. Therefore, to ensure the employee stays without overpayment, this constraint should be met exactly

Furthermore, if the firm pays no wage, its cost is the damage, $(1-\lambda)\bar{A}\Theta^2$. Therefore, the firm offers a wage that induces the employee to stay if:

$$(1-\lambda)\bar{A}\Theta^2 \leq \alpha(1-\lambda)\bar{A}\Theta^2 = w \tag{3.41}$$

This condition holds if $\alpha \leq 1$. If $\alpha > 1$, the firm does not offer a competitive wage for the employee's outside option, as the employee causes less harm than the wage would be. However, if $\alpha < 1$, the wage is $w = \alpha(1-\lambda)\bar{A}\Theta^2$, and thus the firm reduces its costs by inducing the employee to stay and, therefore, causing no damage. The firm follows the same strategy with high ability employees.

3.4.3 Firm size in terms of firm damage and employee's outside option

In this section, the firm size is analyzed with respect to α, the ratio of the employee's outside option to the firm's potential damage. Initially, the focus is on contracts with maximum access ($\Theta = 1$) for an analytical solution is possible. Subsequently, the firm size is numerically examined all (A, α) combinations.

3.4.3.1 Conditional on maximum access

The parameter α plays a key role in determining which agents the firm employs. With a low α, indicating limited employee benefits from external options and higher costs to the firm, there is a lower employment threshold, $\underline{\alpha}(A)$. On the other hand, if α is very high, denote it by $\bar{\alpha}(A)$, the employee's outside option is great and thus he demands a high compensation in the bargaining. Anticipating the large costs the firm does not employ such agents. The following lemma summarizes this result.

Lemma 3.8. *The firm size can be characterized by a lower, $\underline{\alpha}$, and upper, $\bar{\alpha}$, threshold on α.*

3.4.3.2 Numerical simulation

This section presents a numerical simulation of the optimal contract across various (A, α) pairs, including those for the lowest ability employees with $\Theta < 1$. Figure 3.8 illustrates the firm size differences between scenarios with an enforceable noncompete ($\bar{\lambda} = 0.3$, indicated by red and blue areas) and an unenforceable noncompete ($\bar{\lambda} = 0$, shown in blue). The figure demonstrates the expected range of α, marked by $\underline{\alpha}(A)$ and $\bar{\alpha}(A)$.

The analysis then extends to comparing firm sizes under enforceable and unenforceable noncompete scenarios. Notably, for each value of α, the required minimum ability level is lower when the noncompete is enforceable. The reason is that noncompete helps the firm in the bargaining phase, allowing the firm to keep a higher ratio of the surplus. Additionally, the restriction on the employee's external use of access under an enforceable noncompete

enables the provision of higher access, which in turn boosts output. Consequently, the firm's size is larger in scenarios where noncompete agreements are enforceable compared to those where they are not.

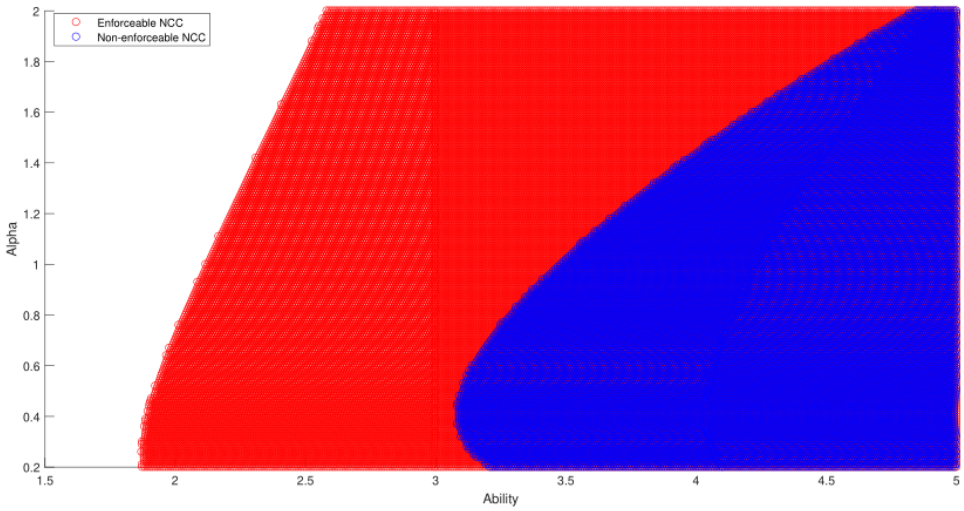


Figure 9 depicts the firm size under two distinct scenarios: when noncompete agreements are enforceable, represented by the colored area with $\bar{\lambda} = 0.3$, and when they are unenforceable, indicated by the blue area. The larger value of $\bar{\lambda}$ facilitates the firm's provision of access, consequently enabling a larger firm size compared to the scenario where noncompete is not enforceable.

Figure 3.8: Firm size

3.5 Efficiency of noncompete

This section analyzes the efficient level of the regulation of noncompete, $\bar{\lambda}$. Social welfare is defined as the sum of profit and agent's utility.[12] A regulator maximizes this social welfare by choosing $\bar{\lambda}$, taking the optimal contract (λ, Θ, w), as given. I assume that ability is nonobservable for the regulator, or, alternatively, writing different regulations for different levels of ability is too costly, thus the regulation cannot be made ability dependent. However, the regulator is able to observe α, which could represent the industry in which the firm

[12]I abstract from the additional profit the competitor firm may make if the agent joins them in the analysis. The reason for this is that I want to avoid that an additional player drives the results of the regulation. However, including the competitor's payoff is also possible. One could imagine that the competitor's profit increases in a similar fashion to the agent's profit, ie.: by $\delta(1-\lambda)\bar{A}\Theta$ for low ability and by $\delta A(1-\lambda)\Theta$ for high ability, where δ is a parameter reflecting the sensitivity of profitability with respect to the agent's join. The analysis could be carried out in a similar fashion to the main text, resulting in a less stringent regulation on noncompete since the competitor's profit is also a decreasing function of the stringency of the noncompete.

operates or long-term prevailing market conditions.

The objective of the regulator takes the following form.

$$\begin{aligned}\max_{\bar{\lambda}} \phi(\bar{\lambda}) = &\int_1^{A_{min}(\bar{\lambda})} \gamma A df(A) \\ &+ \int_{A_{min}(\bar{\lambda})}^{\bar{A}(\alpha,\bar{\lambda})} pA\Theta(\bar{\lambda}) - (1-p)(1-\alpha)(1-\lambda)\bar{A}(\Theta(\bar{\lambda}))^2 df(A) \\ &+ \int_{\bar{A}(\alpha,\bar{\lambda})}^{A_{max}} pA\Theta(\bar{\lambda}) - (1-p)(1-\alpha)(1-\lambda)A(\Theta(\bar{\lambda}))^2 df(A)\end{aligned} \tag{3.42}$$

where F(A) is the cumulative distribution function of A with density f(A). We assume uniform distribution throughout the paper thus $F(A) = \frac{A-1}{A_{\max}}$ and $f(A) = \frac{1}{A_{\max}-1}$ The first line is the payoff of the players when there is no employment, while the rest is the sum of the payoffs arising from employment, for low and high ability respectively. Note that the wage falls out of the objective function, as the firm pays it while the employee receives it.

3.5.1 Firm damage is larger

First consider $\alpha \leq 1$, meaning the damage of the firm is at least as high as the gain of the employee.

Lemma 3.9. *If $\alpha < 1$, it is optimal to set $\bar{\lambda} = 1$, that is the regulator allows the most stringent noncompete.*

Since the employee leaving the firm yields to larger costs than benefits, it is optimal to set $\bar{\lambda} = 1$, which in turn also incentivizes the firm to provide maximum access to the employees.

3.5.2 Employee's outside option is larger

This subsection discusses the scenario when the firm's damage is lower than the employee's gain. The objective function, given the optimal contract offered by the firm, can be written as follows.

$$
\begin{aligned}
\max_{\bar{\lambda}} \phi(\bar{\lambda}) = & \int_1^{A_{min}(\bar{\lambda})} \gamma A df(A) \\
& + \int_{A_{min}(\bar{\lambda})}^{\tilde{A}(\alpha,\bar{\lambda})} pA\Theta(\bar{\lambda}) - (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2 df(A) \\
& + \int_{\tilde{A}(\alpha,\bar{\lambda})}^{\bar{A}(\alpha,\bar{\lambda})} p(A) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))\bar{A} df(A) \\
& + \int_{\bar{A}(\alpha,\bar{\lambda})}^{A_{max}} p(A) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha)) A df(A)
\end{aligned}
\tag{3.43}
$$

After rearranging the first order condition has the following form[13]

$$
\begin{aligned}
& \int_{A_{min}(\bar{\lambda})}^{\tilde{A}(\alpha,\bar{\lambda})} pA\frac{\partial\Theta}{\partial\bar{\lambda}} - (1-p)(1-\alpha)\bar{A}\left(-\Theta^2(\bar{\lambda}) + (1-\bar{\lambda})2\Theta(\bar{\lambda})\frac{\partial\Theta(\bar{\lambda})}{\partial\bar{\lambda}}\right) df(A) \\
& = \frac{\partial A_{min}(\bar{\lambda})}{\partial\bar{\lambda}} f(A_{\min}) \times \left(p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) - (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2 - (\gamma A_{min}(\bar{\lambda})\right) \\
& + \frac{\partial\tilde{A}(\alpha,\bar{\lambda})}{\partial\bar{\lambda}} f(\tilde{A}(\alpha,\bar{\lambda})) \\
& \times \left(p(\tilde{A}(\alpha,\bar{\lambda})) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))A - p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) + (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2\right)
\end{aligned}
\tag{3.44}
$$

The right-hand side of the expression is negative because both $\frac{\partial A_{min}(\bar{\lambda})}{\partial\bar{\lambda}}$ and $\frac{\partial\tilde{A}(\bar{\lambda})}{\partial\bar{\lambda}}$ are negative. This is because the regulator maximizes welfare by making the intervals with higher production (higher access) larger. The left-hand side is broken down as follows. The first part of the expression is the direct benefit of increasing the stringency of noncompete. A more stringent noncompete incentivizes the firm to provide more access, as the employee has to be compensated for the lost outside opportunities while the firm suffers smaller damage than the employee gain. This is socially beneficial as the higher access leads to more expected production. The second part of the expression represents the effect on the damage and gain due to the competitor's offer. From the term $(1-\alpha)$, 1 refers to the firm's payoff, and α refers to the employee's payoff. An increase in $\bar{\lambda}$ has the direct effect of decreasing the outside option (Θ^2), but also has an indirect effect that, due to the larger access, the outside option is bigger ($(1-\bar{\lambda})2\Theta(\bar{\lambda})\frac{\partial\Theta(\bar{\lambda})}{\partial\bar{\lambda})}$).

In conclusion, the regulator must trade off the benefit of strict regulation in terms of

[13]The rearrangement is shown in Appendix B.2.8

facilitating access provision and the cost that great outside options are reduced. However, unlike scenarios where $\alpha < 1$, deriving clear-cut analytical results in this context is not straightforward.

3.6 Conclusion

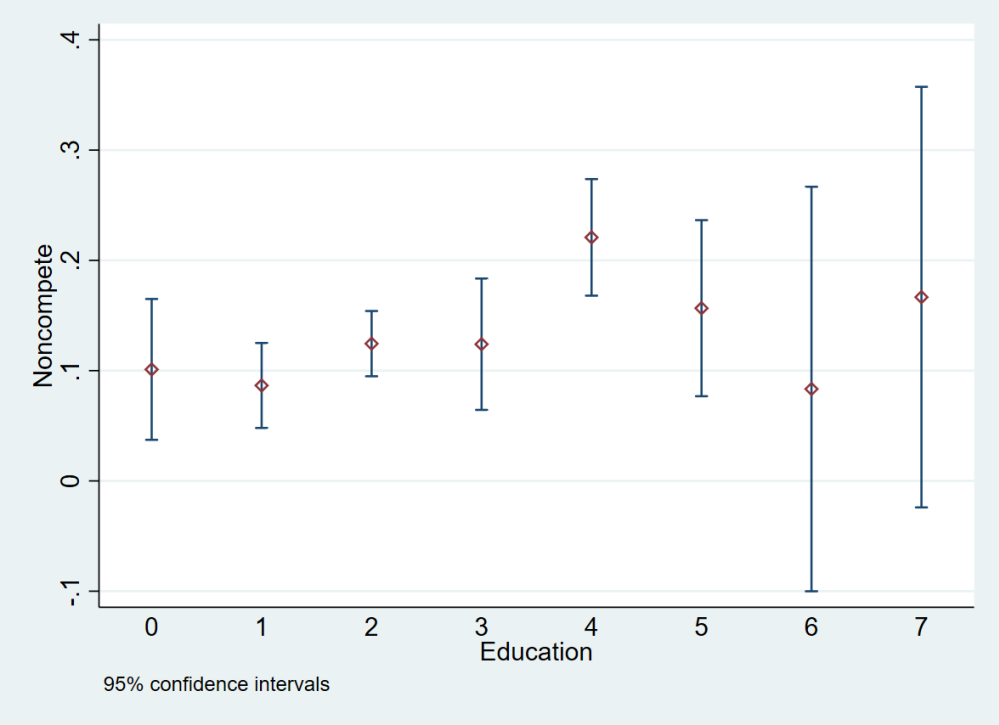
This paper developed a theoretical model to analyze the optimal degree of access and stringency of noncompete in employment contracts. We found that the lowest ability agents are subject to the strongest restrictions, while agents close to the average ability of the firm have milder covenants. However, for the high ability agents, the stringency of noncompete is not decreasing any further as these agents can make the most use of the access granted to them. An important extension of the model is allowing the employee gain from leaving to differ from the firm's damage. We found that if the employee gain is larger than the damage, with a low wage and less stringent noncompete, as it minimizes the firm's cost. However, in the reversed case, a higher wage and stringent noncompete are preferred to minimize the losses arising from the employee's departure.

We also established that the firm size is larger if the regulator enforces noncompetes. With regards to the optimal policy of regulating the stringency of noncompete, the tradeoff is between larger firm size and restricted mobility in cases when mobility would be efficient. It is optimal to regulate the maximum strength of noncompete agreement the firm can impose on the employee only if the employee's gain from joining a competitor is sufficiently larger than the firm's damage.

Appendix B

Appendix

B.1 Figures



The graph shows the noncompete frequency as a function of the employee's education.
Data source: National Longitudinal Survey of Youth Cohort 1979

Figure B.1: Noncompete as a function of education

B.2 Proofs

B.2.1 Proof of Proposition 3.1

Proof. The Lagrangian becomes

$$\begin{aligned}\max_{\Theta,\lambda} L_L(\Theta,\lambda) = & p(1-\beta)(A\Theta) - (1-\lambda)\bar{A}\Theta^2 \\ & - \mu_1(-(p)(\beta)(A\Theta) - (1-\lambda)\bar{A}\Theta^2 + \gamma A) \\ & - \mu_2(\Theta - 1) \\ & - \mu_3(\lambda - \bar{\lambda})\end{aligned} \tag{B.1}$$

In equilibrium, there are multipliers μ_1, μ_2, μ_3, such that

$$\frac{\partial L}{\partial \Theta} = p(1-\beta)A - 2(1-\lambda)\bar{A}\Theta + \mu_1(p\beta A + 2(1-\lambda)\bar{A}\Theta) - \mu_2 = 0 \tag{B.2}$$

$$\frac{\partial L}{\partial \lambda} = \bar{A}\Theta^2 - \mu_1\bar{A}\Theta^2 - \mu_3 = 0 \tag{B.3}$$

$$\mu_1(-p(\beta)(A\Theta - y) - (1-\lambda)\bar{A}\Theta^2 + \gamma A) = 0 \tag{B.4}$$

$$\mu_2(\Theta - 1) = 0 \tag{B.5}$$

$$\mu_3(\lambda - \bar{\lambda}) = 0 \tag{B.6}$$

I start with part 2.) and part 3) of Proposition 1.

