STAR WARS: EXCLUSIVE TALENT AND COLLUSIVE OUTCOMES IN LABOR MARKETS*

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Abstract. Exclusive employment contracts and collusion on wages are alternative mechanisms that firms may use to extract surplus from highly productive workers ("stars"). Exclusivity clauses (i.e., "non-compete clause") are common in many industries, but the Courts often refrain from enforcing them, citing harm to workers due to restricted turnover. We analyze the interaction between these two channels of surplus extraction and argue that in the presence of collusion, enforcement of exclusive contracts can, in fact, benefit the workers. We highlight the following trade-off: a strong enforcement of exclusivity restricts labor turnover but also hinders the firms' ability to sustain collusion in the labor market. The latter effect arises because enforcement of exclusivity increases the firms' punishment payoffs. We characterize the optimal level of enforcement and find that both perfect enforcement and no enforcement can be socially sub-optimal. Moreover, a stronger enforcement can improve matching efficiency by rendering collusion unsustainable, and may lead to a more equitable surplus distribution between the firms and the workers.

JEL Classification: J4, K21, L42, L14, M5.

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1. Introduction

The individual performance of a worker (or a small group of workers) often has a disproportionately large impact on his employer's profitability. The importance of such highly talented workers, or "stars," is well recognized in many industries, such as financial services, information technology, arts and entertainment, news media, professional team sports, etc. (see, for example, Rosen, 1981). Mutual fund managers widely vary in their ability to pick the right stocks, some artists become the key revenue generator for their production companies, and the viewership of a television news channel often depend on its panel of star commentators.

But talent is scarce. And even a talented worker needs substantial investments in human capital to reach his full potential. So, if a firm must invest in young workers with star potential *ex ante*, the firm must also ensure that it extracts the surplus generated by the worker if he becomes a star *ex post*. In his classic treatise on human capital, Becker (1964) argues that such an extraction of surplus is not feasible when all firms in the industry can compete to poach (or raid) a star worker. As competition dissipates all rents, the initial employer

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loses his returns on investment and, consequently, the investment incentives are muted.[1] In order to circumvent this problem, the firms often adopt one of the two policies: (i) implicitly committing to a "no poaching agreement" where all firms in the industry promise not to poach each other's star employees. (ii) Writing an exclusive contract with the worker that (if enforced by the Court) legally prohibits the worker from accepting employment at a rival firm.[2] The goal of our paper is to highlight the interaction between these two channels of surplus extraction and to explore the extent to which the Court should enforce the exclusive employment contracts.

Evidence of collusion among employers has been frequently documented both by the popular press as well as in the Court records. For example, in the 1980s several Major League Baseball teams in US were alleged to have colluded on their wage offers to the top players (Gius and Hylan, 1996). In the arts an entertainment industry, many of the big studios often bargain with the workers collectively as the Alliance of Motion Picture and Television Producers (AMPTP).[3] And more recently, the U.S. Department of Justice has opened an investigation on whether the leading information technology firms in U.S., such as Google and Apple, among other have made naked agreements not to hire each others' employees.[4]

Exclusivity clauses in employment contracts are also extremely common in many industries (see, Bishara, 2006; Garmaise, 2009). However, legal scholars have debated extensively on the efficacy of the exclusive employment contracts (Bishara, 2006; Gilson, 1999). Indeed, different states in the US have taken varied positions regarding the legal enforcement of such exclusivity clauses (see Malsberger (2004) for a state-by-state survey). Some states such as California and North Dakota have adopted an anti-"covenant not to compete" statute, whereas some states such as Massachusetts have held a very favorable view toward enforcing the exclusivity clause in employment contracts. This debate has primarily stemmed from the fact that the enforcement of exclusivity in employment contracts must face a trade-off between labor mobility (i.e., efficient matching) and human capital investment incentives (Bishara, 2006; Posner et. al, 2004).[5]

We contribute to this debate by highlighting a different trade-off associated with the exclusivity enforcement. We abstract away from the question of investment incentives and focus on the alternative mechanisms—exclusive employment contracts and collusion on wages—that the firms may adopt to capture the surplus that is generated once their worker turns out to be a "star".[6] The novel trade-off that we highlight is as follows: when the productivity of star workers depends on the firm specific matching, weak enforcement of the exclusivity clause ensures efficient matching but can also make collusion easier to sustain. In other words, while weak enforcement means that a worker is "freed" more often, a free worker is less likely to benefit from a competitive labor market; market collusion may still lead to inefficient turnover and lower wage offers. The latter effect originates because weak enforcement

[1] Also see Acemoglu and Pischke (1998) on why firms may still invest in general human capital in the face of adverse selection in the labor market.

[2] In the legal terms, such contracts are also known as "covenant not to compete."

[3] See, "Directors reach accord with hollywood studios," by Michael Cieply and Brooks Barnes, *New York Times,* January 18, 2008.

[4] See, "U.S. inquiry into hiring at high-tech companies," by Miguel Helft, *New York Times,* June 3, 2009.

[5] In the R&D–intensive industries such as Information Technology, the exclusivity employment clause may also work as a legal mechanism to protect trade secrecy (see Kräkel and Sliwka, 2009).

[6] Consider the following example from the Portuguese soccer league (see *Jornal a Bola*, March 22, 2007). In 2000, a soccer player, Zé Tó, started a legal process against his club, U. Leiria challenging the no-compete contract that Leiria had with him for the season. The case was eventually tried in the The Supreme Court of Portugal and in 2007 the Court subsequently declared all such no-compete contracts null and void. Immediately after the verdict, all the major clubs from the two major football leagues in Portugal met and publicly announced that they would not hire any player that decided to unilaterally breach contract with his current club.

of exclusive contracts decreases the payoff of a colluding firm on the punishment path (i.e., increases the punishment threat) should it deviate from the collusion.

We use the following stylized model to highlight the role of exclusivity enforcement on the firms' ability to sustain a labor market collusion. Two infinitely-lived firms hire a sequence of short-lived workers, where each worker lives for a "generation." There are two workers in every generation, and the two firms hire one worker each in every generation. Every generation has two periods. At the beginning of period one, both workers are *a priori* identical, but at the beginning of the second period only one of the two workers becomes a star. The identity of the star is publicly revealed. The productivity of a regular worker is normalized to zero. But a star worker's productivity is strictly positive, albeit, *a priori* unknown (it is revealed at the beginning of the second period in every generation). The uncertainty over a star's productivity stems from two sources: (i) the star's innate ability varies across workers (but follows a known probability distribution). (ii) A star worker's productivity also depends on the firm-specific matching. With a given probability, the star can be a better match with the rival firm. When hiring a worker at the beginning of period one, the firm may offer an exclusive contract. At the beginning of the second period, a worker under an exclusivity clause may attempt to void the exclusivity provision by legally "repudiating" the contract. The Court enforces such exclusivity clause with an exogenous probability.[7] If a star is no longer under the exclusivity clause, the rival firm may attempt to poach the star by making a take-it-or-leave-it wage offer. However, the firms may also implicitly agree not to raid each other, in which case the star always stays with his initial employer. Both workers leave the environment at the end of period two and a new generation of workers is hired. Both firms discount the future payoffs by a common factor δ.

We present three key results. First, we argue that the more likely the Court is to enforce an exclusivity clause, the harder it is for the firms to collude in the labor market (i.e., the minimum discount factor (δ) that sustains a "no-poaching" agreement between firms increases with the intensity of enforcement). The intuition behind this finding is as follows. Note that the exclusive employment contracts and collusion between firms in the labor market are substitute methods of appropriating the surplus created by star employees. In the presence of a collusion, exclusivity is often immaterial because firms agree not to compete for (non-exclusive) stars in the market. But if a firm deviates from the collusive agreement, both firms enter into a punishment phase where both firms compete in wages to hire a (non-exclusive) star employee. In such a punishment phase, the exclusivity clause is highly valuable to both firms because it is the only channel through which they can extract the surplus created by the star employee. Hence, on the punishment path, both firms will necessarily offer exclusive employment contracts to the worker. Thus, a firm's punishment payoff increases when the Court is more likely to uphold the exclusivity clause (recall that even on the punishment path the firms compete in the labor market only when a star's exclusivity contract is annulled by the Court). As the threat of future punishment decreases (i.e., the punishment payoff increases), collusion becomes harder to sustain.

[7]The likelihood that exclusivity is enforced may be subject to different interpretations. For example, the uncertainly over enforcement may represent the conflicting and changing legal attitudes toward exclusionary rights (see, e.g., Lafontaine and Slade, 2005). Another reason why enforcement might be uncertain is that the Courts may feel that stipulated damages depart too much from "reasonable" payments, thus dismissing them as inadequate or punitive and refusing to enforce them (see Edlin and Reichelstein (1996) and the literature cited there). Moreover, the contracting parties may not know whether the Court will use a specific standard for judging the benefits and harms due to such conducts. Finally, if the productive interaction between firm and star extends over many periods, one could interpret the probability of enforcement as the maximum duration of the exclusivity provision that courts are prepared to enforce. Any of these interpretations is well-suited to our theoretical framework.

Second, we characterize the socially optimal level of exclusivity enforcement. We find that both of the extreme views of perfect enforcement and no-enforcement can be socially suboptimal. Indeed, we obtain that the optimal enforcement level is an intermediate one, and that it increases with the firms' level of reputation concerns (i.e., the discount factor δ). The intuition is simple. Because both exclusivity and collusion lower social surplus by restricting efficient matching, the socially optimal level of enforcement is the minimum level of enforcement that renders the collusion between the firms nonviable.

Finally, we argue that even when collusion among firms is sustainable, a stronger enforcement of exclusivity clause can make the workers better off. The intuition is as follows. Note that when the star's productivity is *a priori* unknown, the firms may not be able to extract the entire surplus from the worker even on a collusive path. This occurs because a firm's gain from deviation from the "no-raiding" agreement increases with the productivity of the star the firm may attempt to poach. Therefore, the firms cannot sustain a collusion at a uniform wage. On the collusive path, even though there is no turnover, the initial employer must offer a higher wage to a star with higher productivity. Due to this reason a stronger enforcement of the exclusivity clause has two opposing effects on the workers' expected wage. A strong enforcement makes the collusion among firms harder to sustain. So, if the firms are to collude in an environment of strict enforcement, they must leave a larger share of the surplus to the "free" stars on the collusive path (otherwise, the temptation to cheat becomes too strong, and the collusion cannot be sustained). This effect increases the wage of a free star even when the firms are colluding. But under a strong enforcement, stars are freed less often. Thus, the star's initial employer is more likely to expropriate the entire surplus created by the star. Depending on the parameter values, the former effect may dominate the latter, making the workers better off (*ex ante*). An important implication of this finding is that the Courts' oft-cited argument that enforcement of exclusivity clauses harms the workers may be misguided.

Related literature: This article relates closely to the literature on collusion and the literature on exclusive employment contracts, and it attempts to bridge the two in a labor market context.

Starting from the seminal article by Stigler (1964), there is a vast antitrust literature on collusion among firms in the product market (see Jacquemin and Slade, 1989, for a survey; also see Green and Porter, 1984; Rotemberg and Saloner, 1986; and Athey and Bagwell, 2001). However, collusion in the labor market has received relatively less attention in the literature. An important exception is the sports industry, where several authors have studied the alleged collusion among the Major League Baseball clubs in the 1980s (Gius and Hylan, 1996; Vrooman, 1996). In contrast, the exclusive employment contracts have been studied extensively both by the legal scholars (Bishara, 2006; Gilson, 1999; Posner et. al, 2004; Rubin and Shedd, 1981) and by the labor economists (Burguet, et al., 2002; Franco and Mitchell, 2005; Kräkel and Sliwka, 2009).[8] But the literature on exclusive employment contracts has mostly focused on the role of such contracts in fostering investments in human capital and its implications on labor mobility. The impact of the no-compete covenants on the firms' ability to collude has so far been overlooked. In this article, we attempt to fill this gap.

It is important to note that several authors have emphasized other trade-offs that may arise in the context of exclusivity enforcement. Bishara (2006) notes that the exclusive employment contracts must balance the gains from higher investments in human capital with the loss of welfare due to restricted labor mobility (i.e., inefficient matching). This notion is

[8]The labor and the law literature on exclusive employment contracts is also closely related to the exclusive contracts literature in antitrust (see Posner, 1976; Aghion and Bolton, 1987; Bernheim and Whinston, 1998; Rasmusen et al., 1991.)

further developed by Posner et al. (2004) in a formal model. Kim (2007) discusses the role of non-compete clause in preventing predatory hiring. He argues that strong enforcement of such contracts can thwart predatory hiring where an incumbent raids an entrant's key employees only to induce the entrant's exit from the market. Kräkel and Sliwka (2009) highlight another cost of exclusive employment contracts: it can mute the workers' effort incentives by eliminating lucrative outside employment options that would have been available to a successful "free" worker.

Another article that is closely related with our work is that of Burguet et al. (2002). Burguet et al. examine the role of the no-compete clause when the firms compete for talented workers. They find that in the presence of complete information, firms set high buy-out fees to constrain the stars' mobility in order to extract the maximum rent from a more efficient rival. Similarly to the literature on compensation damages for breach of contract (Aghion and Bolton, 1987; Spier and Whinston, 1995), exclusive rights help the worker-employer coalition to capture a larger share of the surplus gains from turnover. Burguet et al. study the link between the level of transparency about the worker's ability and the use on exclusive rights as a rent-extraction mechanism. In contrast, we focus on the effects of the legal enforcement of the exclusivity clause on the extent of collusion in the market for talent.

The fact that exclusive contracts can affect collusion by influencing the firms' punishment payoff is also documented in the industrial organization literature (see, Allain et al, 2009).[9] In a related article, Nocke and White (2007) investigate the role of vertical merger in fostering upstream collusion. In their model, the role of vertical merger is somewhat similar to an exclusive contract with the downstream firm and they argue that such vertical merger can hinder upstream collusion by increasing the punishment payoff of the firms. However, these authors assume that the exclusive contracts are always enforced (a natural assumption in the product market context) and focus on the conditions under which exclusive contracts can hinder or facilitate collusion. In contrast, in a labor market context, the extent of enforcement of the exclusive contracts is under Court's discretion, and we highlight the trade-off between efficient matching and collusion that emerges with such enforcement. Moreover this trade-off is intrinsically different from the trade-offs explored in the existing literature in the product market context.[10]

Finally, our analysis of the sustenance of collusion in the labor market bears resemblance with the product market collusion model considered by Rotemberg and Saloner (1986). Similar to the setting considered by these authors, we consider an environment where the "state variable," i.e., the quality of the star, changes over time. This leads to the finding that the collusive wage is not stationary, and even on the collusive path, the firms may not be able to extract the entire rent from the worker.

The rest of the article is organized as follows: The following section presents the model and Section 3 characterizes the equilibrium. In Section 4 we discuss the impact of exclusivity enforcement on social welfare and distribution of surplus between the workers and the firms as well as across workers with varying productivity level. Section 5 discusses some robustness issues related to our key findings. The final section draws a conclusion.

[9] However, the primary focus of the exclusive contract literature in the antitrust context is on the role of exclusivity in fostering relationship-specific investments by the contracting parties (Segal and Whinston, 2000; De Meza and Selvaggi, 2007).

[10] Segal (2003) also examines the profitability of exclusive contracts and collusive arrangements, but in a completely different environment (i.e., cooperative coalitional bargaining). Also, this article does not analyze the link between the exclusivity enforcement and the sustainability of collusive outcomes, which is at the heart of our paper.

2. The Model

Players: We consider an infinitely repeated game with two infinitely-lived principals ("firms") F_1 and F_2 and a sequence of short-lived agents ("workers") who live for a "generation." In every generation t, there are two agents A_{1t} and A_{2t}. Each generation has two periods.[11] At the beginning of period one, each firm hires exactly one worker who is randomly chosen from the two. But in period two, a worker may switch from his initial employer to the rival firm. Without loss of generality, in generation t, we relabel F_i's hire in period one as A_{it}, $i \in \{1, 2\}$.

Stage game: The stage game is defined as the game played between the two firms and each generation of the workers (i.e., A_{1t} and A_{2t}). The stage game has two periods and can be described in terms of its five key aspects: *technology*, *contracts*, *contract enforcement*, *competition for talent*, and the *payoffs*. We elaborate below on each of these aspects.[12]

Technology: We assume that period one is the "training" period for a young worker where no production takes place. Once a worker is trained, production takes place in the second period.[13] The productivity of a worker depends on his talent or "type." While at the beginning of period one, both workers are *a priori* identical, a worker's type is publicly revealed at the beginning of period two (once his training is complete). Workers are of two types: "star" and "regular." In every generation, exactly one of the two workers becomes a star. This specification has two implications: (i) star workers are a scarce resource. In the labor market, there are more firms than "star" workers available for hire. (ii) Because a firm chooses its worker randomly, at the beginning of period one, both firms are equally likely to employ the future star.