Case I, $\mu_3 = 0$**.**

It follows that $\mu_1 = 1 > 0$ and $\mu_2 = pA > 0$. Thus both the first and second constraint is binding, meaning $\Theta = 1$ and λ is calculated from the binding participation constraint.

$$\lambda = 1 - \frac{\gamma A - p\beta A}{\bar{A}} = \lambda_{\text{pc,L}} \tag{B.7}$$

The sign of the derivative $\frac{\partial \lambda_{\text{pc}}}{\partial A}$ depends on the relation of $p\beta$ and γ which are the marginal effects of the increase in ability on the bargained ratio of the production, $p\beta$, at the firm and the marginal effect of ability under the alternative use of ability γ. If $p\beta > \gamma$, $\frac{\partial \lambda}{\partial A} > 0$

meaning as ability increases, the firm can tighten noncompete. The reason is that at higher ability the employee's payoff from the output $pA\beta$ approaches the outside option $A\gamma$.

For that reason, I make the parameter assumption that $p\beta < \gamma$ resulting in $\frac{\partial \lambda}{\partial A} < 0$. This case the firm has to decrease the level of noncompete to be able to match the participation constraint. Note that $\lambda_{\text{pc}} = \bar{\lambda}$ defines a threshold of A, $\tilde{A}$ below which the contract is not feasible due to the restriction on the stringency of the noncompete.

$$\tilde{A} = \frac{\bar{A}(1-\bar{\lambda})}{\gamma - p\beta} \tag{B.8}$$

Case II, $\mu_3 > 0$

$\mu_3 > 0$ implies $\lambda = \bar{\lambda}$. Start with $\mu_2 > 0$ yielding $\Theta = 1$. If $\mu_1 > 0$ That this implies $p\beta A + (1-\bar{\lambda})\bar{A} = \gamma A$. As $\gamma > p\beta$, the left hand side increases more in A, than the right. Hence above contract cannot be equilibrium.

If $\mu_1 = 0$, the PC may not bind. However, in this case offering $\Theta = 1$ is not optimal, since lowering Θ would yield to higher profit, while still satisfying the participation constraint. Therefore if $\mu_1 = 0$, the access corresponding multiplier must also be 0, that is $\mu_2 = 0$. If $\mu_1 = 0$, then $\Theta = \frac{p(1-\beta)A}{2(1-\bar{\lambda})\bar{A}}$, which the optimal level of access if the PC does not bind. To have an interesting model with a friction, γ must be high enough to exclude this solution. That is, $\underline{\gamma} = \frac{p^2(1-\beta)}{2(1-\bar{\lambda})}$.

$\mu_2 = 0$

If $\mu_1 > 0$, the PC binds, and Θ is defined by the PC. It yields

$$\Theta = \frac{-p\beta A + \sqrt{p^2\beta^2A^2 - 4(1-\bar{\lambda})\bar{A}(-\gamma A)}}{2(1-\bar{\lambda})\bar{A}} = \Theta_{pc(L)} \tag{B.9}$$

Note that

$$\frac{\partial \Theta_{pc(L)}}{\partial A} = -p\beta + \frac{1}{2}\frac{2A\beta^2p^2 + 4(1-\bar{\lambda})\bar{A}\gamma}{\sqrt{p^2\beta^2A^2 - 4(1-\bar{\lambda})\bar{A}(-\gamma A)}} > 0 \tag{B.10}$$

Since after simplification it yields $4(1-\bar{\lambda})^2\bar{A}^2\gamma^2 > 0$

The threshold of A can be calculated from $\Theta_{pc} = \bar{\Theta}$ resulting the same $\tilde{A}$ as before.

$$\tilde{A} = \frac{\bar{\Theta}^2 \bar{A}(1-\bar{\lambda})}{p(\gamma-\beta)} \tag{B.11}$$

For $A < \tilde{A}$, only $\Theta = \Theta_{\text{pc}}$ and $\lambda = \bar{\lambda}$ is feasbile, while is feasible, while for $A > \tilde{A}$ only only $\Theta = 1$ and $\lambda = \lambda_{\text{pc}}$. Thus part 2 and part 3 of the proposition is proven.

■

B.2.2 Proof of Proposition 3.2

Proof. For high ability agents the damage and gain functions depends on $A > \bar{A}$. The problem of the firm is the following

$$\max_{\Theta,\lambda} = \pi_H(\Theta,\lambda)p(1-\beta)(A\Theta) - (1-\lambda)A\Theta^2 \tag{B.12}$$

s.t

$$p\beta(A\Theta) + (1-\lambda)A\Theta^2 \geq \gamma A \tag{B.13}$$

$$\Theta \leq 1 \tag{B.14}$$

$$\lambda \leq \bar{\lambda} \tag{B.15}$$

The Lagrangian hence reads

$$\begin{aligned} \max_{\Theta,\lambda} L_H(\Theta,\lambda) = {} & p(1-\beta)(A\Theta) - (1-\lambda)\Theta^2 \\ & - \mu_1(-p\beta(A\Theta) - (1-\lambda)\Theta^2 + \gamma A) \\ & - \mu_2(\Theta - 1) \\ & - \mu_3(\lambda - \bar{\lambda}) \end{aligned} \tag{B.16}$$

There are multipliers μ_i such that

$$\frac{\partial L}{\partial \Theta} = p(1-\beta)A - 2(1-\lambda)A\Theta + \mu_1(p\beta A + 2(1-\lambda)A\Theta) - \mu_2 = 0 \tag{B.17}$$

$$\frac{\partial L}{\partial \lambda} = A\Theta^2 - \mu_1 A\Theta^2 - \mu_3 = 0 \tag{B.18}$$

$$\mu_1(-p(\beta)(A\Theta - y) - (1-\lambda)A\Theta^2 + \gamma A) = 0 \tag{B.19}$$

$$\mu_2(\Theta - 1) = 0 \tag{B.20}$$

$$\mu_3(\lambda - \bar{\lambda}) = 0 \tag{B.21}$$

The solution looks similar to the proof of Proposition 1.

Case I with $\mu_3 = 0$

It yields to $\mu_1 = 1 > 0$ and $\mu_2 = pA > 0$. Thus $\Theta = 1$ and

$$\lambda = 1 - \frac{\gamma A - p\beta A}{A} = 1 - \gamma + p\beta = \lambda_{\text{pc}}(A > \bar{A}) \tag{B.22}$$

Note that as $\frac{\partial \lambda}{\partial A} = 0$, the optimal stringency of noncompete is not dependent on ability for high ability employees.

Case II $\mu_3 > 0$

In which case $\lambda = \bar{\lambda}$.

Start with $\mu_2 > 0$, leading to $\Theta = 1$. As in the previous case, PC is binding otherwise firm could lower Θ. However, the PC, $p\beta A + (1-\bar{\lambda})A$, is linear in A, so the contract can only be optimal for the whole range of $A \in (\bar{A}, A_{\max})$ if $p\beta + (1-\bar{\lambda}) = \gamma$, which equation depends on the exogenous parameters. Rewriting yields $\bar{\lambda} = 1 - \gamma - p\beta$ which is the same as (B.22) with $\lambda = \bar{\lambda}$

Next, consider $\mu_2 = 0$. If $\mu_1 > 0$, PC binds and it defines access

$$\Theta = \frac{-p\beta A + \sqrt{p^2\beta^2 A^2 - 4(1-\bar{\lambda})A(-\gamma A)}}{2(1-\bar{\lambda})A} = \Theta_{pc,H} \tag{B.23}$$

The two contracts that solve the problem are $(1, \lambda_{\text{pc}}(A > \bar{A}))$ and $\Theta_{pc,H}, \bar{\lambda}$. In both cases, the employee is pushed to the participation constraint. Thus the one with higher access that yields to higher production is the one the firm chooses to offer.

Therefore, for $\bar{A} < A < A_{\max}$, the optimal contract is $(\lambda_{\text{pc}}, 1)$, where (λ_{pc}) is defined from the binding participation constraint and is not dependent on A. ■

B.2.3 Proof of Proposition 3.3

Proof. Calculating the access from the participation constraint of the agent gives

$$\Theta_{\alpha,\text{pc}} = \frac{-p\beta A + \sqrt{p^2\beta^2A^2 + 4(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha))(\gamma A)}}{2(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha))} \tag{B.24}$$

Substituting in above access for the profit yields the following equation

$$\pi(A,\alpha,\Theta_{\alpha,\text{pc}}) = A_{min,\alpha}^2 p^2(1-\beta)[(1-\beta)\alpha+\beta] - (1-\bar{\lambda})\bar{A}\gamma[1-p(1-\beta)(1-\alpha))]^2 = 0 \tag{B.25}$$

Differentiating above with respect to $A_{min,\alpha}$ and α yields

$$\frac{\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial A_{min,\alpha}} = 2A_{min,\alpha}p^2(1-\beta)[(1-\beta)\alpha+\beta] - \frac{1}{2}(1-\bar{\lambda})\gamma[1-p(1-\beta)(1-\alpha))]^2 \tag{B.26}$$

$\frac{\partial\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial A_{min,\alpha}} > 0$ if $(p,(1-\beta))$ high enough.

$$\frac{\partial\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial\alpha} = A_{min,\alpha}^2 p^2(1-\beta)^2 - 2(1-\bar{\lambda})\gamma\bar{A}[1-p(1-\beta)(1-\alpha))]p(1-\beta) \tag{B.27}$$

The expression is highest in terms of α, if $\alpha = 0$.

$$\frac{\partial\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial\alpha}|(\alpha=0) = A_{min,\alpha}^2 p(1-\beta) - 2(1-\bar{\lambda})\gamma\bar{A}[1-p(1-\beta) \tag{B.28}$$

This expression is positive, if $(p,(1-\beta))$ high enough. As α goes up, the expression becomes negative after a threshold (α^T). Calculating the derivative implicitly,

$$\frac{\partial A_{min,\alpha}}{\partial\alpha} = -\frac{\frac{\partial\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial\alpha}}{\frac{\partial\pi(A,\alpha,\Theta_{\alpha,\text{pc}})}{\partial\alpha}} \tag{B.29}$$

yields to the proposition. ■

B.2.4 Proof of Lemma 3.6

Proof.

$$\frac{\partial \pi(A, \alpha, \Theta_{\alpha,\text{pc}}}{\partial \bar{\lambda}} = \bar{A}\gamma[1 - p(1-\beta)(1-\alpha))] > 0 \tag{B.30}$$

As a result $\frac{\partial A_{min,\alpha}}{\partial \bar{\lambda}} < 0$. ■

B.2.5 Proof of Proposition 3.4

Proof. There are multipliers μ_i such that

$$\frac{\partial L}{\partial \Theta} = p(1-\beta)(A+2(1-\alpha)(1-\lambda)\bar{A}\Theta) - 2(1-\lambda)\bar{A}\Theta + \mu_1(p\beta(A+2(1-\alpha)(1-\lambda)\bar{A}\Theta) + 2\alpha(1-\lambda)\bar{A}\Theta) - \mu_2 = 0 \tag{B.31}$$

$$\frac{\partial L}{\partial \lambda} = -p(1-\beta)(1-\alpha)\bar{A} - \mu_1 p\beta(1-\alpha)\bar{A} + \bar{A}\Theta^2 - \bar{A}\alpha\mu_1\Theta^2 - \mu_3 = 0 \tag{B.32}$$

$$\frac{\partial L}{\partial w} = -1 + \mu_1 + \mu_4 = 0 \tag{B.33}$$

$$\mu_1(-p(\beta)(A\Theta - y) - (1-\lambda)\bar{A}\Theta^2 - w + \gamma A = 0 \tag{B.34}$$

$$\mu_2(\Theta - \bar{\Theta}) = 0 \tag{B.35}$$

$$\mu_3(\lambda - \bar{\lambda}) = 0 \tag{B.36}$$

$$\mu_4(\underline{w} - w) = 0 \tag{B.37}$$

If $\mu_3 = 0$, simplifying $\frac{\partial L}{\partial \lambda}$ yields to

$$\mu_1 = \frac{1 - p(1-\beta)(1-\alpha)}{p\beta(1-\alpha) + \alpha} \tag{A.1}$$

Note also that from $\frac{\partial L}{\partial w}$ it follows that

$$\mu_1 = 1 - \mu_4 \tag{B.38}$$

and thus $\mu \leq 1$

If $\alpha < 1$ (A.1) cannot be met. Thus $\mu_3 > 0$, leading to $\lambda = \bar{\lambda}$. $\alpha = 1$ leads the case discussed before.

If $\alpha > 1$, $\mu_1 < 1$ and thus $\mu_4 > 0$. Thus $w = \underline{w}$ and λ is calculated from the binding

participation constraint.

$$\lambda_{\text{pc}}(A < \bar{A}, \alpha) = 1 - \frac{\gamma A - \underline{w} - p\beta A}{\bar{A}(p\beta(1-\alpha) + \alpha} \tag{B.39}$$

If $\mu_3 > 0$, (A.1) becomes

$$\mu_1 = \frac{1 - p(1-\beta)(1-\alpha) - \frac{\mu_3}{\bar{A}}}{p\beta(1-\alpha) + \alpha)} \tag{B.40}$$

Which leads to all constraint binding, ie.: the contract is independent of ability. Note that this leads to contradiction as the participation constraint is a function of ability. [1]

Note that at high ability, $A > \bar{A}$, the noncompete changes to

$$\lambda_{\text{pc}}(A > \bar{A}, \alpha) = 1 - \frac{\gamma A - \underline{w} - p\beta A}{A(p\beta(1-\alpha) + \alpha)} \tag{B.41}$$

■

Furthermore the binding participation constraint for part 2) is

$$\Theta_{\alpha,\text{pc}} = \frac{-p\beta A + \sqrt{p^2\beta^2A^2 + 4(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha))(\gamma A - \underline{w})}}{2(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha))} \tag{B.42}$$

Part 1) follows the same logic as before, we elaborate on it in the section 5.3.