In order to abstract from any potential moral hazard issue, we assume that no effort is needed for the production to take place. The productivity of a regular worker is 0 to both firms. But the productivity of a star is *a priori* unknown and depends on two factors: his innate quality v and a firm-specific matching factor m. We assume that $v \in [\underline{v}, \overline{v}]$ and follows a continuous distribution function $F(v)$. In every generation, at the beginning of period two, the identity of the star along with his productivity is publicly revealed. A star of quality v produces a value of v with his initial employer, but produces $v + m$ with the rival firm, where $m = \mu$ (> 0) with probability α, and $-\mu$ with probability $1 - \alpha$. In other words, a star is a better match with the rival firm with probability α, but is a better match with the initial employer with probability $1 - \alpha$. We assume that $\underline{v} > \mu$, i.e., even the lowest quality star always generates a strictly positive value regardless of the value of the matching gain m.

Contracts: At the beginning of period one, F_i $(i \in \{1, 2\})$ publicly offers A_{it} a take-it-or-leave-it employment contract. The contract offered by F_i is defined by a tuple (w_i, e_i), where w_i denotes the worker's wage to be paid at the end of the generation, and $e_i \in \{$*non-exclusive*, *exclusive*$\}$ represents the absence or presence of an exclusivity clause that forbids employment with the other firm during the worker's life span.

Assumption 1. *The workers are liquidity constrained.*

[11] We will denote the life span of a worker as a "generation" (indexed by t, $t = 1, 2, ...$) and a unit length of time within a generation as a "period."

[12] In what follows, whenever the time dimension does not play any specific role, we will suppress the time subscript t for the clarity of exposition.

[13] We do not explicitly model the exact training process in order to stay focused on our key trade-off between exclusive rights and sustenance of collusion. We simply assume that a young worker must receive "on-the-job" training in period 1 to become a productive worker in period 2.

This assumption is perhaps natural and realistic in our context, since it is virtually impossible for a young worker to borrow money in the market against his unverifiable talent potential. This assumption rules out any up-front transfers from a worker to the firm.[14] Two other important implications of this assumption are: (*i*) contracted wage $w_i \geq 0$; and (*ii*) only a star worker can generate a (strictly) positive surplus for his employer.

Contract enforcement: At the end of period one, the identity of the star is publicly revealed. If the employment contract of the new star includes an exclusionary clause, he may try to get around the exclusivity provision by legally "repudiating" the contract. We assume that the star undertakes a costless legal procedure to try to be released from his exclusivity clause. We assume that even when the exclusive clause is not enforced, the firm is still contractually obligated to pay the initial wage offer w_i if the worker stays with the firm.[15] Let $p \in [0, 1]$ be the probability that an exclusionary clause will be enforced by the Court of law. The enforcement probability is exogenous to the firms' decision as it depends, by and large, on the preexisting legal environment.[16]

Competition for talent: If an exclusionary contract is enforced, a star worker must stay with his current employer and earn the contracted wage w_i. Exclusive stars may not accept other firms' offers. But if a star is non-exclusive, either because his employment contract does not impose exclusivity or because the Court has voided the exclusivity clause, the worker is free to switch employer. If a non-exclusive star is available in the labor market, both firms can simultaneously make a take-it-or-leave-it offer, or "bid," for the star. We will denote the bid of F_i as b_i (≥ 0). If a worker A_{it} accepts the rival firm's bid, he forgoes the contracted wage w_i offered by his initial employer. But if the worker stays with his initial employer, he earns $\max\{b_i, w_i\}$. The worker chooses the firm that offers him the higher payoff. We assume that when facing identical payoffs from the two firms, a worker always leaves for the more efficient firm when the firms compete but stays with the initial employer when the firms collude.[17]

Payoffs: We assume that both the firms and the workers are risk neutral. The payoff of F_i in generation t, say π_{it}, depends on two issues: first, whether F_i's period-one hire, A_{it}, turns out to be the star or a regular worker, and second, whether F_i employs the star in period two. Note that F_i can employ the star in period two under three circumstances: (i) A_{it} is a regular worker but F_i successfully poaches the star from the rival firm, (ii) A_{it} is an exclusive star, and (iii) A_{it} is a non-exclusive star (i.e., either the period 1 contract was

[14]As we will elaborate in Section 3.1, the key trade-off between exclusivity enforcement and collusion disappears if the firms can extract the entire expected surplus from the worker through an up-front payment.

[15]We use this specification for analytical simplicity. However, in some cases, the Court may annul the entire contract when refusing the enforce the exclusivity clause. Our key findings continue to hold even under this setting.

[16]Note that under this modeling specification, the legal process of repudiating the contract is initiated by the star worker and the bidding takes place once the star is "freed" from his exclusive contract. In reality, one may expect that the worker seeks to annul the exclusivity clause only when he has an offer in hand from the raiders. Even in this setting, the key economic effects we highlight in this article continue to hold. See section 5 for a discussion on this issue.

[17]The assumption that the workers adopt different tie-breaking rules depending on whether the firms collude or compete is made entirely for analytical simplification. This assumption can be conceived as a limiting case of a scenario where the workers bear a job switching cost when changing employers but switch to a more efficient employer if her payoff *net* of the switching cost is the same with both firms. If there is a small switching cost (relative to the matching gains), under competition, the more efficient rival firm will outbid the inefficient initial employer. But under collusion, when both firms bid the same wage, it is strictly optimal for the worker to stay with his initial employer. The assumption above corresponds to the limiting case where the switching cost is arbitrarily small.

non-exclusive or the Court declined to enforce the exclusivity clause) and F_i successfully bids for him. Given that only a star worker produces a positive revenue for the firm, the firm's payoff in each of these scenarios can be derived as follows:

$$\pi_{it} = \begin{cases} -w_i & \textit{if } A_{it} \textit{ is regular and } F_i \textit{ does not hire the star in period two} \\ -w_i + v + m - b_i & \textit{if } A_{it} \textit{ is regular and } F_i \textit{ poaches the star in period two} \\ v - w_i & \textit{if } A_{it} \textit{ is an exclusive star} \\ v - \max\{b_i, w_i\} & \textit{if } A_{it} \textit{ is a non-exclusive star and } F_i \textit{ retains the worker} \\ 0 & \textit{if } A_{it} \textit{ is a non-exclusive star and poached by the rival} \end{cases}.$$

Finally, the payoff of A_{it} if he accepts F_i's contract offer in period one, say u_{it}, is:

$$u_{it} = \begin{cases} w_i & \textit{if } A_{it} \textit{ is an exclusive worker in period two} \\ \max\{b_1, b_2, w_i\} & \textit{if } A_{it} \textit{ is a non-exclusive worker in period two} \end{cases}$$

and 0 if he rejects F_i's contract offer.

Time line: The timing of the stage game is summarized as follows

- **Period 1.0:** F_i makes a take-it-or-leave-it offer (w_i, e_i) to A_{it}. If A_{it} rejects, he gets his outside option 0. If at least one worker accepts his corresponding employer's offer, the game goes on to period 2. Otherwise the game ends, and all players earn 0.
- **Period 2.0:** The identity of the star, his productivity (v) and the matching gain (m) are publicly revealed.
- **Period 2.1**: The star worker attempts to "repudiate" the exclusivity clause in the initial contract, if any.
- **Period 2.2**: Exclusive worker stays with his initial employer. A "free" worker may receive take-it-or-leave-it offers b_1 and b_2 from both firms, and leaves for the highest bidder.
- **End of Period 2**: Production takes place, wages (w_i and/or b_i) paid, and the game ends.

Repeated game: The repeated game is simply the stage game repeated in every generation. We assume that both firms have a common discount factor of $\delta \in (0, 1)$ per generation. So, the life-time payoff of F_i, say $\Pi_i = \sum_{t=0}^{\infty} \delta^t \pi_{it}$. Neither the firms nor the workers discount their payoffs across periods within a given generation.