Moreover $\Theta_{\alpha,\text{pc}} = 1$ if

$$\tilde{A}_\alpha = \frac{(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha) + w}{p(\gamma - \beta)} \tag{B.43}$$

$$w_{\text{pc,L}} = p\beta(A\Theta + (1-\alpha)(1-\lambda)\bar{A}\Theta^2) + \alpha(1-\lambda)\bar{A}\Theta^2 - \gamma A \tag{B.44}$$

$$w_{\text{pc,H}} = p\beta(A\Theta + (1-\alpha)(1-\lambda)A\Theta^2) + \alpha(1-\lambda)A\Theta^2 - \gamma A \tag{B.45}$$

[1] Technically we could make $\mu_1 = 0$ so that the PC would not bind but that is not of particular interest

$$\frac{\partial \Theta_{\alpha,\text{pc}}}{\partial \bar{\lambda}} =$$
$$\frac{-0.5(p^2\beta^2A^2 + 4((1-\bar{\lambda})\bar{A}(\alpha + p\beta(1-\alpha)(\gamma A - \underline{w}))^{-0.5}(4\bar{A}(\alpha + p\beta(1-\alpha))(\gamma A - \underline{w})}{(2(1-\bar{\lambda})\bar{A}(\alpha + p\beta(1-\alpha)))}$$
$$+ \frac{(-p\beta A + \sqrt{p^2\beta^2A^2 + 4(\alpha(1-\bar{\lambda})\bar{A} + p\beta(1-\bar{\lambda})\bar{A}(1-\alpha)(\gamma A - \underline{w}))}(2\bar{A}(\alpha + p\beta(1-\alpha)))}{(2(1-\bar{\lambda})\bar{A}(\alpha + p\beta(1-\alpha))^2} > 0 \tag{B.46}$$

B.2.6 Proof of Lemma 3.8

Proof. Denote the ability level for which the optimal contract is $\Theta = 1$, $\lambda = \bar{\lambda}$ and $w = \underline{w}$ by A^F. Note that A^F exists independent of the value of α, as it only influences the exact level of ability for which this is the optimal contract. The firm's profit that has to be at least as large as the participation constraint is given by

$$\pi_L = p(1-\beta)(A + (1-\alpha)(1-\bar{\lambda})\bar{A}) - (1-\bar{\lambda})\bar{A} - \underline{w} \geq 0 \tag{B.47}$$

$$\pi(A \geq \bar{A}) = p(1-\beta)(A + (1-\alpha)(1-\bar{\lambda})A) - (1-\bar{\lambda})A - \underline{w} \geq 0 \tag{B.48}$$

with low and high ability employees respectively. The upper threshold on α is

$$\bar{\alpha}_L = 1 - \frac{\bar{A}(1-\bar{\lambda}) - p(1-\beta)A - \underline{w}}{p(1-\beta)\bar{A}(1-\bar{\lambda})} > 1 \tag{B.49}$$

and

$$\bar{\alpha}(A \geq \bar{A}) = 1 - \frac{A(1-\bar{\lambda}) - p(1-\beta)A - \underline{w}}{p(1-\beta)A(1-\bar{\lambda})} > 1 \tag{B.50}$$

The participation constraint of the employee for low and high ability respectively are

$$U_L = p\beta(A - y + (1-\alpha)(1-\bar{\lambda})\bar{A}) + \alpha(1-\bar{\lambda})\bar{A} + \underline{w} \geq \gamma A \tag{B.51}$$

$$U(A \geq \bar{A}) = p\beta(A - y + (1-\alpha)(1-\bar{\lambda})\bar{A}) + \alpha(1-\bar{\lambda})\bar{A} + \underline{w} \geq \gamma A \tag{B.52}$$

The lower threshold becomes

$$\underline{\alpha}_L = \frac{\gamma A - p\beta A - (1-\bar{\lambda})\bar{A}p\beta - \underline{w}}{(1-\bar{\lambda})\bar{A}(1-p\beta)} \tag{B.53}$$

$$\underline{\alpha}(A \geq \bar{A}) = \frac{\gamma A - p\beta A - (1-\bar{\lambda})Ap\beta - \underline{w}}{(1-\bar{\lambda})A(1-p\beta)} \tag{B.54}$$

For $A > A^F$ the optimal contract changes. If $\alpha > 1$, the noncompete stringency is decreased as ability increases. If $\alpha < 1$ the wage is increased. I focus on $A > A^F > \bar{A}$ and $\alpha > 1$ to derive a relevant upper bound $\bar{\alpha}(A > A^F > \bar{A})$ with the optimal contract $(\Theta = 1, \lambda = \lambda_{\text{pc}}(A > \bar{A}), w = \underline{w})$.

$$\bar{\alpha}(A > A^F > \bar{A}) = \frac{2p^2\beta(1-\beta)(A) - \underline{w}(1+2p\beta-p) + (1-p(1-\beta))\gamma A}{\gamma A p(1-\beta) + p\beta\underline{w} + (A)(p^2\beta(1-\beta)-p)} \tag{B.55}$$

Note that $\frac{\partial\bar{\alpha}(A>A^F>\bar{A})}{\partial A} > 0$, meaning that higher ability agents are employed even when their outside option is better, as they are more productive.

For $\alpha < 1$, $\bar{A} > A > A^F$, for increasing ability the wage is increased which does not affect production/outside option, thus the lower bound remains unchanged. $\frac{\partial\underline{\alpha}_L}{\partial A} > 0$ with similar argument as before.

■

B.2.7 Proof of Lemma 3.9

Proof. The first term of the second and third lines are positive, while the second term is at most 0. Moreover, the firm chooses $\lambda = \bar{\lambda}$ irrespective of ability. Given that $\frac{\partial\Theta(\bar{\lambda})}{\partial\bar{\lambda}} \geq 0$ and if $\Theta = 1$, $\frac{1}{\partial\bar{\lambda}} = 0$, it is optimal from the regulator to choose $\bar{\lambda} = 1$. In that case, access is maximized making the first term as large as possible. The second term becomes 0, which is the maximum of that expression. The optimal degree of access is $\Theta = 1$, as the employee cannot inflict damages on the firm. ■

B.2.8 Rearranging first order condition of equation 3.43

The first order condition reads

$$
\begin{aligned}
&\frac{\partial \phi(\bar{\lambda})}{\partial \bar{\lambda}} = \frac{\partial A_{min}(\bar{\lambda})}{\partial \bar{\lambda}}(\gamma A_{min}(\bar{\lambda}))f(A_{\min})) \\
&+ \frac{\partial \tilde{A}(\alpha,\bar{\lambda})}{\partial \bar{\lambda}}\left(p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) - (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2\right) f(\tilde{A}(\alpha,\bar{\lambda})) \\
&- \frac{\partial A_{min}(\bar{\lambda})}{\partial \bar{\lambda}}\left(p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) - (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2\right) f(A_{\min}) \\
&+ \int_{A_{min}(\bar{\lambda})}^{\tilde{A}(\alpha,\bar{\lambda})} pA\frac{\partial \Theta}{\partial \bar{\lambda}} - (1-p)(1-\alpha)\bar{A}\left(-\Theta^2(\bar{\lambda}) + (1-\bar{\lambda})2\Theta(\bar{\lambda})\frac{\partial \Theta(\bar{\lambda})}{\partial \bar{\lambda}}\right) dF(A) \\
&- \frac{\partial \tilde{A}(\alpha,\bar{\lambda})}{\partial \bar{\lambda}}\left(p(\tilde{A}(\alpha,\bar{\lambda}) - y) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))\bar{A}(\alpha,\bar{\lambda})\right) f(\tilde{A}(\alpha,\bar{\lambda})) \\
&+ \frac{\partial \bar{A}(\alpha,\bar{\lambda})}{\partial \bar{\lambda}}\left(p(\bar{A}(\alpha,\bar{\lambda}) - y) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))A+\right) \bar{A}(\alpha,\bar{\lambda}) f(\tilde{A}(\alpha,\bar{\lambda})) \\
&- \frac{\partial \bar{A}(\alpha,\bar{\lambda})}{\partial \bar{\lambda}}\left(p(\bar{A}(\alpha,\bar{\lambda}) - y) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))A+\right) \bar{A}(\alpha,\bar{\lambda}) f(\tilde{A}(\alpha,\bar{\lambda})) = 0
\end{aligned}
\tag{B.56}
$$

After rearranging the first order condition has the following form

$$
\begin{aligned}
&\int_{A_{min}(\bar{\lambda})}^{\tilde{A}(\alpha,\bar{\lambda})} pA\frac{\partial \Theta}{\partial \bar{\lambda}} - (1-p)(1-\alpha)\bar{A}\left(-\Theta^2(\bar{\lambda}) + (1-\bar{\lambda})2\Theta(\bar{\lambda})\frac{\partial \Theta(\bar{\lambda})}{\partial \bar{\lambda}}\right) dF(A) \\
&= \frac{\partial A_{min}(\bar{\lambda})}{\partial \bar{\lambda}} f(A_{\min}) \times \left(p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) - (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2 - (\gamma A_{min}(\bar{\lambda})\right) \\
&+ \frac{\partial \tilde{A}(\alpha,\bar{\lambda})}{\partial \bar{\lambda}} f(\tilde{A}(\alpha,\bar{\lambda})) \\
&\times \left(p(\tilde{A}(\alpha,\bar{\lambda})) - (1-p)(1-\alpha)(1-\lambda_{pc}(A<\bar{A},\alpha))A - p(\tilde{A}(\alpha,\bar{\lambda})\Theta(\bar{\lambda})) + (1-p)(1-\alpha)(1-\bar{\lambda})\bar{A}(\Theta(\bar{\lambda}))^2\right)
\end{aligned}
\tag{B.57}
$$

All parts of the expression build on the tradeoff between the outside option and access provision. The main text elaborates on the tradeoff more.

B.3 Parameter values

	Figure 3	Figure 4	Figure 5	Figure 6	Figure 7	Figure 8	Figure 9
p	0.7	0.8	0.8	0.7	0.5	0.5	0.6
β	0.5	0.2	0.2	0.5	0.25	0.7	0.25
$A_{\min}$	1	1	1	1	1	1	1
$A_{\max}$	5	5	5	5	5	5	5
y	0.05	0.05	0.05	0.05	0.05	0.05	0.05
(A)	3	3	3	3	3	3	3
$\bar{\Theta}$	1	1	1	1	1	1	1
$\bar{\lambda}$	0.8	0.2	0	0.8	0.8	0.8	0,0.3
γ	0.6	0.6	0.6	0.6	0.4	0.4	0.2
$\underline{w}$	-	-	-	0.05	0.05	0.05	0.05
α	1	1	1	1	.9	1.1	varies

Chapter 4

How to Enforce Platforms' Liability?

4.1 Introduction

The economic and societal relevance of online platforms has been on the rise. Platforms like Facebook, Twitter, and YouTube have attained immense popularity. According to COOK [2023], more than 5 billion YouTube videos are viewed daily, and Twitter publishes over 500 million tweets each day as of December 2023.[1] However, hosting platforms also contribute to disseminating illegal material, such as hate speech on social media platforms or copyright violations on media platforms. In response, today's online intermediaries regulate users' access to platforms and police their behavior and expression on their platforms. Despite their efforts, [2] the public pressure is mounting on platforms to do more to combat offenses committed under their supervision and on regulators to force platforms to police [Buiten et al., 2020]. The Directive on electronic commerce in the European Union and Section 230 in the United States Communications Decency Act granted immunity to online platforms with respect to third-party content for the past 20 years. However, these regulations are considered outdated and new laws and proposals have been made. The German Network Enforcement Act (Netzwerkdurchsetzungsgesetz, henceforth NetzDG) was enacted in 2018. Moreover, the Digital Services and Markets Act in Europe, the online safety bill in the UK,[3],

[1] The daily number of tweets is reported by worldometers.info.

[2] In 2019, Facebook CEO Mark Zuckerberg declared that they would be allocating 5% of the firm revenues, 3.7 billion, on content moderation[Roettgers, 2019]

[3] UK Online Safety bill

and a heated policy debate on reform and court cases in the US indicate an increased liability platforms are facing.[4]

A fundamental question is how a regulator can enforce social media platforms' liability for offenses committed by platform users. The key friction is that the platform has a technological advantage over the regulator in detecting offenses and may strategically use it to circumvent regulatory objectives. The theoretical model, which mirrors the German NetzDG, introduces a novel aspect wherein the platform engages in cherry-picking, to opportunistically punish select users on the platform.[5] The platform's aim is to create an illusion of compliance with regulatory standards and avoid sanctions. By selectively punishing certain users, the platform reduces the likelihood of the regulator detecting violations and subsequently penalizing the platform. Cherry-picking is particularly harmful if the platform provides preferential treatment to users with large audiences whose contributions to the platform's profit are the largest, but whose offenses can cause the greatest societal damage.

Regulations, such as the NetzDG, that do not take cherry-picking into account can actually incentivize this behavior and decrease social welfare. To prevent cherry-picking, the regulator can implement a mechanism where the size of the fine depends on how the platform handles violations by users with small audiences compared to users with large audiences. The optimal schedule for sanctions can be nonmonotonic in the offenses the regulator detects on the platform. Specifically, the sanction may be higher when the regulator detects fewer violations on the platform. The reason is that from the regulator's point of view, there are two punishable actions: the offense by the user and the cherry-picking by the platform.

A key example of the phenomenon depicted by the model is Twitch's "do-not-ban-list." This list reveals that top streamers were given special treatment when it came to suspending their streaming accounts [Grayson, 2021]. Another example is the Twitter posts from the account of President Donald Trump. Despite frequently sharing highly controversial content, his account remained active for an extended period, only being suspended following the tragic events at Capitol Hill [Andrews, 2020]. When Twitter did suspend the account, its share

[4]See, for example, the court cases and rulings of Bolger v. Amazon, Loomis v. Amazon, and Reed [2023] for legislative changes.

[5]The idea that under certain liability regimes platforms may cherry-pick on what to remove (because risky) and what to maintain (because generating substantial revenues) first appears in Lefouili and Madio [2022].

price plummeted by 12%, causing an approximate instantaneous loss of 5 billion dollars to the platform [Theron, 2021]. This decline in revenue can be attributed to a decrease in platform visits and subsequent advertising income, given that the account boasted one of the largest follower bases worldwide. This example highlights the misalignment of private incentives with social ones, as platforms may hesitate to take action against top users, potentially causing substantial societal harm.

An alternative narrative to the model is the extent to which (social) media platforms' algorithms promote content that may be exploitative or harmful to certain groups. These algorithms prioritize content that generates higher engagement rates, such as views, comments, and likes, without necessarily considering the actual content of the message [Baluja et al., 2008]. As a result, the platform may promote content that titillates, shocks, enrages, divides, or is fake, aiming to exploit users' cognitive limitations [Bhargava, 2022, Rosenquist et al., 2022, Montag et al., 2019, Bhargava and Velasquez, 2021]. Fake news is a notable example of such content [Van Alstyne et al., 2023]. This issue's real-world implications are evident in recent legal proceedings. For instance, in Reynaldo Gonzalez v. Google, the plaintiff argues that Google's content promotion on its platforms contributed to the radicalization of individuals, and subsequent terrorist attacks, making the company liable for the harm caused in the Paris 2015 attacks [McCabe, 2023]. Similarly, Meta is facing a lawsuit for allegedly disseminating personal information that ultimately led to an individual's murder, despite receiving reports and requests for its removal [Perrigo, 2022]. In both cases, private incentives to promote harmful content may have outweighed the socially optimal level, resulting in significant societal harm.

The core of the theoretical model lies in the platform's cherry-picking behavior. The platform maximizes its profit by selecting which user's content to retain and which to delete if it does not adhere to the regulator's rules. Users are heterogeneous; higher type users generate larger revenue for the platform, leading to a significant revenue loss if their content is deleted. When subjected to a flat fine and with the regulator monitoring all content having been published[6] on the platform, the platform is incentivized to delete the content of low-type users to reduce the probability of the fine, while retaining top users' content to

[6]deleted or retained by the platform

boost revenue. Cherry-picking decreases social welfare if the platform removes content with positive social value, that is if the content of low types is socially valuable.[7] Increasing the fine exacerbates the platform's cherry-picking incentive, indicating that merely raising the fine does not solve the regulator's problem, contrary to classical crime models like Becker [1968].

The regulator can employ alternative strategies in overseeing the content on the platform in order to improve social welfare. Specifically, the regulator can focus only on content that the platform chooses to retain. However, this approach also has its inherent drawbacks. For one, the platform might deliberately eliminate content with positive social value without any repercussions. The platform could intentionally remove socially valuable content without facing any consequences. For example, YouTube curtailed the visibility of videos pertaining to the Hong Kong protests in 2019 [Oremus, 2019]. In a separate incident, Twitter, in 2022, suspended several journalist accounts at the behest of Elon Musk [Sayantani, 2022]. Furthermore, any inadvertent removals by the platform would remain unchecked by the regulator, leading to potential issues. In 2019, YouTube mistakenly purged numerous accounts and videos associated with cryptocurrency education [Danny Nelson, 2019].

Another approach is to condition the size of the fine on the user's type. For instance, failing to penalize a popular user results in a larger fine for the platform. Such type-dependent regulation has the potential to achieve the first best outcome ex post. However, this method also presents challenges. First, since the platform cannot pay infinitely large fines, the regulator needs to possess advanced enough technology to increase the expected fine. Achieving the necessary technological proficiency might be prohibitively expensive. For tasks like text reading where AI can be utilized, the marginal cost of technological enhancement might be relatively low. In contrast, especially for nuanced or audio-visual content, the marginal cost may remain high. Second, the regulator would need to anticipate the harm caused by violating content for each user type and adjust the fine accordingly, which could be challenging and potentially too costly.

Hence, I propose a mechanism that allows for user-type differentiation but only requires that the relative types of users be observed by the regulator. This approach effectively filters

[7]The social value takes into account the societal harm a violation causes and the cost of detection.

out cherry-picking. Thus, the regulator can impose a different fine depending on whether the platform retains the content of lower or higher type violators, or both. Importantly, the fine is steeper if the content of only higher type violators is retained, compared to retaining content from both types. The reason is that both the violating content and cherry-picking, which in this case means the concealment of high-type violating content, decrease social welfare.

The remainder of the paper is structured as follows: Section 4.2 introduces the related literature and presents empirical evidence supporting the concept of cherry-picking. The model is detailed in Section 4.3, followed by an analysis in Section 4.4. Section 4.5 proposes a strategy for regulators to counteract cherry-picking. Sections 4.6 and 4.7 discuss potential extensions and further applications, respectively. Finally, Section 4.8 concludes the paper.

4.2 Related Literature

This paper contributes to the existing literature on online platform governance as well as the law and economics of crime and torts. Additionally, the model introduced in this paper falls within the scope of principal-supervisor-agent type models.

Online platforms

The economic effects of introducing liability of online platforms were first analyzed in non-formalized studies Buiten et al. [2020], Lefouili and Madio [2022]. My paper provides a formalized model building on some of the economic insights also mentioned in the non formalized studies, such as the notion of cherry-picking. The closest models to mine are developed by Liu et al. [2022] and Madio and Quinn [2023]. They study platforms' incentives to engage in content moderation under the two prevalent business model for revenue source, advertising and subscription. The main overlapping feature of their model with mine is that the platform uses content moderation to increase revenue and may not have incentives to improve the technology/moderate (some) users. In other words, content moderation does not merely depend on technological capabilities but also on economic incentives. The main novelty of my paper is to look at how regulations change economic incentives of the platform

and hence the policing strategy the platform implements.

Jiménez Durán [2022] studies the incentives of social media platforms to enforce regulations and ban users for toxic content. The platform monetizes users' participation with ads and trades-off users' engagement from both safe and unsafe content. As a result, the platform moderates toxic content to the extent to which it raises advertising revenues. The tradeoff is similar to the one presented in this paper, however I focus on endogenizing the regulation and allow the platform to strategically react to it.

Wu [2024] examines two channels used by content creators to disseminate unsafe content: a well-known channel that is easier for regulators to monitor, and a secret channel accessible only to sophisticated consumers and challenging for regulators to oversee. The study reveals that increased regulatory stringency, such as censorship, may inadvertently shift communication from the open to the secret channel, potentially causing greater harm. The key distinction in my paper is the endogenization of regulation, while also considering the platform as a strategic player. Additionally, my model offers a more generic interpretation of social welfare, enabling a more comprehensive analysis of the regulator's choice.

A larger body of literature focuses on copyright violations and liability policies, more specifically how liability regimes change the incentives of the platform for monitoring and eventually the content available on the platform [Beard et al., 2018, De Chiara et al., 2021, Landes and Lichtman, 2003]. Notably, Jeon et al. [2022] considers a tradeoff similar to the one in this paper: low-quality merchants (including intellectual property rights infringers) might increase the platform's sales and hence revenue, and therefore, the platform may not have incentives to monitor and delist the IP infringer merchant.The primary distinctions in my paper are the platform's strategic removal of individual users' content and the assumption that copyright violations are not expected to result in significant social harms.

Law and economics literature of crime and liability

Becker [1968] starts the economics literature of crime with the model in which the offender realizes a gain from the violation. In my model, however, (part of) the gain is not realized by the offender but by the platform. The main difference stems from the detection incentives and technology. The platform has an incentive to cover the violation of the user, hence, the technology is not only endogenous to the regulator's choices but also to the platform's

choice. That is, the platform is not a benevolent public enforcer.

The platform acts as both the beneficiary of the user's output but also as the private enforcer of the law. Becker and Stigler [1974]argue for private enforcement over public enforcement, especially on the basis of aligned incentives and cost effectiveness. The idea of this paper challenges this view, as the private enforcer's incentives may not be aligned to social the optimal one, moreover, the private enforcer is subject to different constraints. Polinsky [1980] compares private and public enforcement of fines. However, his model does not involve the main friction of this paper, that is the private party may not want to enforce the law.

The paper also relates to the vicarious liability models started by Sykes [Sykes, 1981, 1984, 1988] and Kornhauser [1982]. The main difference, however, is that the contract between the platform and the user is standardized, the platform cannot internalize the regulation in the contract. The closest paper to mine that models vicarious liability is Arlen and Kraakman [1997], in particular the extension of adjusted quasi-strict liability. Adjusted quasi-strict liability is a strict liability regime with the sanction the firm, or in this case, the platform, faces varying depending on whether the firm reports the wrongdoing of the user. The regime implemented in my model is also an adjusted quasi-strict liability regime, with the fine being 0 if the platform reports/removes the violations itself.

Principal-supervisor-agent models

The model also relates to the literature on principal-supervisor-agent (PSA) theory that was started by Tirole [1986] with the idea of including a supervisor in the standard principal-agent model. The supervisor's role is to obtain more information about the agent's activity than the principal could do. The emphasis of the PSA literature is on the potential collusion between parties, especially between the supervisor and the agent, and what the optimal contract the principal offers is. This paper's model can be interpreted as a special case of such models where the principal is the regulator, the supervisor is the platform, and the supervisor and the agent may collude. Note that one crucial difference between my model and PSA is that the supervisor does not directly work for the principal, therefore he cannot be offered a contract that could incentivize him for truth-telling. The regulators only have punishment (fine) under their disposal for disciplining, but no rewards.

Tirole and Laffont [1991] and Suzuki [2018] analyze a regulatory framework where the agent (firm) and supervisor (government or agency) can collude and falsify evidence reported to the principal (supranational regulator). In this setup, the regulator observes only an aggregate measure, such as air quality in Suzuki [2018], but not the specific type of the agent, which is similar to the approach in my model. The government may observe the firm's type and report it to the regulator. These papers investigate the optimal contracts between the regulator and government, and between the regulator and firm, in scenarios where collusion (side contracts between government and firm) is either impossible or possible. To ensure truthful reporting, the principal's problem includes an incentive constraint for the supervisor. My paper can be seen as addressing the scenario where this incentive constraint cannot be satisfied.

4.2.1 Empirical evidence for cherry-picking

4.2.1.1 Twitch's "Do-not-ban list"

In October 2021, an unprecedented leak of Twitch data occurred, revealing a list of streamers with the file name "do-not-ban-list" [Grayson, 2021]. This list suggested that top streamers were given special treatment when it came to suspending their streaming accounts. According to anonymous employees, Twitch's punishment mechanism worked as follows. Twitch administrators received reports against streamers who were believed to have broken the rules. Punishments for non-partnered streamers were decided by the administrators, whereas matters involving partnered streamers were escalated to a separate partner conduct team, which would issue warnings or make its own judgments [Grayson, 2021]. The "do-not-ban-list" served as a reminder to administrators that they could not decide on punishing certain streamers themselves and instead had to escalate the issue to other Twitch staffers or make exceptions to the rules.

Although the exact workings of Twitch's sanctioning mechanism were not revealed, this example illustrates the concept of cherry-picking. Top users on the platform (partners) were given exemptions when they violated the platform's rules because their contribution to the platform's revenue was deemed too important to just have them banned. Consequently,

different staff members made decisions about their potential sanctions based on guidelines that may have been different from those used for other users. Non-partnered users, on the other hand, could have been punished more quickly and with less contemplation by the administrators.

4.2.1.2 YouTube's take-down policy

Erickson and Kretschmer [2018] explores the factors that prompt copyright owners to request the removal of potentially infringing user-generated content. These measures, known as "notice-and-takedown", are available in the European Union through the Directive on Electronic Commerce (2000/31/EC) and under Section 512 of the U.S. Copyright Act. According to their findings, there is an inverse relationship between the number of views of a video and the likelihood that YouTube will remove it. Since views increase the revenue of the platform, the incentives of YouTube are similar to the platform's described in the model.

4.2.1.3 YouTube Partnership Program

In 2018, YouTube faced a significant crisis known as the "Adpocalypse," where a massive advertiser boycott highlighted the platform's content moderation challenges Nicas [2017], Alexander [2019]. As a response to this backlash, YouTube tightened the eligibility criteria for its partnership program. This adjustment led to a reduced number of users being able to monetize their content. As a result, videos without monetization were often sidelined by YouTube's algorithm in favor of content that generated more revenue for the platform Kumar [2019]. Additionally, the updated partnership program introduced a threshold for users to contest YouTube's monetization decisions, a move that disproportionately benefited larger users by giving them a unique privilege to appeal Patel Sahil [2017].

4.3 Model

4.3.1 Model Description

The model considers a social media platform with a large number of users, such as YouTube or Twitter. Users generate content for the platform. Each user (she), can choose between two actions when contributing to the platform: she can either comply with the rules set by policymakers (denoted by C) or violate them (denoted by V).[8] Each user has a type x, representing her popularity, such as the number of followers or subscribers. The user population has a probability density function $g(x)$, a cumulative density function $G(x)$, and a support range $x \in [0, 1]$. Additionally, the pdf satisfies $g'(x) \leq 0$ that is there are weakly fewer higher type users than lower type ones. The continuous support captures the vast number of users on these platforms. A user with type x generates revenue for the platform $I(x, A)$,[9] where the action A can be either compliance or violation.[10] Content that violates the rules results in harm, $h_p(x, V) > 0$, to the platform. However, the net profit (revenue minus harm) from such content, represented by $r(x, V) = I(x, V) - h_p(x, V)$, can be either positive or negative. For tractability, I assume that $r(x, V)$ is either monotonically increasing or monotonically decreasing based on the user's type across the entire domain:

$$\frac{\partial r(x, V)}{\partial x} > 0 \quad \text{or} \quad \frac{\partial r(x, V)}{\partial x} < 0 \tag{4.1}$$

Violations cause societal harm. This harm is a result of users breaching legal standards or societal norms. Recent studies, such as Jiménez Durán et al. [2022], Müller and Schwarz [2021, 2023], Olteanu et al. [2018], Bursztyn et al. [2019], have underscored the connection between online behavior on social media platforms and real-world criminal activities. Neither the platform nor the user internalizes the social harm caused by violations. A notable in-

[8] According to the Digital Services Act, illegal content is defined as "any information that, in itself or in relation to an activity, including the sale of products or the provision of services, is not in compliance with Union law or the law of any Member State which is in compliance with Union law, irrespective of the precise subject matter or nature of that law." (Article 3h)

[9] The platform's revenue may come from advertising or subscription fees; the model does not differentiate between them.

[10] Both YouTube and Twitch have both types of income sources.

stance of online actions leading to offline consequences is the events at Capitol Hill [Andrews, 2020]

This framework is reminiscent of classical liability models introduced by Becker [1962] and later expanded to encompass vicarious liability in works such as Polinsky [1980] and Arlen and Kraakman [1997]. In these models, as in this paper, agents' violations increase a principal's instantaneous income. A unique aspect of this model is the differentiation of users by their type, x, which determines revenue, rather than by wealth. Social welfare is represented by $W(x, A)$ with $W(x, V) = I(x, V) - h_p(x, V) + h_s(x)$ and $W(x, C) = I(x, C) - h_p(x, C) + h_s(x)$. Here, h_s denotes the societal value of the content, encompassing societal harm, detection, and enforcement costs, as well as benefits like disseminating accurate news or educational material. The paper primarily concentrates on harmful content, hence generally focusing on $h_s(x) < 0$. Importantly, while the platform might favor a violation as the user's action if $r(x, V) > r(x, C)$, it could be the inefficient action if $W(x, V) < W(x, C)$. When the platform deletes a user's content, both the associated harm and revenue are negated.

The regulator monitors the actions of both the user and the platform. If violating content is detected on the platform, the platform can be subject to a monetary fine $f < \bar{f}$. However, if the platform correctly addresses the violation or if no violation took place, no fine is imposed. The fine is set endogenously by the regulator, however, it cannot exceed $\bar{f}$, the maximum fine the platform can pay. The regulator has a technological disadvantage in two dimensions. First, the regulator cannot monitor all content. Hence, violations can be identified by regulators with probability p, and I explore both exogenous and endogenous technology in my analysis in subsequent sections. Second, the regulator may be unable or unwilling to differentiate based on the users' type x. This assumption aligns with the already enacted regulation of the NetzDG since sanctions are not dependent on the type of the user.[11] In contrast, the platform can observe all the actions and the types of the users costlessly.

A key assumption of this model is that the regulator's sanctions are directed solely at the platform, not individual users. This approach aligns with prevailing regulatory practices.

[11] This assumption is relaxed in later sections.

The rationale behind this regulatory choice, although not explicitly stated by authorities, could stem from several factors. For instance, users may be spread across different countries and jurisdictions, complicating the identification of the appropriate regulatory body for enforcement. Furthermore, users often lack the financial means to pay substantial fines, making enforcement potentially more costly than the fines collected.[12]

The actions of the game are illustrated in the figure below.

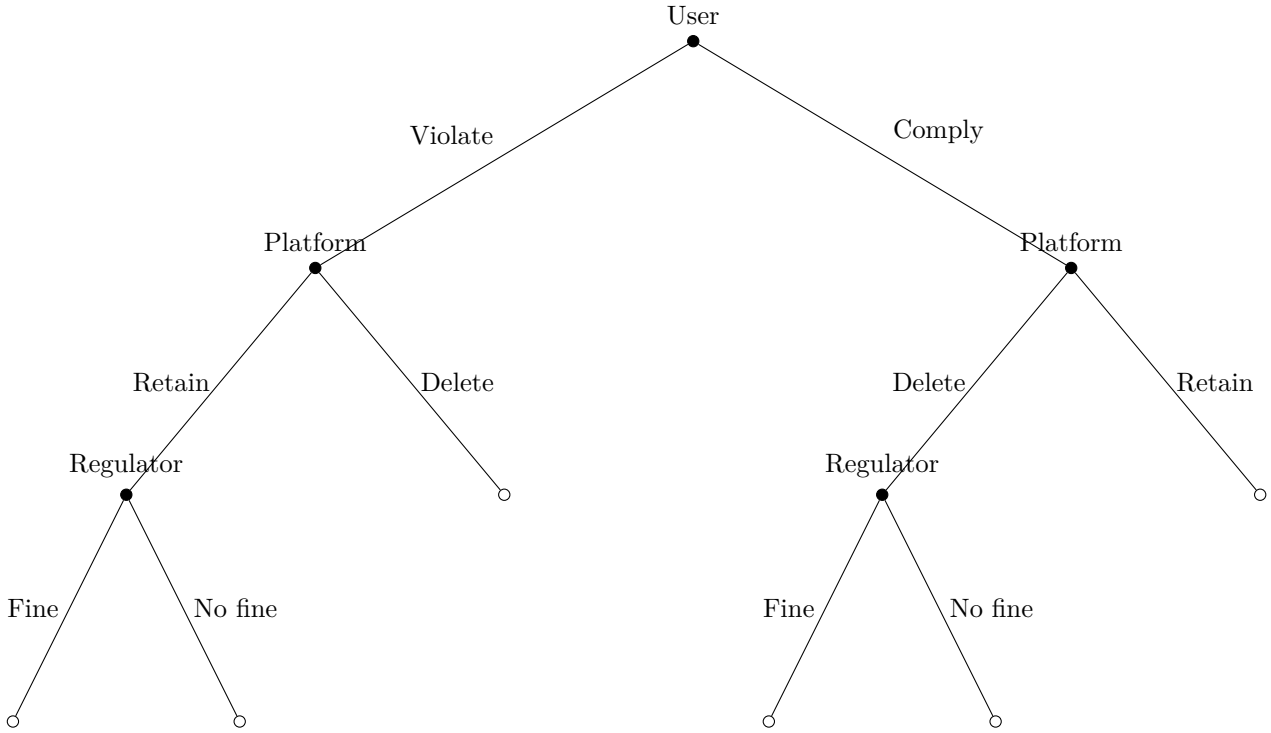


Figure 4.1: Decisions of the game

The timeline of the model is as follows.

t=0: Nature draws each users' type x which is privately observed by both the user and the platform.

t=1: The regulator sets the fine, f.

t=2: The users take action, they either violate or comply.

t=3: The platform observes the action of the users and decide which content to retain and which to delete.

t=4: The regulator samples from the platform and imposes a fine if a violation is detected.