Strategies and equilibrium: We will focus only on pure strategies for their analytical simplicity. The strategy of firm F_i has two components. Depending on the history of the game, in every generation, F_i decides (i) the contract (w_i, e_i) offered to A_{it}, and (ii) the bid b_i if there is a "free" star employee in period 2. In contrast, the strategy of A_{it} has three components: (i) whether to accept or reject F_i's offer in period one, (ii) whether to attempt to repudiate the exclusivity clause (if any) at the end of period one, and (iii) which firm's bid to accept at the beginning of period two (if there are any bids).

Because we are primarily interested in "collusive" equilibrium outcomes that permit firms to appropriate the surplus created by stars, we use *Subgame Perfect Nash Equilibrium in trigger strategies* as a solution concept. In the subgame following a defection from the collusion, the firms revert back to the (static) Bertrand-Nash equilibrium of the one-shot game.

Given the above description of the model, we now highlight how the enforcement of the exclusivity clause affects the sustenance of collusion among the firms.

3. Enforcement of exclusivity and sustenance of collusion

In this section, we explore the relationship between the level of enforcement of exclusive employment contracts and the firms' ability to sustain collusion in the labor market. The first step toward exploring this relationship is to characterize the solution to the stage game played between the firms and the workers in a given generation.

3.1. **Optimal contract in a stage game.** The stage game has a unique equilibrium where both firms offer exclusive contracts with an initial wage $w_i = 0$. In what follows we present the argument in two steps. We will first argue that under both optimal exclusive and optimal non-exclusive contracts, the initial wage $w_i = 0$. Then, we will compare the firms' payoffs from the optimal exclusive contract and the optimal non-exclusive contract to show that the former always dominates.

It is clear from direct inspection of firm's payoff function, π_{it}, that it is always non-increasing (and strictly decreasing in some cases) in the initially contracted wage w_i. This is due to the fact that by offering a high w_i, the firm is committed to pay a high wage in period two even when a lower wage would be enough to retain the worker. (This is the case, for example, when the worker becomes a regular worker in period two or when the worker becomes a star but is exclusive.) Thus, a firm can benefit from a high w_i offer only if it helps the firm to keep a star worker in period two as firms compete in wages to hire the star.

Note that when the star is free in the market and is a better match with F_1, i.e., $m = -\mu$, in equilibrium both firms bid $v-\mu$ and the star remains with F_1 which earns $v-(v-\mu) = \mu$.[18] So, the only case in which a firm, say F_1, is unable to retain a star worker in the bidding game is when the star is free in the market and the star is a better match with the rival firm F_2, i.e., if $m = \mu$. But in this case, F_2 can bid up to $v + \mu$ and profitably raid the star. So, if F_1 attempts to set w_1 high enough to ensure no turnover, then F_1 needs to set $w_1 > v + \mu$. But with such a wage F_1 is better off by letting the worker leave. Thus, irrespective of the presence or absence of the exclusivity clause, the firm is better off by setting $w_i = 0$.

Next, we argue that an exclusive contract (with $w_i = 0$) is optimal for firms. Before proceeding, note that when the initial contract specifies a wage of zero, the contract affects a firm's payoff only if its first period hire becomes the star. If the worker is of "regular" type, the firm's payoff from the worker is zero irrespective of whether the contract includes an exclusivity clause or not. So, to evaluate the optimality of an exclusive contract we can focus on a firm's payoff when its first period hire becomes the star.

Consider first the payoff of an exclusive contract. Suppose F_1 offers an exclusive contract with zero wage to worker A_1 in period one and that A_1 becomes a star with productivity v. If exclusivity is enforced, which occurs with probability p, F_1 retains the star and earns v on him. In contrast, if exclusivity is not enforced then both firms compete in wages. The equilibrium bids must be equal to the star's value at the firm where he is least productive. If the star is a better match with F_1 (i.e., $m = -\mu$), which occurs with probability $(1 - \alpha)$, both firms bid $b_1 = b_2 = v - \mu$, and the star remains with F_1 whose profit is $v - (v - \mu) = \mu$. But if the star is a better match with the rival firm F_2 (i.e., if $m = \mu$), which occurs with probability α, then there is turnover. Both firms bid $b_1 = b_2 = v$ for the star and the star

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[18] It is worth noting that there is a continuum of equilibria in the bidding subgame where both firms place identical bids b, and b can be any value between the highest and the lowest valuation of the star in the two firms (e.g., when the initial employer is a better match, any value of b between $v - \mu$ and v can be sustained as an equilibrium of the bidding game). However, it is more natural to consider the equilibrium where no firm submits a bid that is higher than its valuation for the star. Such an equilibrium is "trembling hand perfect" in the sense that if there is a small probability that the worker may mistakenly accept the inefficient firm's bid, then the firm is strictly better off by not placing a bid that is higher than its valuation for the star. Such an equilibrium also satisfies the "market-Nash" refinement of Waldman (1984).

joins the more efficient firm F_2. F_1's payoff in this case is zero. Thus, F_1's payoff from a star worker with productivity v under the contract $\{w_1 = 0,\ exclusive\}$ is

$$\pi_1^e(v) = pv + (1-p)(1-\alpha)\mu.$$

Consider now the payoff from a non-exclusive contract. Suppose that A_1 becomes a star with productivity v. In this case, the star is always free talent in period two and firms bid competitively in wages for the star. If the star is a better match for F_1 (i.e., $m = -\mu$), both firms bid $b_1 = b_2 = v - \mu$, F_1 retains the star and gets a payoff of μ. If the star is a better match with F_2 (i.e., $m = \mu$), both firms bid $b_1 = b_2 = v$ and the star leaves for F_2. Thus, the payoff from a non-exclusive star with productivity v is

$$\pi_1^{ne}(v) = (1-\alpha)\mu.$$

Since $\mathbb{E}(v) > \mu$, $\mathbb{E}\pi_1^e(v) > \mathbb{E}\pi_1^{ne}(v)$. Hence, the optimal contract in the stage game is an exclusive contract with wage $w_1 = 0$. Since firms are ex-ante symmetric, in equilibrium, both firms offer contract $\{w_i = 0,\ exclusive\}$. The expected payoff of F_i ($i \in \{1, 2\}$) in equilibrium depends on the payoff in case A_i becomes a star and on the payoff in case A_i becomes a regular worker. The payoff of F_i in case A_i becomes a regular worker is precisely $(1-p)\alpha\mu$. With probability (1-p) the rival's worker becomes a free star and with probability α the star is a better match for F_i. In this case, both firms bid v for the worker, the worker accepts F_i's offer who then gets $v + \mu - v = \mu$. Thus, the expected payoff of a firm F_i, in equilibrium is

$$\pi_*^e = \frac{1}{2}\mathbb{E}[\pi_i^e(v) + (1-p)\alpha\mu] = \frac{1}{2}\left[p\mathbb{E}(v) + (1-p)\mu\right]. \tag{1}$$

We complete the discussion of the stage game with the following observation: in our model, the firms do not incur any additional cost of writing exclusive contracts. That is, they do not incur any additional cost of eliciting exclusivity from workers in period one. This is due to the liquidity constraint on the workers. To see this, note that the liquidity constraint implies that F_i must leave rents to the worker. Indeed, in the second period, a worker is expected to earn $\frac{1}{2}(1-p)(v-(1-\alpha)\mu)$ under the optimal exclusive contract and $\frac{1}{2}(v-(1-\alpha)\mu)$ under the optimal non-exclusive contract. Thus, if there were no liquidity constraints on the worker, the firm could extract an up-front payment of $\frac{1}{2}(1-p)(v-(1-\alpha)\mu)$ while offering exclusive contracts and, even a larger amount, $\frac{1}{2}(v-(1-\alpha)\mu)$, while offering contracts with no exclusivity clause. This means that in the absence of liquidity constraints on the worker, there is a cost of eliciting exclusivity from a worker, which is precisely the difference between these two amounts, $\frac{1}{2}p(v-(1-\alpha)\mu)$. However, the liquidity constraint on the worker mutes this effect by ruling out any up-front payments, and both the exclusive and the non-exclusive contracts cost the same to the firms.

More importantly, the trade-off between exclusivity enforcement and collusion is relevant *only* when the firms cannot extract the value of a worker up front. If up-front payments from the workers at the contracting stage are feasible, the firms can appropriate the expected surplus through a suitable (signing-up) fee. Therefore, neither collusion nor exclusive contracts are necessary to extract surplus. As the gains from collusion evaporate, exclusivity no longer plays any role on the firms' ability to sustain collusion.