[12] 4.6.3 examines scenarios where users are also subject to liability.

4.3.2 Comments on the model setup

4.3.2.1 NetzDG

The model setup resembles the legislative framework of the German Netzwerkdurchsetzungsgesetz (NetzDG), which was introduced in 2018 to combat hate speech on major social media platforms. Similar to the model, the rules of NetzDG involve imposing a penalty fee on platforms, regardless of the user's type, if violations are detected on the platform that the platform fails to remove appropriately and promptly.[13] However, one key difference between the NetzDG and the model is that in the model, users are not held liable for violations, whereas they may face a penalty fee under the NetzDG. This distinction is relevant in an international context, as individual liability may be difficult to enforce and costly, while individuals may lack the financial resources to pay monetary fines. Hence, the NetzDG stipulates that platforms may be subject to much larger fines than individuals. Individual liability is considered in section 4.6.3.

The enforcement mechanism of the NetzDG is not specified in the regulation. Users can report content they believe to be unlawful, and the platform has the discretion to delete or take no action on the reported content. If the regulator detects violations that are not punished by the platform, both the user and the platform may be held liable and subjected to a preset penalty fee. Unlike in the model, the NetzDG imposes fines on platforms for systemic failures rather than individual cases[14], and platforms may be subject to much larger fines than individual users. However, the exact mechanism by which user reports lead to sanctions on the platform is unclear.

4.3.2.2 Digital Services Act

The Digital Services Act of the European Union (DSA) introduces liability provisions for online platforms, primarily targeting large platforms, regarding third-party content, coming in full force by the 17th of February, 2024. Liability of individual users is not the main

[13]The penalty fee increases proportionally with the size of the social network platform size, as measured by the number of users, but not by the size of the individual user. Moreover, all the largest social media networks fall into the same category.

[14]Implementing systemic failures would keep the model qualitatively intact

focus of the DSA. According to Article 3(h), illegal content is defined as any information that does not comply with Union law or the law of any Member State that aligns with Union law, regardless of the specific subject matter or nature of that law. Under the DSA, platforms have the option of conducting voluntary content moderation (Article 7), where they independently investigate and take measures to detect, identify, remove, or disable access to illegal content. Consequently, platforms can be exempt from liability for hosting illegal activities or content if they promptly remove or disable access to such content (Recital 22). The model primarily emphasizes that platforms can avoid liability by engaging in voluntary content moderation, driven by the potential liability they may face. However, it is important to note that the Digital Services Act (DSA) includes additional measures to regulate online platforms. These measures encompass mandatory content moderation, the involvement of trusted flaggers, and independent auditing.

Mandatory content moderation The DSA establishes mandatory content moderation (Article 9), wherein platforms are required to take action against illegal content upon receiving an administrative or judicial order [Hoboken et al., 2023]. In this scenario, mandatory content moderation can be seen as a mechanism for regulators to observe the platform's actions regarding violating content directly. This is a less interesting part of the moderation policy, since the platform would comply by removing the illegal content in equilibrium to avoid having to pay the fine. Mandatory content moderation leaves out the part of the implementation on how the regulator may uncover the violations.

Trusted flaggers Articles 16 and 22 of the DSA establish that platforms must provide a mechanism for individuals or entities to notify them of potentially illegal content. In particular, notifications form the so called trusted flaggers must be dealt with without delay. One advantage of the system is that it allows multiple individuals to report the same content which could indicate that the content may be illegal with a higher likelihood.[15] However,

[15]Another advantage of the system of trusted flaggers is that the knowledge of experts is elicited in deciding what content is illegal. However, I do not explicitly model this in the model rather assume the regulator is the best expert.

content created by high type users tends to reach a larger audience, increasing the likelihood of it being reported. As a result, individual reporting ultimately relies on the regulator's ability to monitor and evaluate the platform's decisions regarding reported content. Consequently, the efficacy of individual reporting hinges on the regulator's capacity to monitor and assess the platform's responses to reported content, a facet embedded within the model's framework.

Independent audit Article 37 of the DSA stipulates that providers of very large online platforms and search engines are required to undergo independent audits, conducted at their own expense and at least once a year. In the model's context, this means that a private auditor replaces the regulator in assessing the platform's compliance. Hence the model remain unchanged if the auditor has the same incentives as the regulator. [16]

In summary, the mechanisms discussed ultimately center around the regulator's ability to monitor the platform's actions, an aspect highlighted in the model. Whether through voluntary or mandatory content moderation, involvement of (trusted) flaggers, or implementation of independent audits, the regulator has a pivotal role in overseeing and ensuring compliance with regulations.

4.4 Analysis

The analysis proceeds in several steps. First, I present a baseline scenario where the platform does not purposefully influence the probability that the regulator detects violating content on the platform. In other words, the detection probability is only a function of the regulator's actions. Subsequently, I allow the platform to influence detection by strategically choosing which content to retain and which to delete, engaging in cherry-picking. I consider both naïve users who have an intrinsic motivation to violate the rules and also strategic users who anticipate the action of the platform correctly with respect to the retention/deletion of their content.

[16] Arguably, the private auditor may not fully endogenize the external harm, hence the outcome may be worse from a social point of view than in the model.

4.4.1 Baseline model

In this scenario, the regulator varies a fine, f_p to incentivize the platform to delete violating content. Following the principles established by Becker [1962], increasing the fine, f_p is recognized as a more cost-effective strategy than enhancing detection technology p. This is because raising the fine incurs no additional costs, whereas improving technology demands costly investments. Consequently, I keep the detection probability, p constant in this analysis and only vary the fine, f_p.

For simplicity I assume that all users, irrespective of their type x, violate the rules, similar to Wu [2024]. Users derive no utility from these violations and face no liability for them. This assumption can be motivated by the fact that users may not consider how a policy change by a regulator alters the platform's incentives for content moderation, thus they are naïve. This assumption does not change the message of the baseline model and is relaxed later.

4.4.1.1 Deterrence

The payoff of the platform from retaining the content of a user with type x is

$$\pi(x, V, R, f_p) = I(x, V) - h_p(x) - pf_p, \tag{4.2}$$

where R denotes retaining the content. To simplify notation, I use $r(x, V) = I(x, V) - h_p(x)$, as the net income of the platform.

$$\pi(x, V, R, f_p) = r(x, V) - pf_p. \tag{4.3}$$

If the platform deletes the content, denoted by D, the payoff is 0.

$$\pi(x, V, D, f_p) = 0 \tag{4.4}$$

Hence, the platform retains content if $r(x, V) - pf_p > 0$. The platform's overall profit is

$$\pi(x, V, R, f_p) = \int_V r(x, V)g(x)dx - p\int_V f_p g(x)dx. \tag{4.5}$$

The regulator does not make the fine, f_p a function of the type of the user. The fine does not enter the welfare function directly since that is a transfer between the platform and the regulator. Denote the welfare function with W.

$$W(x, V, f_p) = \int_V r(x, V) + h_s(x)g(x)dx. \tag{4.6}$$

Consider that for some x, $r(x, V) > 0$ and $W = r(x, V) + h_s(x) < 0$ holds, meaning the platform benefits from retaining the content of some users on the platform, however, the content is harmful, $h_s(x) < 0$ with $r(x, V) < -h_s(x)$, once societal harm is considered. For example, such content, like fake news tweets, engages readers and increases their time on the platform, allowing for more advertisement exposure and boosting the platform's revenue. However, this content causes societal harm due to the misinformation it spreads [Van Alstyne et al., 2023, Bhargava, 2022].

The regulator's objective is to set the fine so that it incentivizes the platform to remove content if it results in societal harm, $W(x) < 0$, and to retain content if it contributes positively to societal welfare, $W(x) > 0$. Moving forward, I differentiate cases based on the interplay between the platform's optimal decisions and the regulator's preferences, as determined by the functions $r(x, V)$ and $h_s(x)$. I assume that these two functions intersect at a single point. No intersection yields a trivial result, while multiple intersection can be fundamentally reduced to a combination of the subsequent two cases discussed.

Lemma 4.1. *If a violation of low types is efficient, the regulator either imposes the maximum fine or does not impose any fine.*

Proofs are in the Appendix.

Figure 4.2 depicts the above condition visually, with V_s and C_s denoting the socially efficient action. Hence, x_s becomes the socially efficient cutoff. In words, violating is a socially efficient action for low types, however, it becomes socially inefficient for the high types. A possible interpretation is that the social harm increases as the type of the user increases, outweighing the benefits, while the detection cost is constant, making it inefficient to detect violations of the lowest types. Note that the detection costs are embedded in $h_s(x)$. Since the platform's profit is increasing in type, large enough fines are required to

incentivize the platform to delete the content of higher types. However, a large fine also lead the platform to delete socially efficient content. If the regulator does not impose a fine, all users commit violations and the platform does not delete any of them. Under the maximum fine, the platform deletes all content, meaning the platform ceases to exist. Which extreme is optimal depends on how harmful the content is without any liability when all users are violating, that is, whether

$$W(x, V, 0) > W(x, V, \bar{l}) \tag{4.7}$$

Lemma 4.2. *If violation of high types is efficient, the first best outcome is achievable.*

$$f_p^* = \frac{r(x_s, V) + h_s(x_s)}{p} \tag{4.8}$$

Below graphic visually shows the condition.

Figure 4.2: Violation of low types is efficient

The fine is not type dependent, yet it induces the efficient outcome. The reason is that the fine needed to ensure the platform has sufficient incentives to punish type x_s is also large enough to deter lower types. This fine exceeds the revenue minus the harm due to the imperfect technology p. Furthermore, the state lacks the incentive to enhance the technology if it can simply increase the fine, a notion consistent with the early findings of Becker [1968].

4.4.2 Cherry-picking

In this section, the platform responds to the regulator's enforcement strategy by strategically deleting content from users on the platform. This approach is adopted to reduce the likelihood of incurring fines. Consequently, the effectiveness of enforcement hinges on the actions of both the regulator and the platform. The regulator conducts random checks on content published on the platform, which may or may not be available at the time of review, and imposes fines for any violating content that the platform has retained. Additionally,

the regulator examines content that the platform has already removed to ensure that benign content is not being unjustly deleted.

The regulator's strategy is characterized by (n, f_p), where n denotes the number of users sampled, and $f_p(\cdot)$ represents the fine structure. In the simplest scenario, the regulator samples once and imposes a fine if a violation is found in content that the platform failed to delete. This approach, which I term 'uniform regulation,' is akin to the policy outlined in Germany's NetzDG. Proceeding with the assumption that all users are violators, the probability of the platform receiving a fine is determined by the ratio of the mass of retained content to the total mass of users. Therefore, the likelihood of the platform being fined is

$$p = \frac{\text{mass of violators}}{\text{mass of participants}} = \int_V g(x)dx \tag{4.9}$$

that is the integral over the area(s) of violations, that is where the platform does not delete the violating content.

The profit of the platform for any arbitrary f_p is

$$\pi(x, f_p) = \int_V r(x, V)g(x)dx - \int_V g(x)f_p d(x) \tag{4.10}$$

Definition 4.1. ***Cherry-picking:*** *For violating users, if $x' > x$, the platform's action of deleting the content of user x while retaining x' is termed as cherry-picking.*

By cherry-picking, the platform selectively deletes content from users whose contribution to its profit is low, thereby reducing the likelihood of the regulator imposing a fine. This strategy is feasible because the regulator faces a technological disadvantage in preemptively identifying the users' types. Essentially, cherry-picking results in preferential treatment for higher type users, allowing them to commit violations that lower type users would be penalized for.

Proposition 4.1. *Uniform regulation with $f_p > 0$ provides incentives for cherry-picking under Case I, where violations of high type users are socially inefficient (figure 4.2).*

Since the regulator's fine is not conditioned on the user's type, the platform is incentivized to penalize users who contribute little to its profit, thereby reducing the chance of receiving

a fine. However, the platform retains the content of top users to maximize revenue. The platform, however, does not punish the top users to increase revenue. The higher the fine, f_p, the more incentive the platform has to decrease the mass of users who violate.

Next, consider how the regulator sets the optimal fine, f_p^*, and how the platform reacts in terms of the cutoff type x_p, that is the lowest type the platform keeps the content of.

Proposition 4.2. *If the violation is socially optimal for high types,*

$f_p^* = r(x_s, V)$ and $x_p^* = x_s$ are the optimal choices by the regulator and platform respectively, that is the first best outcome is achieved.

If violations by high type users are socially optimal, the first-best outcome can be attained by setting the fine as high as the platform's revenue at cutoff value x_s, or $f_p^* = r(x_s, V)$. This fine incentivizes the platform to remove content from users of type $x < x_s$ while retaining content from those of type $x > x_s$, achieving the first best outcome.

Proposition 4.3. *If the violation is socially optimal for low types,*

$$\begin{cases} f_p^* = 0 \text{ and } x_p^* = 0, & \text{if } W(x, V, 0) > W(x, V, f_p) \\ f_p^* = \bar{f}_p \text{ and } x_p^* = r^{-1}(\bar{f}), & \text{otherwise} \end{cases}$$

are the optimal choices by the regulator and platform respectively, and the first best outcome cannot be achieved.

When violations by top users are socially harmful, a uniform regulation where $\bar{f} > f_p > 0$ cannot be optimal because of cherry-picking. In order to minimize the probability of the fine f_p, the platform deletes content from users at the lower end of the type distribution, signaling "good" behavior, consistent with the good Samaritan approach highlighted by Buiten et al. [2020]. Such deletions reduce overall social welfare. Hence, the classical results of Becker [1968] that the regulator should increase the fine to improve social welfare does not hold in the current setup.

If violations by high-type users are efficient, setting the fine according to $f_p^* = r(x_s, V)$ solves the regulator's problem. Therefore, the subsequent sections of this paper focus on

the case where violations by top users lead to significant, and often offline, social harms, rendering them inefficient.

4.4.2.1 Strategic users

This section allows for strategic behavior by users (referred to as 'she'). Specifically, users decide whether to comply or violate rules based on their expected payoff. Under the assumption that violating content generates more revenue than benign content, conditional on being retained, the user's utility satisfies the following inequality:

$$U(x, V, R) > U(x, C, R) \tag{4.11}$$

If the user's content is deleted, her payoff is zero, i.e.,

$$U(x, A, D) = 0. \tag{4.12}$$

Consequently, the user receives the highest payoff if she violates and her content is retained. However, she prefers retained benign content over deleted violating content.[17] The augmented game's timing is as follows:

1. All players learn the type-distribution of the users on the platform.

2. The regulator publicly announces the fine f_p that the platform has to pay if violating content is uncovered.

3. Users sequentially choose whether they comply or violate the rules in the order of their type. The largest user moves first, then the second largest etc.

4. Platform decides which content to retain

5. Regulator samples randomly and imposes the fine f_p if violating content is found on the platform.

[17] Alternatively, the user might not derive benefit from compliant content but dislikes having her content removed. This scenario results in a qualitatively similar equilibrium.