Note that this is why the liquidity constraint assumption is important in our model. The firms cannot impose a sign-up fee to extract surplus up front precisely because the liquidity constraints are binding for the workers. Indeed, in many industries where one observes the star workers, the entry level wages are order of magnitude lower than what the stars make (see, Rosen, 1981). For example, in United States, the minor league Baseball players are paid a few thousand dollars per month where as the star players in the major league commands a wage of a few million dollars. The same wage variation is also well documented in other sports such as National Basketball Leagues (Hausman and Leonard, 1997) as well as in entertainment industries such as popular music (Krueger, 2005). Moreover, a worker may find it difficult to borrow money against her future potential. These observations suggest that junior workers are most likely to face liquidity constraint rendering up-front surplus extraction infeasible.

3.2. **Collusive equilibrium in the infinitely repeated game.** Having characterized the optimal contract in the static game, we now investigate the repeated game where the two firms may tacitly agree not to compete for a free star in the labor market. That is, we look at a collusive equilibrium where F_1 refrains from poaching a free star who was initially hired by F_2, and vice versa. In what follows, we analyze the "best" collusive equilibrium of this game from the firms' perspective. That is, we characterize the collusive equilibrium that is associated with the lowest sustainable collusive wage offered to the free star.

First, consider the punishment payoff of the firm—that is, the firm's payoff if it deviates from the collusion. Under trigger strategies, following any deviation both firms revert back to playing the static Nash equilibrium of the stage game in every generation. Thus, from equation (1), one obtains that the continuation value of a firm when they play the static Nash equilibrium in every generation is (recall that $w_i = 0$ in the stage game equilibrium):

$$\underline{\tilde{\Pi}} = \frac{\delta}{1-\delta}\pi_*^e = \frac{\delta}{1-\delta}\frac{1}{2}\left[p\mathbb{E}v + (1-p)\,\mu\right]. \tag{2}$$

Note that $\underline{\tilde{\Pi}}$ is increasing in p. That is, a stronger enforcement of the exclusivity clause increases the payoff of the firm on the punishment path. As we will see below, this effect will have an important implication for the sustenance of the collusion.[19]

Next, we analyze the payoff of the firm on the most profitable collusion path. Here, the heterogeneity in a star's productivity introduces an important issue. When the star's productivity varies across generations, so do a colluding firm's gains from deviation. The gains from deviation increase with the star's productivity level. Therefore, if the firms attempt to collude on a uniform collusive wage regardless of the quality of the star, such a collusion may not be sustainable. But instead, the firms can attempt to collude on a wage schedule $w^C(v)$ that varies with the quality of the star.[20] Such a wage schedule can ensure that the firms'

[19] The analysis presented here relies on the assumption that the players use trigger strategies. Trigger strategies have been widely used when modeling long-term cooperation (see, for example, Baker et al, (1994) and Levin (2003) for applications in relational contracts and Tirole (1988) for applications in product market collusion). However, in general, such trigger strategies need not be the optimal punishment mechanism. As argued by Mailath et al (2006), in an extensive form stage game like ours, the optimal punishment can be more nuanced than a simple reversion to the static Nash equilibrium. While a complete analysis of the optimal punishment is beyond the scope of this article, we expect the key economic effects to continue to hold even under the optimal punishment. Observe that on the punishment path, it is always feasible for the firm to offer exclusive contracts. So, a sequentially rational punishment strategy must ensure that the continuation value of a firm on the punishment path is at least as much as the value the firms can get by offering the exclusive contract. Thus, a stronger enforcement of the exclusive clause may still increase the punishment payoff of the firm, leading to the same effect as discussed above.

[20] Two issues are important to note in regard to this formulation. First, as we will see below, in equilibrium, w^C also depends on the other parameters of the model, p, μ, and δ. However, for expositional clarity, we will suppress these arguments of w^C function except in cases where they are directly relevant for the discussion. Second, one may also consider a more general formulation where the firms collude on wages that not only

gains from deviation do not vary with the star's quality, and consequently, can facilitate collusion. We will elaborate on the derivation of the equilibrium $w^C(v)$ shortly.

In order to analyze the most profitable collusive equilibrium, we need to compare the firms' payoff from the (most profitable) collusive outcome with and without the exclusivity clause. First, consider the case where the firms offer exclusive contracts on the collusive path. Similar to the case of static game, under the optimal exclusive contract the firms offer a period-one hiring wage 0 to each generation of workers. In period two, under collusion, the firms refrain from competing for the star and both firms bid a collusive wage $w^C(v)$. As a consequence, the star always stays with his initial employer. Now, suppose in a given generation, F_1's hire turns out to be a star with quality v. The payoff of F_1 in this generation is $pv + (1-p)[v - w^C(v)]$ and the payoff of the rival firm F_2 is 0. As in every generation both firms are equally likely to hire the future star, the continuation payoff of the two firms in a collusive equilibrium is:

$$\tilde{\Pi}^C = \frac{\delta}{1-\delta}\frac{1}{2}\mathbb{E}\left[v - (1-p)w^C(v)\right]. \tag{3}$$

Note that a comparison of equations (2) and (3) implies that a firm's payoff under collusion is exactly equal to the (discounted) payoff of the firm in the absence of collusion if exclusive contracts are always enforced (i.e., when $p = 1$). This observation is intuitive because exclusion and collusion are two different mechanisms to ensure that the firm extracts the entire surplus from a star worker. However, as we will discuss below, the probability of enforcement of exclusive contracts governs the firms' ability to maintain their collusive behavior.

Now, for a given wage schedule $w^C(v)$, collusion is sustained if a firm's continuation payoff in equilibrium is at least as large as its payoff from the most profitable deviation. For any given v, the maximum immediate gains from deviation occur when the star is a better match with the rival firm, i.e., when $m = \mu$. In that case, the rival firm gains $v + \mu - w^C(v)$ when it deviates from the collusive path by making a take-it-or-leave-it offer to the star that outbids the initial employer by a penny. So, a collusive wage schedule $w^C(v)$ is sustainable in equilibrium if and only if $\tilde{\Pi}^C \geq \left[v + \mu - w^C(v)\right] + \underline{\tilde{\Pi}}$ for all v; i.e.,

$$\frac{\delta}{1-\delta}\frac{1}{2}(1-p)\mathbb{E}\left[v - \mu - w^C(v)\right] \geq \sup_v \left[v + \mu - w^C(v)\right]. \tag{4}$$

Thus, for a given δ, when firms use exclusive contracts, collusion can be sustained if there exists a wage schedule $w^C(v)$ that satisfies the above condition. Because we are interested in the most profitable collusive outcome for the two firms, $w^C(v)$ is simply the minimum wage the firms must bid for a free star of quality v such that the condition (4) is satisfied.

The analysis for the case where the firms do not use exclusive contracts on the collusive path is similar. In this case, the firms' payoff on the collusive path is $\delta\mathbb{E}\left[v - w^C(v)\right]/2(1-\delta)$, and a collusive outcome can be sustained as long as there exists a $w^C(v)$ schedule that satisfies the following "no deviation" constraint:

$$\frac{\delta}{1-\delta}\frac{1}{2}\mathbb{E}\left[(1-p)(v-\mu) - w^C(v)\right] \geq \sup_v \left[v + \mu - w^C(v)\right]. \tag{5}$$

depend on v but also depend on the realized matching gain m. As we will discuss later in Section 5, the qualitative nature of our results continues to hold even under this general formulation. In this section we abstract away from this general formulation for expositional clarity.

Note that for a given $w^C(v)$, a firm's payoff on the collusive path in the absence of any exclusive contract is less than its payoff when exclusive contracts are offered. Moreover, a given collusive wage schedule w^C is easier to sustain when firms use exclusive contracts on the collusive path (i.e., the condition (4) is weaker than the condition (5)).

The following proposition suggests that the firms can collude in equilibrium as long as δ is sufficiently large, and the firms will always prefer to write exclusive contracts even on the collusive path.

Proposition 1. *Given $p \in [0,1)$, there exists a value of δ, say $\tilde{\delta}(p)$, such that a collusive equilibrium exists if and only if $\delta \geq \tilde{\delta}(p)$. Moreover, in the most profitable collusive equilibrium, in every generation, in period one, the firms offer an exclusive contract with 0 wage; and in period two, firms bid $\tilde{w}^C(v)$ for a free star of productivity v, where*

$$\tilde{w}^C(v) = \begin{cases} 0 & \text{if} \quad v < v^* \\ v - v^* & \text{if} \quad v \geq v^* \end{cases},$$

and $v^* \in (\underline{v}, \overline{v}]$ depends on the parameters p, μ, and δ.