Users observe the fine the platform may face and also the type of other users on the platform, hence they can calculate the payoff of all users and the platform. [18]

Lemma 4.3. *Users with high enough type, $(x \geq r^{-1}(f_p, V))$, violate the rules while the rest comply.*

Intuitively, users expect the platform to retain content from top users and delete content that violates rules from those at the lower end of the distribution. Anticipating the deletion of their content, users prefer to comply with the rules. Users thus self-sort into two groups: those who comply and those who violate rules but expect the platform to retain their content regardless. For the equilibrium characterization, denote with x_u the lowest type that violates.

Proposition 4.4. *In equilibrium, the optimal policy, f_p^* and the optimal cutoff value x_u^* are as follows*

$$\begin{cases} f_p^* = 0 \text{ and } x_u^* = 0, & \text{if } W(x, V, 0) > W(x, V, f_p) \\ f_p^* = \bar{f}_p \text{ and } x_u^* = r^{-1}(\bar{f}), & \text{otherwise} \end{cases}$$

Moreover, the platform retains all content.

The proof follows directly from proposition 4.3 and lemma 4.3. Comparing the equilibrium outcome to proposition 4.3, the same set of users' violations are retained. This is because both the users and the platform have similar incentives: they prefer violations from top users while disfavoring violations from the bottom. As a result, strategic users at the bottom do not commit violations and rather opt to publish benign content.

I continue the analysis under the assumption that users are not strategic for two reasons. Firstly, the information structure required to include them as strategic players is complex and unrealistic. Secondly, even if users were strategic, the equilibrium outcome would be similar, as demonstrated above.

4.4.3 Improving technology

The regulator's technology is characterized by the size of the sample, n, used for monitoring whether the platform deletes violating content. Therefore, enhancing this technology can

[18] The setup is similar to Halac et al. [2020] in which investors of different endowments observe the interest rates ex ante and may opt to invest in a risky project.

be achieved by increasing the sample size. However, an increase in sample size does not necessarily lead to a higher probability of imposing fines due to the platform's strategy of cherry-picking. To illustrate this point, consider a scenario where the regulator samples n times with replacement and imposes a fine on the platform if any violation is detected.[19] For simplicity, also consider that sampling is not costly.

$$\pi(x, f_p) = \int_V r(x, V)g(x)dx - n \int_V g(x)f_p d(x). \tag{4.13}$$

Lemma 4.4. *Improving the technology, that is increasing the sample size n, provides incentives for cherry-picking.*

The lemma echoes the findings of 4.1, illustrating a consistent pattern: as the regulator attempts to heighten the expected sanctions, the platform counteracts by intensifying its cherry-picking strategy. Consequently, enhancing the monitoring technology does not necessarily translate into a higher expected sanction for the platform.

4.5 Extending the regulator's strategy

To effectively counteract cherry-picking, the regulator must consider strategies beyond the random sampling from all user-generated content and the use of a uniform fine. This necessitates utilizing information about the types of users on the platform. While specific regulations like the NetzDG or the Digital Services Act do not explicitly mandate this strategy, its implementation appears necessary. The following subsection, 4.5.1, investigates the scenario where the regulator assigns in the sampling process, based on their types. Meanwhile, subsection 4.5.2 moves away from a uniform fine structure, introducing fines that vary depending on user type. Note that the solutions are not directly comparable since the regulator's choice set differs.

[19] Given the continuum of users, the choice of sampling with or without replacement does not alter the outcome.

4.5.1 Weighting users

It is plausible that the regulator possesses ex ante knowledge about the types of users, for example, based on the number of followers or subscribers a user has. Anticipating the platform's cherry-picking strategy, the regulator might design rules that place additional emphasis on auditing top users. Instead of selecting randomly from the user base, the regulator could implement an ex ante announced rule of selection, denoted as $w(x)$. This changes the probability of detection to:

$$p = \int_V w(x)dx, \tag{4.14}$$

Here, the regulator's preferred distribution $w(x)$ replaces the true population $g(x)$. The firm's profit then becomes:

$$\pi(x, f_p) = \int_V r(x, V)g(x)dx - \int_V w(x)f_p d(x), \tag{4.15}$$

The regulator's objective is:

$$W(x, V, C, f_p) = \int_0^1 r(x, V) + h_s(x)w(x)dx > 0, \tag{4.16}$$

In this scenario, the regulator has the ability to choose the function $w(x)$. By choosing a type-dependent weight, the regulator can achieve the first best in numerous ways. For example, consider the rule that the regulator only samples if the user has a large enough type, that is from $x > x_s$. The probability of a fine then becomes:

$$p = \int_{V|x>x_s} g(x)dx, \tag{4.17}$$

The firm's profit under this regulation is:

$$\pi(x, f_p) = \int_V r(x, V)g(x)dx - f_p \int_{V|x>x_s} g(x)dx, \tag{4.18}$$

Since the regulator never chooses users with $x < x_s$, the platform does not penalize these users, which is the efficient action. Here, cherry-picking means the platform penalizes users

when it is efficient to do so. However, unless the weights are sufficiently type-dependent, the regulator might still fail to penalize top users. A further challenge with this regulatory approach is the necessity to announce the weights ex ante to guide the platform's actions. Consequently, both the platform and users are aware of which users have a diminished (or potentially zero) chance of selection, which the platform could further exploit by overregulating, or individuals could oppose such regulation when the regulator announces that the decision on their content is not being monitored. Therefore, while weighting users might achieve the first best outcome, its implementation by a regulator seems improbable.

The model assumes that all illegal content is reported, as platforms are not liable until a third party flags the content. In reality, the frequency of reporting can differ; notably, content from more popular users may attract more reports. Nonetheless, under current regulations like NetzDG and DSA, a single report obligates the platform to respond. Since the model focuses on user content that generates revenue, it presumes popular enough users. Therefore, the assumption that the probability of at least one report of violating content is equal across types looks realistic.

4.5.2 Type dependent fine

The standard solution for optimal deterrence, provided by Becker [1968], is to set the fine high enough so that

$$f_p(x) = \frac{-h_s(x)}{p}. \tag{4.19}$$

In this case, the size of the fine depends on the type of the user, for example, on how many followers the user has or how many views the content has received.

The probability p represents the likelihood that the regulator audits a specific user's content. Given that the type distribution is modeled as a continuous variable, we have $\Pr(X = x) = 0$. Hence, consider that the regulator pools types together to create a discrete distribution with groups $x_1, x_2, ...x_n$. For instance, x_1 might represent the lowest percentile in terms of follower count, while x_{100} represents the highest. The optimal fine, (4.20), can then be rewritten as

$$f_p^*(x_i) = \frac{-h_s(x_i)}{p(x_i)}, \tag{4.20}$$

where i belongs to the set {1,2,3,...,n}. Given the potential for numerous groups x_i, the implementation of such regulation can closely approximate the first best outcome. However, this approach presents potential challenges. First, considering that the platform's maximum payable fine is $\bar{f}$, achieving the necessary technological proficiency might be prohibitively expensive. For applications like text reading where AI can be employed, the marginal cost of technological enhancement might be relatively low. In other contexts, especially when the content is nuanced or audio-visual, the marginal cost may remain high. As highlighted in previous sections, expanding the range x_i for a given fine $f_p(x_i)$ can lead to increased cherry-picking by the platform. Second, the regulator would need to anticipate the harm caused by violating content for each type x and adjust the fine accordingly, which could be challenging and potentially too costly.

One feature that a type-dependent regulation misses is that it does not explicitly anticipate the cherry-picking of the platform. The next section introduces a mechanism that incorporates such a feature.

4.5.3 Fines as a function of relative type

This section proposes a mechanism to mitigate cherry-picking by combining enhanced technology with the notion that the regulator possesses some information about user types on the platform. The enhanced technology allows the regulator to sample from the platform multiple times. To maintain a realistic and limited information requirement, consider the following mechanism: The regulator samples twice from the platform and observes not only the users' actions but also their relative types, i.e., which user's type is higher. This data might reflect the user's network size, indicated by metrics like the number of followers, subscribers, or views. Such information is publicly available on popular platforms like YouTube or Twitch. Essentially, the regulator aims to influence the platform's behavior to retain content from low-type users and delete content from high-type users, aligning with socially efficient actions, under the assumption that all users violate.

Under this information structure, the regulator can impose the following fines:

- f_1: the fine if the platform deletes the content of the lower type user but retains that of the higher type user, i.e., if cherry-picking is detected.
- f_2: the fine if the platform deletes the content of the higher type user but retains that of the lower type user.
- f_3: the fine if the platform does not penalize either user.

The subsequent graph illustrates full cherry-picking.

Figure 4.3: Full cherry-picking

$C_{p'}$ denotes the range where the platform deletes the content of the violating user, indicating compliance with the regulator's rules from the platform's perspective, while $V_{p'}$ denotes the area where the platform retains the violating content.

The platform's profit under full cherry-picking is

$$\pi_2(x'_p) = \int_{x'_p}^{1} r(x)g(x)dx - 2G(x'_p)(1 - G(x'_p))f_1 - (1 - G(x'_p))^2 f_3. \tag{4.21}$$

To decrease cherry-picking, the area with violations at the top, represented by $V_{p'}$, must be reduced. Consider the alternative strategy depicted in graph 4.4.

Decreasing cherry-picking means reducing the area with violations at the top, denoted by $V_{p'}$. Consider the alternative strategy depicted on graph 4.4.

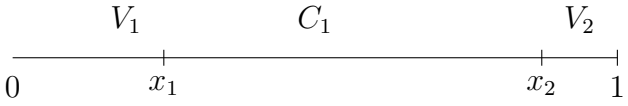


Figure 4.4: Decreased cherry-picking

The corresponding profit is

$$\pi_2(x_1, x_2) = \int_0^{x_1} r(x)g(x)dx + \int_{x_2}^{1} r(x)g(x)dx$$
$$- [G(x_1) + 1 - G(x_2)]^2 f_3 - 2[G(x_2) - G(x_1)](1 - G(x_2))f_1 - 2G(x_1)[G(x_2) - G(x_1)]f_2 \tag{4.22}$$

The objective function of the regulator is

$$\max_{l_1,l_2,l_3} W = \int_0^{x_p^*} r(x)g(x)dx + \int_0^{x_p^*} h_s g(x)dx \tag{4.23}$$

Lemma 4.5. *To alleviate cherry-picking, $f_1^* > f_2^*$ must hold.*

The fine must be larger if the user with higher type violates. This decreases the platform's incentive for cherry-picking.

Proposition 4.5. *To alleviate cherry picking $f_1^* > f_3^*$, must hold.*

While it may seem surprising to punish fewer violations with a higher fine, the reasoning is straightforward. From the regulator's perspective, two actions warrant sanctions. These are the user's violation and the platform's attempt to cover it through cherry-picking. Therefore, imposing a large fine when the regulator detects that content from a higher type user is retained while that of a lower type user is not, aims to disincentivize cherry-picking.

Alternatively, if the regulator prefers to stop violations at the top, that is

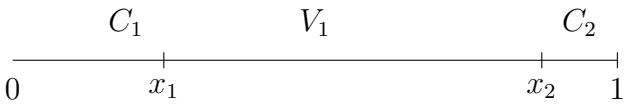


Figure 4.5: Decreased cherry-picking

Yields a similar condition on f_1, f_2, f_3 based on a similar argument.

4.5.4 First best with sufficiently high fine against cherry-picking (f_1)

Proposition 4.5 establishes the importance of imposing a sufficiently high fine f_1, that explicitly disincentivizes cherry-picking. The larger f_1 is, the larger is the expected punishment

for cherry-picking, therefore the platform engages less in it.

Consider that the maximum fine the regulator can impose, $\bar{f}$, is sufficiently high.[20]

The regulator's objective function is

$$\max_{f_1,f_2,f_3} W = \int_0^{x_p^*} r(x)g(x)dx + \int_0^{x_p^*} h_s g(x)dx \tag{4.24}$$

The regulator's objective to reach the first best outcome can be broken into two parts as follows. First, the platform must have incentives to punish violations by the top users.

The platform's profit under the behavior preferred by the regulator is

$$\pi_1(x_p) = \int_0^{x_p} r(x)g(x)dx - G(x_p)^2 f_3 - 2G(x_p)(1 - G(x_p))f_2 \tag{4.25}$$

The platform's profit under cherry-picking, however, is

$$\pi_2(x_p') = \int_{x_p'}^1 r(x)g(x)dx - 2G(x_p')(1 - G(x_p'))f_1 - (1 - G(x_p'))^2 f_3 \tag{4.26}$$

Second, the platform has to choose $x_p = x_s$ for the first best outcome to realize.

Proposition 4.6. *The optimal policy either reaches first best or there is underdeterrence in equilibrium.*

The regulator sets f_1 high to deter cherry-picking and assigns $f_2 = 0$, indicating no penalty if the platform behaves in line with the regulator's preference. The fine f_3 for allowing both violations is set to discourage cherry-picking and to guide the platform's behavior towards the desired outcome. Given that $f_3 < f_1$ needs to hold, setting f_3 too high could counteract the deterrent effect of f_1 on cherry-picking. If f_3 is lower than its optimal value, underdeterrence occurs because the platform faces a reduced expected fine. Conversely, over-deterrence is not a concern; if f_3 exceeds its optimal value, the regulator can simply reduce it while ensuring $f_3 < f_1$.

[20]It is common to assume that individuals have a finite wealth, see for example Polinsky and Shavell [1984]. Platforms, however, face astronomical fines in regulations, such as the GDPR.

4.6 Model extensions

In this section, I explore extensions to the model, accounting for users' intrinsic preferences to adhere to regulations and the platform's potential imperfections in detection technology.

4.6.1 Compliant agents

This part introduces that some users do not commit violations and comply with the rules. Content that complies with the rules and creates positive value for the platform and for society is efficiently kept on the platform. Therefore, I disregard this type of content. By doing so, the regulator's job is simplified, in other words, considering these content increases the incentives for cherry-picking. For simplicity, I assume that the net value from compliance to the platform is $r(x, C) = r_C < 0 \quad \forall x$, while the net social value is $s_C > 0$. Examples of compliant content being removed include YouTube's suppression of videos related to the Hong Kong protests in 2019 [Oremus, 2019] due to concerns about aggressive content discouraging advertisers. In late 2022, Twitter removed accounts of several journalists at the request of Elon Musk [Sayantani, 2022]. Moreover, in 2019, YouTube mistakenly deleted numerous accounts and videos related to cryptocurrency education [Danny Nelson, 2019].In terms of regulation, however, platforms are also not allowed to arbitrarily delete content [Global Freedom Expression, 2023]. [21]

If the regulator detects content that is not a violation but deleted by the platform, a fine of f_C is imposed on the platform. If violating content is found on the platform, the fine is f_V.

Consider that z is the fraction of compliant users. Denote with k the ratio of the benign content the platform decides to keep. The platform's objective is

[21] In Europe, social media platforms have to consider fundamental rights, shown for example by the cases Forza Nuova v. Facebook Ireland NTD and Ein Prozent v. Facebook Ireland Ltd [Global Freedom Expression, 2023]. In the US, Section 230 gives more opportunities to platforms to delete content they dislike, however, new laws are emerging there too, especially around censoring political candidates. See for example NetChoice v. Attorney General, State of Florida [Global Freedom Expression, 2023].

$$\pi(x, r_C, r_V) = z(kr_C - (1-k)f_C) + (1-z)\int_V r(x)g(x)dx - \Pr(f_V)f_V \tag{4.27}$$

Importantly, $\Pr(f_V) = \int_{x_p}^{1} g(x)dx$, just as before, and hence the same first order condition arises as in (4.13). The reason why the regulator monitors all content that is produced is now also explicitly shown. The platform has incentives to delete content that is not a violation.

The first order condition with respect to the compliant content is

$$z\left(\frac{\partial \pi(x, r_C, r_V)}{\partial k}\right) = z(r_C + f_C) = 0 \tag{4.28}$$

That is, the platform's problem has a corner solution. It keeps all the content if $f_C > -r_C$, and deletes all otherwise. The regulator hence sets up f_C so that the above inequality is satisfied and the platform keeps the benign content on the platform in equilibrium.

4.6.1.1 Policy

The regulator might weigh the harm caused by not removing harmful content against the harm of deleting benign content. Notably, the issue of cherry-picking can emerge when the regulator aims to address both simultaneously. By intending to oversee both existing and previously deleted content, the platform can strategically remove content based on the revenue it produces. Consequently, an alternative approach surfaces where the regulator concentrates solely on currently available content. Through this method, cherry-picking is eradicated, but at the expense of permitting the platform to delete any content they choose, thereby negating its social value.

By not monitoring the content that platforms remove, regulators effectively allow platforms to exclude any material they choose. If platforms foresee potential backlash from subscribers or advertisers regarding specific content, they might opt to remove it, even if it complies with their terms of service. This becomes particularly concerning given that a substantial segment of the population relies on digital platforms for news [Forman-Katz and Matsa, 2022].[22] Furthermore, evidence suggests that platforms might be motivated to censor

[22]Roughly 50% of Americans source their news from social media, as indicated by Forman-Katz and

certain content [Oremus, 2019]. Another point of contention is the potential lack of incentive for platforms to rectify errors, exemplified by YouTube's decision to remove educational cryptocurrency videos [Danny Nelson, 2019].

4.6.2 Platform's imperfect technology

This section reconsiders the assumption that the platform possesses the perfect detection technology for identifying violations. In practice, regulations like NetzDG account for potential inaccuracies in the platform's violation detection capabilities. As such, the regulator neither assumes nor demands that the platform's detection technology be perfect. Here, "technology" denotes the platform's capacity to precisely assess users' actions in alignment with the regulator's perspective.

4.6.2.1 Compliant agents

Consider that the platform's technology is imperfect, meaning the platform categorizes the users' content correctly with a probability less than 1. In essence, the platform only receives a signal about the action taken by the user, and the quality of the signal is independent of the user's type. Identifying a violation by a higher or lower type user is equally challenging for the platform. The efficacy of the platform's technology does not directly influence how users interpret the content. Rather, the technology serves to identify violations and helps the platform avoid sanctions from the regulator.

If the platform categorizes the user's content to be a violation, it is truly a violation with probability $\frac{1}{2} \leq q_V \leq 1$. Similarly, if the platform categorizes the content as compliance, it is correct with $\frac{1}{2} \leq q_C \leq 1$. Consider that the platform's income from benign content is $r(x, C) > 0$ with $\frac{\partial r(x,C)}{\partial x} \geq 0$.[23]

Lemma 4.6. *The platform cherry-picks, that is the platform does not delete the content if the type of the user is high enough.*

Matsa [2022].

[23]Both a constant revenue for the platform from the compliant users's content, like before, or a revenue function that is increasing in the type yield similar results. Allowing some of the benign content to yield negative revenue for the platform would also leave results qualitatively intact.

Proof follows in the text.

The platform's choice to retain violating content boils down to the inequality

$$\pi(x, V, q) = q_V \left[r(x, V) - pf_V\right] + (1 - q_V)r(x, C) > 0 \tag{4.29}$$

Given technology q_V, the platform retains the content of the user if her type is large enough, that is

$$q_V r(x, V) + (1 - q_V)r(x, C) > pf_V \tag{4.30}$$

Since $r(x, V) > r(x, C)\ \forall x$, the inequality is satisfied for high enough types. In particular, if the firm has the worst technology, $q_V = \frac{1}{2}$, the platform still retains the content of types for which $r(x, V) - r(x, C) > pf_V$ is satisfied. In other words, if the type of the agent is high enough, the platform is going to retain her content. The better the technology is, that is the more certain the platform is that the user's content is a violation, the higher the threshold becomes for cherry-picking.

Next, the platform is certain with q_C probability, if the user's content is categorized as compliance. The platform's profit is then

$$\pi(x, C, q) = q_C r(x, C) + (1 - q_C)[r(x, V) - pf_V] > 0 \tag{4.31}$$

Consider low types such that $r(x, V) - pf_V < 0$ is satisfied. Hence, the platform needs to be certain enough, that is q_C must be high enough for the platform to retain the content. Similarly to the violation case, if the type of the agent is high enough, the platform retains her content even with the worst technology.

4.6.2.2 Regulator's Sampling

I endogenize the regulator's technology in the usual manner, defining p as the ratio of the mass of violators to the mass of participants, i.e., $p = \frac{\text{mass of violators}}{\text{mass of participants}}$.

Proposition 4.7. *A better platform technology results in a platform that retains a few high-type violators and both high and low-type compliants.*

The proof is in the appendix.

Better technology reduces the platform's error's when evaluating both compliants and violators. In the case of compliants, improved technology lowers the threshold above which the user's content is retained. This implies that as technology advances, the content of lower-type users is also retained. Conversely, if the technology becomes more adept at detecting violators, only the highest type violators are retained, as only their contribution to the platform's revenue is substantial enough.

4.6.3 User liability

Consider a scenario where the regulator can identify and fine individual users, akin to regulations like NetzDG.[24] In this setup, the platform can avoid penalties by reporting content that violates regulations, thereby shifting the burden of fines f_u onto the individual users. However, the platform prefers to retain content rather than report it, as long as it can evade sanctions. This is because the platform generates revenue from user content. Consequently, top users anticipate that the platform will engage in cherry-picking, favoring their content in order to maximize revenue. To conclude, individual sanctions do not significantly alter the model's outcomes. Note that since the model deals with a continuum of types, each type x is drawn with 0 probability, so a formal analysis is not possible. The intuition, however, is straightforward to highlight, as done above.

4.7 Additional application

The European Commission put forward a proposal concerning supply chain liability in 2022, titled The Directive on Corporate Sustainability Due Diligence [European Comission, 2022]. This directive institutes a corporate due diligence duty and introduces liability for European businesses regarding violations occurring within their supply chains outside the European Union.[25]

[24] In a large, international context, such an assumption might seem unrealistic.

[25] `https://ec.europa.eu/info/business-economy-euro/doing-business-eu/corporate-sustainability-due-diligence_en`

In the context of supply chain liability, consider a scenario involving a regulator, a firm, and its suppliers. As previously discussed, the firm's profit increases when a supplier commits a violation, such as paying below the minimum wage to reduce production costs. The regulator inspects a supplier with an exogenous probability p, and, as in section 4.4.1, the firm's highest profit is associated with the greatest societal harm.[26] Mirroring earlier findings on cherry-picking, the firm optimally retains suppliers whose contribution to profit exceeds the potential sanction.

Improving the regulator's approach to monitoring is straightforward: in anticipation of cherry-picking, the focus should be on inspecting suppliers that contribute most to the firm's profits. Identifying these key suppliers could feasibly be achieved through the analysis of the firm's financial accounting.

4.8 Conclusion

Online platforms play an indispensable role in today's economic and social landscape. Yet, the increasing pressure on these platforms and their regulators to address illegal activities presents new challenges. This paper explores how regulators might enforce the liability of social media platforms for user-generated content. The theoretical model introduced here highlights 'cherry-picking', where platforms selectively penalize users to create an illusion of compliance and avoid sanctions. Cherry-picking becomes particularly detrimental when platforms favor users with vast audiences. While these users significantly boost the platform's profits, their offenses can cause considerable societal harm.

To counteract cherry-picking, regulators could devise a mechanism linking the severity of sanctions to how platforms address offenses from users with smaller audiences versus those with larger followings. The optimal schedule for sanctions might not follow a straightforward pattern based on the offenses the regulator identifies on the platform. Specifically, the sanction may be higher when the regulator detects fewer violations on the platform. This result arises because, from the regulator's perspective, there are two punishable actions: the offense committed by the user and the act of cherry-picking by the platform.

[26] Unlike in the platform scenario, the firm is unlikely to influence p

Another approach to curbing cherry-picking is for regulators to cease monitoring content deleted by the platform. However, this could lead to platforms deleting socially valuable content, either deliberately or accidentally, without any oversight or remedy from the regulator.

Appendix C

Appendix

C.1 Proofs

C.1.1 Proof of Lemma 4.1

Proof. First, consider that the maximum fine $\bar{f}$ is large enough, that is $r(1, V) < \bar{f}$. Since $\frac{r(x,V)}{x} > 0$, a larger fine is required to incentivize the platform to delete content created by higher types. Hence, a fine that results in deleting the content of types $x > x_s$ also yields deleting the content of type $x < x_s$. Therefore the problem of the regulator has a corner solution, and it is either optimal to impose the maximum fine or no fine at all. Second, consider that the maximum fine is not enough to incentivize the platform to delete content of the top users. The above argument still holds why an interior solution cannot be optimal. ■

C.1.2 Proof of Lemma 4.2

Proof. The profit of the platform for type x_s is

$$\pi(x_s, V, R, f_p) = r(x_s, V) - pf_p \tag{C.1}$$

Since the regulator's objective is to deter violations for types $x < x_s$, the optimal fine is

$$f_p^* = \frac{r(x_s, V) + h_s(x_s)}{p} \tag{C.2}$$

Under f_p^* the platform suspends only users with types lower than x_s. ■

C.1.3 Proof of Proposition 4.1

Proof. First, note that since the platform's profit increases in the type of the user while the regulator does not condition the fine on the type of the user, the profit of the platform can be rewritten as

$$\pi(x, f_p) = \int_R r(x, V)g(x)dx + \int_V r(x, V)g(x)dx - \int_V f_p g(x)d(x) \tag{C.3}$$

Where R denotes the region where the firm suspends the user. In that region, the revenue is 0.

The platform deletes the content of the users at the bottom of the type distribution while allowing violations at the top. Denote with x_p the largest type the platform deletes the content of. The platform's problem becomes

$$\max_{x_p} \pi(x, f_p, x_p) = \int_0^{x_p} 0dx + \int_{x_p}^1 r(x, V)g(x)dx - \int_{x_p}^1 f_p g(x)d(x) \tag{C.4}$$

The first order condition yields

$$\frac{\partial \pi(x, f_p, x_p)}{\partial x_p} = -r(x_p, V)g(x_p) + f_p g(x_p) = 0 \tag{C.5}$$

which can be rewritten as

$$r(x_p, V) = f_p. \tag{C.6}$$

The second order condition is also satisfied,

$$\frac{\partial^2 \pi(x, f_p, x_p)}{\partial^2 x_p} = g'(x_p)(f_p - r(x_p, V)) - g(x_p)\frac{\partial r(x_p, V)}{\partial x_p} < 0. \tag{C.7}$$

The interpretation of equation (C.6) is straightforward. The platform deletes the content of types whose contribution to the profit is less than 0, that is, for whom the fine is larger than the revenue from the content. That also means that an increase in fine decreases retention. Since the platform retains the content of the top users, cherry-picking is also increased with the larger fine.

$$x_p^* = r^{-1}(f_p, V) \tag{C.8}$$

■

C.1.4 Proof of Proposition 4.2 and 4.3

Proof. The problem of the regulator writes as

$$\max_{f_p} W(x, f_p) = \int_0^{x_p(f_p)} 0dx + \int_{x_p(f_p)}^1 [r(x, V) + h_s(x)]g(x)dx \tag{C.9}$$

The first order condition reads

$$\frac{\partial W(x_p^* f_p)}{\partial f_p} = g(x_p^*)\left[r(x_p^*, V) + h_p(x_s^*)\right]\frac{\partial x_p^*}{\partial f_p} = 0 \tag{C.10}$$

with $\frac{\partial x_p^*}{\partial f_p} = \frac{1}{r'(r^-1(f_p,V),V)}$. Hence to satisfy the first order condition for interior maximum,

$$r(x_p^*, V) = -h_s(x_p^*) \tag{C.11}$$

Combining (C.11) and (C.6) yields

$$f_p^* = r(x_s, V) \tag{C.12}$$

Note that the type for which the benefit and harms are equal is denoted by x_s. Hence it follows that the fine, f_p is set such that $x_p^* = x_s$

To check the sufficient condition the second derivative yields

$$\begin{aligned}\frac{\partial^2 W(x_p^*, f_p)}{\partial^2 f_p} &= \frac{\partial g(x_p^*)}{\partial x_p^*}\frac{\partial x_p^*}{\partial f_p}\left[r(x_p^*, V) + h_s(x_p^*)\right]\frac{\partial x_p^*}{\partial f_p} \\ &+ g(x_p^*)\left[\frac{\partial r(x_p^*, V)}{\partial x_p^*} + \frac{\partial h_s(x_p^*)}{\partial x_p^*}\right]\frac{\partial x_p^*}{\partial f_p}\frac{\partial x_p^*}{\partial f_p} \\ &+ g(x_p^*)\left[r(x_p^*, V) + h_s(x_p^*)\right]\frac{\partial^2 x_p^*}{\partial^2 f_p} \leq 0\end{aligned} \tag{C.13}$$

With $r(x_p^*, V) = h_s(x_p^*)$ the second order condition also becomes 0. However, inspecting the objective function yields a clear conclusion. If the violation is efficient for high types, $f_p = r(x_s, V)$ is the maximum of the objective. Low types for whom violation is inefficient are deterred, while high types are not. However, if violations of high types are inefficient, the above fine yields a minimum. Hence, the optimal fine has a corner solution, either allowing all users to violate or none of them. It depends on whether the platform generates social value if all users violate on the platform

$$W(x, f_p) = \int_0^1 r(x, V) + h_s(x)g(x)dx \geq 0 \tag{C.14}$$

■

C.1.5 Proof of Lemma 4.3

Proof. Given the information structure, the users can calculate the threshold on types, $x_p(f_p)$ the platform applies for retaining content. Hence, they correctly anticipate that if their type is lower than $r^{-1}(f_p, V)$ the firm would punish them. Therefore, in equilibrium, users self-select to be compliant if $x < r^{-1}(f_p, V)$ and to be violators if $x \geq r^{-1}(f_p, V)$. ■

C.1.6 Proof of Lemma 4.4

Proof.

$$\pi(x, f_p) = \int_V r(x, V)g(x)dx - n\int_V g(x)f_p d(x). \tag{C.15}$$

The first order condition reads

$$r(x_p, V) = nf_p \tag{C.16}$$

It follows that the larger n is, the higher the choice of the platform x_p is.

■

C.1.7 Proof of Lemma 4.5

Proof. Consider that $f_2 \geq f_1$. Take any choice of x_1 and x_2. By setting $V_p' = V_1 + V_2$, the platform's profit is always larger under full cherry picking. Hence, it follows that the regulator chooses $f_1 > f_2$. ■

C.1.8 Proof of Proposition 4.5

Proof. To simplify notation, I use $r(x, V) = r(x)$. Take a threshold y such that the revenue of the platform is equal under full cherry picking and decreased cherry-picking, that is

$$\int_0^{x_1} r(x)g(x)dx + \int_{x_2}^1 r(x)g(x)dx = \int_{x_2-y}^1 r(x)g(x)dx. \tag{C.17}$$

Hence y can be calculated from

$$\int_0^{x_1} r(x)g(x)dx = \int_{x_2-y}^{x_2} r(x)g(x)dx \tag{C.18}$$

The right handside is decreasing in y. The larger $r(x_2)$ is, that is equivalent the steeper the function $r(x)$ is, the larger y becomes. In other words, the more incentive the platform has to cherry pick, the smaller $x_2 - y$ is.

Intuitively, the larger the difference in the platform's revenue between high and low types, the larger y is, meaning a smaller increase in the violating area. Mathematically, since $r'(x) > 0$, $\Pr(x < x_2 - y) > \Pr(x_1 < x < x_2)$ that is

$$G(x_2 - y) > G(x_2) - G(x_1). \tag{C.19}$$

Moreover, $\Pr(x > x_2 - y) > \Pr(x > x_2)$, that is

$$G(x_2) > G(x_2 - y) \tag{C.20}$$

The probability of being fined with f_1 is $\Pr(f_1|\text{Fully cherry-picking}) = 2G(x_2 - y)(1 - G(x_2 - y))$ and $\Pr(f_1|\text{Decreased cherry-picking}) = 2(G(x_2) - G(x_1))(1 - G(x_2))$ under full-cherry picking and decreased cherry picking, respectively.