Proposition 2. *$\tilde{\delta}(p)$ is increasing in p.*

Propositions 1 and 2 have several important implications. First, they capture the key trade-off between exclusivity enforcement and collusion: as the probability of enforcement (p) increases, collusion becomes harder to sustain. The intuition behind this finding is as follows. Here, an increase in p has two effects. As discussed earlier, an increase in p increases a firm's punishment payoff. Thus, firms need to be more patient in order to sustain a collusion. But, there is also a countervailing effect. The level of enforcement (p) also increases the firms' payoffs on the collusive path, and collusion becomes easier to sustain. However, the former effect dominates because the marginal effect of enforcement in firms' payoffs is higher in the punishment phase than under collusion. Under the punishment phase, the firms have to pay the free stars their competitive wage whenever the exclusivity is not enforced. But under collusion, the firms only have to pay the collusive wage $w^C(v)\,(< v - \mu)$ if the exclusivity clause is not enforced. Thus, the marginal impact of p on the punishment payoff is higher than its impact on collusive payoff.

Second, note that the collusion can be sustained even if one assumes that a deviation from collusion can trigger immediately (i.e., in the period in which the deviation occurs) a bidding war. We have maintained the assumption that both firms make a take-it-or-leave-it offer to a free star. This is perhaps a natural assumption in our setting as it is in the interest of a raiding firm to ensure that the initial employer does not get to respond to its offer. If a deviation leads to an instantaneous bidding war that dissipates all surplus, the collusion is always sustainable and the trade-off between exclusivity enforcement and collusion disappears. But in the presence of firm-specific matching gains, the trade-off continues to hold even if one allows the initial employer to match the raider's offer. A bidding war following any deviation does not dissipate all surplus because the better matched firm can win the bidding war at a bid that equals the productivity of the star at the rival firm. So, a deviation from the collusive path can be profitable, and the sustenance of collusion depends on the underlying parameter values.

Third, even under collusion, a free star may get to keep a share of the surplus. Note that in the most profitable collusive equilibrium, a free star below a productivity threshold earns 0, but above this productivity threshold, the collusive wage $\tilde{w}^C(v)$ is positive and increasing in the star's productivity. The intuition behind this finding is simple. As discussed before, the gains from deviation increase with the quality of the star. If firms attempt to collude on a fixed wage, firms may honor this agreement when the star is of low productivity, but they may be tempted to renege when the star is of high productivity (because there is more to be gained by deviating). One way to get around this problem is to set the fixed wage high enough so that even for the highest productivity star, a deviation is unprofitable. But such an agreement might be unprofitable for the firm at the first place, because it leaves too much surplus with the worker and too little for the colluding firms. Instead, the firms are better off by colluding on a wage schedule that is (weakly) increasing in the productivity of the star. By doing so, the firms ensure that the gains from deviation do not become too large even when the star is of the highest quality. Consequently, collusion becomes easier to sustain.[21] The collusive wage schedule also has important implications for the surplus allocation between the worker and the firms. We will revisit this issue in the following section.

Finally, Proposition 1 also indicates why a firm would always prefer to write an exclusive contract even under collusion. As discussed above, even the colluding firms must leave a share of the total surplus with a free star. So, if exclusivity is enforced, the initial employer of the star appropriates an additional surplus $\tilde{w}^C(v)$ that would have gone to the worker in the absence of exclusivity. Thus, as long as the probability of enforcement is positive, firms are *ex ante* strictly better off by offering exclusive contracts even on the collusive path. Clearly, this observation holds even if there is a transaction cost of writing exclusive contracts, as long as such a cost is not too large.

We conclude this section by revisiting the issue of human capital investments by the firm in their workers. In order to stay focused on the role of exclusivity enforcement on collusion, our model abstracts away from the issue of investment. However, one might expect that by investing more in a worker during the workers' training period, a firm may affect the worker's productivity later on. How would our analysis change if we consider that firms can invest in workers during period one and that investment affects the worker's productivity in period two in the event he becomes a star? Two issues are worth noting here. First, in the absence of collusion, the higher is the enforcement level of exclusivity, the higher is a firm's investment in the worker. This result, which follows directly from Segal and Whinston (2000), stems from the fact that with higher enforcement of exclusivity, the firms are more protected from competition for their workers, appropriate more of the surplus the workers generate, and therefore appropriate more of the marginal gains from the investments. In other words, non-compete clause can increase the firms' investment incentives by alleviating potential hold-up threats. Second, for the same level of enforcement, firms invest more under collusion than in the absence of it. This is because, similar to case of higher enforcement of exclusivity, when firms collude in the labor market they appropriate more of the surplus generated by the workers than when they compete.

4. Implications for welfare and distribution of surplus

4.1. **Welfare implications and optimal enforcement.** The enforcement of exclusivity may have important welfare implications. In what follows, we take the "joint surplus" per generation, say S, that the two firms and the two workers together produce in a given generation as our measure of social welfare. In any generation, the joint surplus is maximized when the star worker works for the firm where he is a better match. Note that both collusion and

[21]This observation is reminiscent of Rotemberg and Saloner (1986). Rotemberg and Saloner obtained a result in similar spirit in the context of price-fixing in product markets. They argued that when demand is uncertain, a cartel may agree on setting a low price in the periods of high demand and a high price in the periods of low demand. This happens because firms have more incentives to deviate in the periods of high demand. A lower cartel price in high demand periods countervails such incentives for deviation and, consequently, makes the cartel sustainable.

exclusive contracts reduces the joint surplus by restricting efficient turnover. Consequently, a high rate of exclusivity enforcement affects the social welfare in two opposing ways: (i) it directly restricts turnover because a star is less likely to be able to "free" himself from the exclusivity clause, (ii) it indirectly facilitates the turnover of a "free" star by hindering collusion in the labor market.

The optimal level of enforcement is the one that maximizes the joint surplus by balancing the trade-off between restricting turnover and hindering collusion. When the Court is too favorable toward enforcement of exclusivity it does reduce the possibility of collusion in the labor market, but it directly restricts the likelihood that a star worker would be able to change his employer even if his turnover may enhance his productivity. On the other hand, if the Court is too reluctant to enforce an exclusivity contract, there is a higher likelihood that a worker may be able to seek employment elsewhere, but it may not be worthwhile for the worker to do so as the firms are more likely to collude on wages. This observation suggests that neither of the extreme stances of perfect enforcement or no enforcement may be socially optimal. The following proposition further elaborates on this issue.

Proposition 3. *The joint surplus per generation* (S) *as a function of the likelihood of exclusivity enforcement* (p) *is given as follows: for* $\delta < \tilde{\delta}(0)$

$$S = \mathbb{E}v + (1-p)\,\alpha\mu,$$

and for $\delta \geq \tilde{\delta}(0)$,

$$S = \begin{cases} \mathbb{E}v & \text{if } p \leq \tilde{p} \\ \mathbb{E}v + (1-p)\,\alpha\mu & \text{if } p > \tilde{p} \end{cases},$$

where the cutoff value $\tilde{p}$ *increases with* δ.

Recall that for $\delta < \tilde{\delta}(0)$, collusion is not feasible regardless of the level of exclusivity enforcement. Thus, there is always efficient turnover for a free star, and a higher p only reduces the probability that a worker would be able to void his exclusivity clause and switch to the better matched employer. Consequently, the joint surplus is maximized when the Court never enforces an exclusive contract. But if $\delta \geq \tilde{\delta}(0)$, the level of exclusivity enforcement does affect the firms' ability to sustain collusion. For values of p below a threshold, say $\tilde{p}$ (which varies with δ), collusion is sustainable, and the joint surplus is at its lowest. But collusion breaks down once p crosses this threshold, and a free star can move to the rival firm whenever he is more productive with the rival. Thus, the joint surplus increases. However, if p is above the threshold $\tilde{p}$, a further increase in p has no additional effect on collusion and merely reduces the likelihood that a star would be able to repudiate his exclusivity clause. As a result, p only restricts turnover and the joint surplus starts to decrease with p.

Corollary 1. *For* $\delta < \tilde{\delta}(0)$*, it is socially optimal not to enforce the exclusive contracts. Otherwise, the optimal enforcement is the minimum enforcement level that renders any collusion infeasible. Moreover, the optimal enforcement level increases with* δ.