It follows from inequality (C.19) (C.20) that

$$\Pr(f_1|\text{Fully cherry-picking}) > \Pr(f_1|\text{Decreased cherry-picking}). \tag{C.21}$$

Similarly, $\Pr(f_3|\text{Fully cherry-picking}) = (1-G(x_2-y))^2$ and $\Pr(f_3|\text{Decreased cherry-picking}) = (G(x_1) + 1 - G(x_2))^2$. It follows form above that

$$\Pr(f_3|\text{Fully cherry-picking}) < \Pr(f_3|\text{Decreased cherry-picking}) \tag{C.22}$$

The platform may pay f_2 only under decreased cherry-picking.

Comparing the profit of the platform under the two strategies, (4.21) and (4.22) the platform prefers decreased-cherry picking if

$$\begin{aligned}
&(1 - G(x_2 - y))^2 f_3 + 2G(x_2 - y)(1 - G(x_2 - y)) f_1 \\
&\qquad\qquad \geq \\
&(G(x_1) + 1 - G(x_2))^2 f_3 + 2(G(x_2) - G(x_1))(1 - G(x_2)) f_1 - 2G(x_1)(G(x_2) - G(x_1)) f_2
\end{aligned} \tag{C.23}$$

.

Combining (C.23) with inequalities (C.21) and (C.22) yields that the regulator sets $f_1 > f_3$.

■

C.1.9 Proof of Proposition 4.6

Proof. The regulator's problem can be written as

$$\max_{f_1,f_2,f_3} W = \int_0^{x_p^*} r(x)g(x)dx + \int_0^{x_p^*} h_s g(x)dx \tag{C.24}$$

s.t.

$$\pi_1(x_p^*) \geq \pi_2(x_p'^*) \tag{C.25}$$

$$f_1, f_2, f_3 \leq \bar{f} \tag{C.26}$$

Under $\pi_1(x_p)$, the first order condition for the optimal cutoff point of the platform is

$$\frac{\partial \pi_1(x_p)}{\partial x_p} = r(x_p)g(x_p) - 2f_3 G(x_p)g(x_p) - 2f_2(1-2G(x_p))g(x_p) = 0 \tag{C.27}$$

and second order condition

$$\begin{aligned}\frac{\partial^2 \pi_1(x_p)}{\partial x_p^2} &= g'(x_p)[r(x_p) - 2f_3 G(x_p)g(x_p) - 2f_2(1-2G(x_p))g(x_p)] \\ &\quad + g(x_p)[r'(x_p) - 2g(x_p)f_3 + 2g(x_p)f_2] < 0\end{aligned} \tag{C.28}$$

Under $\pi_2(x_p')$, the first order condition for the optimal cutoff point is

$$\frac{\partial \pi_2(x_p')}{\partial x_p'} = -r(x_p')g(x_p') - 2f_1(1-2G(x_p'))g(x_p') + 2f_3(1-G(x_p'))g(x_p') = 0 \tag{C.29}$$

Increasing f_1 decreases the optimal choice $x_p'^*$, while increasing f_3 decreases it.

The second order condition is

$$\begin{aligned}\frac{\partial^2 \pi_2(x_p')}{\partial^2 x_p'^2} &= g'(x_p')[-r(x_p) - 2f_1(1-2G(x_p')) + 2f_3(1-G(x_p'))] \\ &\quad + g(x_p')[-r'(x_p') + 2g(x_p)f_1 - 2g(x_p)f_2] < 0\end{aligned} \tag{C.30}$$

The Lagrangian of the regulator is

$$\mathcal{L} = \int_0^{x_p^*} r(x)g(x)dx + \int_0^{x_p^*} h_s g(x)dx - \mu_0(\pi_2(x_p'^*) - \pi_1(x_p^*)) - \mu_1(f_1 - \bar{f}) - \mu_2(f_2 - \bar{f}) - \mu_3(f_3 - \bar{f}) \tag{C.31}$$

The first order conditions for an interior solution with $i = \{1, 2, 3\}$

$$\frac{\partial \mathcal{L}}{\partial f_i} = g(x_p^*)[r(x_p^*) + h(x_p^*)]\frac{\partial x_p^*}{\partial f_i} - \mu_0 \left(\frac{\partial \pi_2(x_p'^*)}{\partial x_p'^*}\frac{\partial x_p'^*}{\partial f_i} - \frac{\partial \pi_1(x_p^*)}{\partial x_p^*}\frac{\partial x_p^*}{\partial f_i} \right) - \mu_i = 0 \tag{C.32}$$

with complementary slackness conditions

$$\mu_0(\pi_2(x_p'^*) - \pi_1(x_p^*)) = 0 \tag{C.33}$$

$$\mu_i(f_i - \bar{f}) = 0 \tag{C.34}$$

First, note that f_1 only decreases the profit under π_2 but does not decrease the objective function W. Hence, by setting f_1 high the regulator can shift the incentives of the platform from cherry-picking to the higher social welfare option with profit denoted by π_1. f_2 only decreases the platform's profit under π_1, therefore it is optimal to set $f_2 = 0$. Substituting $x_s = x_p^*$ into (C.27) yields

$$r(x_s) = 2f_3 G(x_s) \tag{C.35}$$

or

$$f_3 = \frac{r(x_s)}{2G(x_s)} \tag{C.36}$$

Which is the first best value of f_3. However, this may not be achievable. Proposition 4.5 establishes that $f_1 > f_3$ and

$$\Pr(f_3|\text{Fully cherry-picking}) < \Pr(f_3|\text{Decreased cherry-picking}) \tag{C.37}$$

Since f_3 is constrained by f_1, the regulator may not be able to set f_3 high enough since that would countereffect the impact of f_1 on cherry-picking. From (C.27) it follows that a

lowering f_3 yields a higher threshold, x_p^* and hence under deterrence occurs. Overdeterence is not possible, since if f_3 is too high, the regulator would decrease it to the first best level, which must also satisfy (C.25).

■

C.1.10 Proof of Proposition 4.7

Proof. The platform's expected profit when all agents violate on the platform is

$$\pi(x, f_p, q_V) = \int_V q_V r(x, V) g(x) dx + \int_V (1 - q_V) r(x, C) g(x) dx - \int_{V_p} q_V g(x) f_p d(x) \quad \text{(C.38)}$$

As established in the previous section, the platform follows a threshold strategy, that is the platform retains the content only if the agent's type is high enough. Hence, the objective reads similar to (C.4).

$$\pi(x, f_p, q_V) = \int_{x_p(q_V)}^1 q_V r(x, V) g(x) dx + \int_{x_p(q_v)}^1 (1 - q_V) r(x, C) g(x) dx - \int_{x_p(q_V)}^1 q_V g(x) f_p d(x) \quad \text{(C.39)}$$

The first order condition writes

$$-q_V r(x_p, V) - (1 - q_V) r(x_p, C) + q_V f_p = 0 \quad \text{(C.40)}$$

Since $r(x, V) > r(x, C)$, the better the technology of the firm, represented by q_V, the higher the threshold, $x_p^*(q_V)$ becomes. The better technology means the firm is more certain than agent is violating therefore only contents of high types are retained.

Next, consider that all agents are compliant on the platform.

$$\pi(x, f_p, q_C) = \int_C q_C r(x, C) g(x) dx + \int_C (1 - q_C) r(x, V) g(x) dx - \int_C (1 - q_C) g(x) f_p d(x) \quad \text{(C.41)}$$

As established before, the firm follows a threshold strategy with compliants too. If the

the type of the agent is high enough, the platform retains her content.

$$\pi(x, f_p, q_C) = \int_{x_p(q_c)}^{1} q_C r(x, C) g(x) dx + \int_{x_p(q_c)}^{1} (1 - q_C) r(x, V) g(x) dx - \int_{x_p(q_c)}^{1} (1 - q_C) g(x) f_p d(x) \tag{C.42}$$

With first order condition

$$-q_C r(x_p, C) - (1 - q_C) r(x_p, V) + (1 - q_C) f_p = 0 \tag{C.43}$$

The threshold $x_p^*(q_C)$ becomes smaller the better the technology is. That is, the more certain the platform is that the users are complying with the rules, the more content the platform retains.

Finally, consider that with z probability all agents are violent, and with $1 - z$ probability all agents are compliant. [1] The platform's objective is then

$$\begin{aligned}
&\pi(x, f_p, q_V, q_C, z) = \\
&z \left[\int_{x_p(q_V)}^{1} q_V r(x, V) g(x) dx + \int_{x_p(q_v)}^{1} (1 - q_V) r(x, C) g(x) dx + - \int_{x_p(q_V)}^{1} q_V g(x) f_p d(x) \right] \\
&(1 - z) \left[\int_{x_p(q_c)}^{1} q_C r(x, C) g(x) dx + \int_{x_p(q_c)}^{1} (1 - q_C) r(x, V) g(x) dx - \int_{x_p(q_c)}^{1} (1 - q_C) g(x) f_p d(x) \right].
\end{aligned} \tag{C.44}$$

The objective yields identical first order conditions to (C.40) and (C.43), hence leads to the same result as previously. ■

[1] Similar is if z proportion of the agents are violent.

Chapter 5

Summary

English summary

This thesis consists of three articles, presented in Chapters 2 through 4. Below, I provide a summary of each.

Chapter 2: Non-competition Agreements and Dedicated Human Capital

How does the optimal stringency of a non-competition agreement (noncompete) vary with the employee's position inside a firm's hierarchy? I propose a theoretical model in which the employee's productivity increases with their position. A noncompete tilts the holdup power towards the firm. In equilibrium, employees in top positions are subject to a noncompete and the firm promises high compensation to ensure that they exert effort. Employees in middle positions are free from the covenant so that they maintain their incentives to exert effort for a lower wage. Strikingly, noncompete reappears at the bottom of the firm's hierarchy. Since the employees' productivity is low, their compensation does not incentivize effort. A policy prohibiting noncompetes for bottom positions can enhance social welfare if the expected quality of labor is moderate.

Chapter 3: Guarding Expertise and Assets: Non-competition Agreements and Their Implications

The degree of access granted to employees to a firm's critical asset is a pivotal organizational decision. This access can boost the employees' productivity within the firm but also enables them to become competitors after leaving, leading to a holdup problem. Economic theory suggests that non-competition agreements (noncompetes) can mitigate this issue. This paper examines the optimal compensation package for an employee, considering access, wage, and noncompete clauses. I demonstrate that firms compensate lower ability agents primarily through access, coupled with the minimum wage and strictest noncompete agreements since access not only increases the employee's utility but also the firm's production. For higher ability agents, the maximum degree of access is provided, while the wage and stringency of the noncompete depends on the damage the employee causes with competing. For low damages, the firm offers a lax noncompete with lower wages. Conversely, high potential damage necessitates higher wages and a stricter noncompete. The study's findings are consistent with observed patterns in CEO contracts.

Chapter 4: How to Enforce Platforms' Liability?

New regulations are emerging to address the increase of illegal content on online platforms, highlighted by initiatives like the Digital Services Act. This paper presents a theoretical model examining how such regulations shift the economic incentives for social media platforms to moderate user-generated content. The model focuses on a strictly liable platform with heterogeneous users who may breach the rules set by a regulator. The larger the audience of the user, the higher the benefit she brings to the platform, but also the larger the societal harm if she violates the rules. The paper argues that oversimplified regulations may worsen the problem of cherry-picking, where platforms penalize only low type users and not high type ones for violations. To combat cherry-picking, one option for the regulator is to stop monitoring content that the platform has already removed, but this could lead to over-moderation. Another strategy involves the regulator enhancing its technology to monitor more content and adjusting fines based on the ex post observable size of the audience of

users. Intriguingly, under this approach, the optimal fine might be reduced when more users commit violations.

Dutch summary

Titel: Essays in Recht en Economie

Hoofdstuk 2: Non-competition Agreements and Dedicated Human Capital

Hoe varieert de optimale strengheid van een concurrentiebeding ten aanzien van de positie van de werknemer binnen de hiërarchie van een bedrijf? Ik ontwikkel een theoretisch model waarin de productiviteit van de werknemer stijgt met zijn senioriteit. Een concurrentiebeding verschuift onderhandelingsmacht naar het bedrijf. In het evenwicht zijn werknemers in toppositities onderworpen aan een concurrentiebeding en om ervoor te zorgen dat werknemers zich inspannen betaalt het bedrijf hen hogere lonen. Werknemers in middenposities zijn niet gebonden aan het convenant, en behouden derhalve hun prikkels om zich in te spannen voor een lager loon. Opvallend is dat het concurrentiebeding weer van toepassing is aan de onderkant van de bedrijfshiërarchie. Aangezien de productiviteit van de werknemers laag is, geeft hun beloning geen prikkels voor inspanning. Een beleid dat concurrentiebedingen verbiedt voor posities onderaan de bedrijfshiërarchie kan de sociale welvaart verhogen als de verwachte kwaliteit van arbeid laag is.

Hoofdstuk 3: Guarding Expertise and Assets: Non-competition Agreements and Their Implications

De mate waarin werknemers toegang hebben tot de kritische activa van een bedrijf is een cruciale organisatorische beslissing. De toegang hiertoe kan de productiviteit van de werknemers binnen het bedrijf verhogen, maar stelt hen ook in staat om concurrent te worden na hun vertrek, wat leidt tot een 'hold-up probleem'. De economische theorie suggereert dat concurrentiebedingen dit probleem kunnen verlichten. Dit artikel onderzoekt de optimale compensatiestructuur voor een werknemer, rekening houdend met toegang, loon en concurrentiebedingen. Ik toon aan dat bedrijven laaggeschoolde werknemers voornamelijk compenseren door toegang, gekoppeld aan het minimumloon, en het meest stricte concur-

rentiebedingen, omdat toegang niet alleen het nut van de werknemer verhoogt, maar ook de productie van het bedrijf. Hoger geschoolde werknemers verkrijgen de maximale mate van toegang, terwijl het loon en de strengheid van het concurrentiebeding afhangen van de schade die de werknemer kan veroorzaken door te concurreren. Indien deze schade laag is biedt het bedrijf een laks concurrentiebeding aan met lagere lonen. Anders vereist een hoge potentië le schade een hoger loon en een stricter concurrentiebeding. De bevindingen van deze studie komen overeen met feitelijke observaties binnen CEO-contracten.

Hoofdstuk 4: How to Enforce Platforms' Liability?

Nieuwe regelgeving wordt ingesteld om de toename van illegale inhoud op online platforms aan te pakken, zoals blijkt uit initiatieven als de Digital Services Act. Dit artikel ontwikkelt een theoretisch model om te onderzoeken hoe dergelijke regelgeving de economische prikkels van social media platforms verandert om door gebruikers gegenereerde inhoud te modereren. Het model focust zich op een strikt aansprakelijk platform met heterogene gebruikers die de regels van een regelgever mogelijkerwijs overtreden. Hoe groter het aantal gebruikers, des te groter het voordeel voor het platform, maar dit vergroot ook de maatschappelijke schade indien de regels worden overtreden. Dit paper stelt dat overgesimplificeerde regelgeving het probleem van 'cherry-picking' kan verergeren, waarbij platformen alleen gebruikers van een laag type straffen voor overtredingen maar niet de gebruikers van het hoge type. Een mogelijkheid om cherry-picking tegen te gaan ishet stoppen van het monitoren van inhoud die het platform al heeft verwijderd door de regelgever.Dit kan echter ook leiden tot overmoderatie. Een andere strategie is dat de toezichthouder zijn technologie verbetert om meer inhoud te controleren en de boetes aanpast op basis van de ex post waarneembare omvang van het gebruikerspubliek. Opermkelijk genoeg kan de optimale boete binnen deze aanpak worden verlaagd indien meer gebruikers overtredingen begaan.

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