Corollary 1 highlights the socially optimal level for exclusivity enforcement: for low δ when collusion is not feasible, it is socially optimal not to enforce any exclusivity clause. In this case, enforcement of exclusivity can only reduce the social welfare by restricting turnover. There is no benefit from hindering collusion since collusion is not feasible to begin with. For higher δ, sustainability of collusion depends on the level of exclusivity enforcement. Thus, the optimal enforcement is the minimum enforcement level that renders any collusion infeasible (i.e., $\tilde{p}$). Any lower p leaves room for the firms to collude and distorts efficient turnover of a free star, and any higher p has no marginal impact on collusion but simply reduces the probability that a star can move to a better matched employer. Moreover, because $\tilde{p}$ is increasing in δ, the optimal enforcement level increases when the firms are more patient.

How could the Court implement the optimal policy? Note that the probability of enforcement (p) can be interpreted as the share of the star's value that the initial employer expects to retain by offering an exclusivity clause. So, an intermediate value of p reflects the case where the Court allows the firm to retain only a faction of the star's value through the use of the exclusive contracts. Corollary 1 suggests that if δ is low enough, the Court should not enforce any exclusive contract. Otherwise, the Court should choose a level of enforcement (p) that balances the matching gains from turnover with the risk of facilitating labor market collusion. The Court can implement such an intermediate value of p by requiring the employer to offer some specific considerations to the worker in exchange of the exclusivity provision. A smaller p represents a more generous consideration; for example, the Court may enforce the exclusivity clause only if it is effective over a short time span or in a narrow geographical area.[22]

One may also ask whether the presence of human capital investments by the firms changes our findings. When firms' investment level in workers is important, total welfare depends on both the matching and the investment efficiency. But in the environment where firms attempt to collude, investment incentives can be fostered by both very high or very low level of enforcement: A high level of enforcement give direct incentives for investment as the firm is ensured to keep the returns on its investment. In contrast, a low level of enforcement can offer "indirect" incentives for investments by facilitating collusion (and ensuring that the returns on the investment are not dissipated by competition). However, in both of these cases, matching efficiency is largely sacrificed. This suggests that as long as the firms' investment in workers is not disproportionately more important to total welfare than efficient matching between workers and firms, our result that neither of the extreme cases of no enforcement and full enforcement is optimal remains.

4.2. **Implications for allocation of surplus.** A related question to the optimal exclusivity enforcement is the following: how does the enforcement of exclusivity affect the allocation of surplus between the star worker and the two firms? As Proposition 1 highlights, in the presence of firm-specific matching gains and heterogeneity among the stars' productivity, the firms may not be able to retain the entire surplus produced by a free star. The allocation of surplus depends on the stars' equilibrium wages along the (most profitable) collusive equilibrium. Therefore, in order to investigate the role of exclusivity enforcement on surplus allocation, we first need to study the impact of p on the collusive wage schedule w^C. (In what follows, we denote the w^C function as $w^C(v;p)$, and the associated productivity cutoff level as $v^*(p)$ in order to explicitly recognize their dependence on p.)

Proposition 4. *The optimal collusive wage $w^C(v;p)$ is increasing in p and $v^*(p)$ is decreasing in p.*

Proposition 4 establishes that stars' wages increase as exclusivity is more tightly enforced by the Court.[23] This comparative static result may seem self-evident, since tighter enforcement of non-compete covenants ultimately means that principals have to pay more to hire their

[22] See Garmaise (2009) and Malsberger (2004) for a discussion on how different states of USA have adopted different standard on what constitutes a reasonable consideration that the employer must offer to the workers in exchange of an exclusive agreement.

[23] In fact, as shown in the proof of Proposition 4, w^C strictly increases in p for $v \geq v^*$, and v^* strictly decreases in p as long as $v^* \in (\underline{v}, \overline{v})$.

agents exclusively. However, the underlying mechanism at work is much subtler. When the level of enforcement of exclusive contracts increases, the future punishments on deviants become less severe. Thus, collusion becomes more difficult to sustain. In order to sustain optimal collusive equilibria, firms must therefore permit high-ability stars to earn higher wages and content themselves with lower profits. In that way, neither firm finds it profitable to deviate from the agreement.

Figure 2 illustrates the impact of p on w^C as given by Proposition 4. As p rises from p_0 to p_1, the wage schedule w^C shifts upwards and the cut-off value v^* decreases.

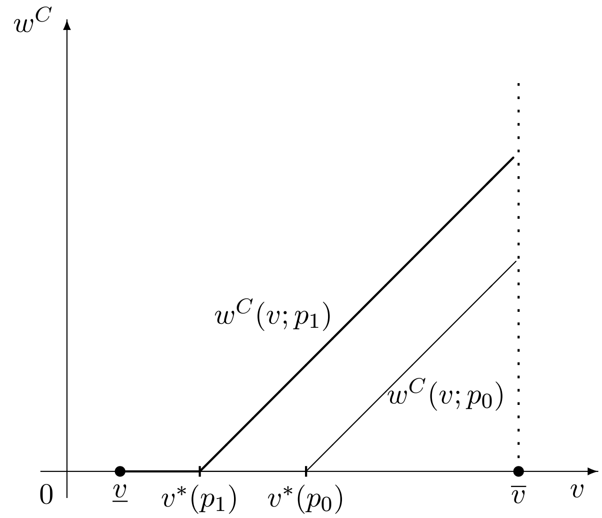

Figure 2. Collusive wage schedule and its shift for a change in p, $(p_1 > p_0)$.

Proposition 4 allows us to explore what happens to the expected discounted payoffs to stars and the firms as the probability of enforcement changes. That free stars of relatively high ability earn higher equilibrium wages when p goes up implies that they may actually gain from tighter enforcement of exclusivity clauses. The flip side, of course, is that the stars are less likely to become free. The following proposition summarizes our finding.

Proposition 5. *Consider the most profitable collusive equilibrium. As the probability of enforcement increases from p_0 to p_1 the payoff to all workers with productivity $v \in [\underline{v}, v^*(p_1)]$ remains the same, but the payoff to all workers with productivity $v \in (v^*(p_1), \overline{v}]$ changes in the following fashion: either all workers with productivity $v \in (v^*(p_1), \overline{v}]$ are better off or there exists $\widetilde{v} \in (v^*(p_1), \overline{v}]$ such that all workers with productivity $v \in (v^*(p_1), \widetilde{v})$ are better off and all workers with productivity $v \in (\widetilde{v}, \overline{v}]$ are worse off. Moreover, the firms' expected payoff may decrease.*

There are two important implications of Proposition 5: first, our finding is contrary to the commonly held view that exclusivity enforcement harms the workers and favors the employers. We argue that when collusion among firms is a concern, exactly the opposite may be true. Second, the changes in the enforcement level need not have the same impact on the well-being of all stars. A shift in the legal environment toward stricter exclusivity enforcement may induce a redistribution of expected surplus from top stars to stars of relatively low ability.

The intuition behind this finding is as follows: when p rises, there are two opposite forces at work: (i) a larger fraction of the surplus created in the market accrues to the colluding firms because the stars are freed less often. (ii) Collusion is harder to sustain; it leads to a (weakly) higher collusive wage schedule w^C and lower expected profits for the colluding firms. The interaction between these two effects ultimately determines whether the firms and the star workers lose or gain from a change in the enforcement level. For example, consider a relatively low value of v such that the collusive wage of a free star, $w^C(v)$, is low. In such a scenario, as p increases, the marginal loss from the decreasing likelihood of becoming free is low (which is simply equal to $w^C(v)$), and therefore, the second effect of increased collusive wage may dominate. Consequently, the stars are better off when the enforcement likelihood increases. In contrast, when v is high, the colluding firms need to offer premium wage to the free stars. Therefore the marginal loss from being free in the market less often is high. This loss may be large enough to offset any marginal gains from the increase in the collusive wage. In this case, the first effect dominates, and the star workers are worse off in a heightened enforcement regime.

5. Discussion

The model we have used above captures the interplay between the enforcement of exclusive contracts and the sustenance of collusion and offers important insights on the optimal enforcement of exclusivity clauses and its implications on welfare and distribution of surplus. Nevertheless, our model abstracts away from several issues that are not only interesting from a technical point of view, but may also be empirically relevant. This section discusses the implications of some of these issues on our findings.

5.1. **Pareto improving reallocation of star workers.** Recall that in our model, under both collusion and no-compete clause, a star worker stays with his initial employer even if he is better matched with the potential raider. However, one might assume that a firm may actually prefer to have turnover when turnover is jointly profitable for the firm and the raider. For example, if the star is more productive with the raider, the firm may let the worker leave for the raider but charge a "transfer fee" from the raiding firm. If the star is under a no-complete contract, such transfer fee can be a part of the contract renegotiation. And under collusion, the better matched firm may "poach" the star by bidding a penny more than the initial employer and compensate the initial employer by offering a side payment. More generally, under collusion the firms may agree on a more sophisticated bidding behavior where, heuristically speaking, the more productive firm always bids the collusive wage plus a penny to lure away the star. If firms are symmetric (i.e., in every generation, both firms are equally likely to be the better matched firm for the star) both firms earn more profit under this type of collusion as they retain the gains from efficient turnover.

One might be interested to know whether the findings of this article extend to such an environment. Indeed, the qualitative nature of all our findings, except those on efficiency, continues to hold. Analogous to our discussed in section 3.2, even with transfer payments and/or collusion with efficient turnover a stronger enforcement of no-compete clause continues to increase a firm's punishment payoff more than it increases the firm's payoff on the equilibrium path. So, a strong enforcement makes collusion harder to sustain. By the same token, a stronger enforcement may still shift the distribution of surplus in favor of the workers. But note that if we allow for a renegotiation of the no-compete contract and/or assume that turnover is efficient even under collusion, the allocation of the star worker will always be efficient. Consequently, the enforcement of exclusive contracts will not affect the aggregate social surplus and the question of optimal enforcement is no longer relevant in such a setting.

However, it is important to note that in reality both contract renegotiation and collusion with efficient turnover have their own sets of implementation problems. For example, an efficient renegotiation need not take place if the size of the matching gains is not publicly known. Also the firms may not form a collusion with side payments since the payment trails may make the collusion vulnerable to antitrust scrutiny. More importantly, in absence of side payments, a collusive agreement that allows for efficient turnover is harder to sustain if the firms are asymmetric; i.e., when some firms are consistently more likely to be a better match for the star (i.e., more efficient) than the other. Thus one may except the efficiency issues to continue to play an important role in determining the optimal enforcement (of no-compete clause) in a broad range of labor market environments.

5.2. **Timing of the raid.** We assume that it is the star worker who initiates the legal process of repudiating the exclusivity clause and the bidding takes place after the worker is "freed" by the Court. But such a legal process is often initiated by the raider—the worker attempts to repudiate his initial contract only after he has an offer in hand from the rival firm. However, our model can easily be extended to capture such a scenario, and the key economic effects continue to hold.

Consider the following modifications to our model. For the sake of analytical simplicity, ignore the uncertainty in the star's productivity level and the firm specific matching gains. That is, assume that a star's productivity is a known value v and $\mu = 0$. Suppose that there are three periods in each generation. A worker's type is revealed at the beginning of period two. A star produces 0 in period 1 and v in both period 2 and period 3. A regular worker produces 0 in all periods. An exclusive contract, enforced by the Court with probability p, ties the worker with his initial employer only for the first two periods. A worker is always free to switch jobs in the third period; in other words, a worker cannot remain exclusive throughout his entire career. Both the initial employer and the rival firm can make take-it-or-leave-it offers to the worker at the beginning of period 2 and the worker may decide to repudiate his exclusive contract if he receives an offer from the rival. We keep all other aspects of our model unchanged. In this setting, under collusion firms agree not to compete for the rival's star (i.e., neither in period 2 nor in period 3), and bids 0 in both periods (period 2 and 3).

Under collusion, the per-generation expected payoff of a firm is v (recall that the total payoff from a star in a given generation is $2v$ and in every generation, a firm employs the future star employee with probability $1/2$). But in the punishment phase, both firms will compete to hire a star. In period 3, the worker is necessarily free, and the two firms will bid up to his full value v. In period 2, the rival will bid v for the star (giving the star an expected payoff of $v\,(1-p)$ as the star appeals to the Court to repudiate his exclusive contract) and the initial employer will bid $v\,(1-p)$. So, the initial employer's expected payoff is $vp/2$. Because the one-shot gain from deviation is larger in period 3 (equals to v), the firms can sustain the collusion only if

$$\frac{\delta}{1-\delta}v \geq v + \frac{\delta}{1-\delta}\frac{1}{2}vp. \tag{6}$$

It is clear from the above condition that the higher is the value of p the harder it is for the firms to sustain collusion.[24]

5.3. **Exclusive employment contracts with break-up fee.** The class of exclusive employment contracts that we have considered in our model simply forbids the worker to accept an employment contract from a rival firm. In reality, however, many employers offer exclusive contracts that allow the worker to switch to the rival firm provided that the worker pays a pre-specified "break-up fee" to his initial employer (see Aghion and Bolton (1987) on the exclusionary implications of this type of contract in the product market). In fact, in the presence of firm-specific matching gains, the firms may strictly prefer to offer a contract that allows the worker to switch jobs after paying a break-up fee rather than an exclusive contract that outright prohibits job switching.

The qualitative nature of our results continue to hold even if we allow for such break-up fee. The intuition is as follows: suppose that a contract is specified as (w, P), where, as before, w is the initial wage offer to be paid at the end of the second period, and P is a break-up fee/penalty that the worker has to pay to the initial employer if she decides to join the rival firm at the beginning of period two. As before, under collusion, the firms agree not to hire each other's stars and offer collusive wage $w^C(v)$ (both when the contract is enforced and when it is not). Note that under contracts with break-up provision, the punishment payoff of the firms will be higher (compared to the case of pure exclusive contracts) because the firms will be able to capture some of the matching gains. So, under this class of contracts, for a given level of contract enforcement, collusion is harder to sustain.[25] However, the firms' punishment payoff continues to increase in the level of enforcement, which implies that the stronger is the enforcement, the harder it is to sustain collusion. Because collusion erodes matching efficiency, the optimal enforcement is the minimum level of enforcement that makes collusion infeasible. Moreover, because collusion is harder to sustain when p increases, the optimal collusive wage $w^C(v)$ is increasing in p. Consequently, a stronger enforcement may lead to more surplus for the workers.

An important issue to note is that when exclusive contracts allow for break-up (with penalty), the efficiency implications for collusion and full enforcement of exclusive contracts are no longer the same. Collusion necessarily destroys all matching gains that could have been obtained from efficient turnover, whereas full enforcement of contracts with break up fee does leave room for efficient turnover. But, in general, with full enforcement there will be some matching inefficiency because in the presence of a break-up fee it may not be optimal for a star with lower productivity (i.e., low v) to switch jobs even when she is more productive with the rival firm.

5.4. **Collusive wage contingent on the presence of matching gains.** We have maintained a simplifying assumption that the collusive wage w^C is not contingent on realization of the matching gains. However, one can conceive a more general setting where the firms' collusive wage offer w^C not only depends on the productivity of the star (v) but also on the value of $m \in \{-\mu, \mu\}$ in a given generation. The qualitative nature of our

[24]One can also consider a weaker form of collusion where the firms agree not to raid each other's worker only at the beginning of period 2. Even under collusion firms are allowed to compete in period 3. However, when it is possible to sustain such a collusion, it is also possible to sustain collusion in both periods. Hence, if firms attempt to collude, it is optimal to collude in both periods (in every generation).

[25]Similar to the argument discussed by Aghion and Bolton (1987), when choosing P, a firm takes into account two effects. A higher P means a higher compensation when the star switches to the more efficient rival. This is a positive effect. On the other hand, with a higher P it is less likely that the raider-worker pair will find it worthwhile to switch job by paying the break-up fee. This effect may imply inefficient turnover, and hence, loss of matching surplus. The optimal P balances these two effects.

results continue to hold in this general setting. In this case, the difference between the payoff under collusion and the payoff under the punishment phase $\tilde{\Pi}^C - \underline{\tilde{\Pi}}$ is given by $\frac{\delta}{1-\delta}\frac{1}{2}(1-p)\mathbb{E}\left[v-\mu-\alpha w^C(v,\mu)-(1-\alpha)w^C(v,-\mu)\right]$, and the no-cheating condition (4) must be modified as,

$$\begin{array}{c}\frac{\delta}{1-\delta}\frac{1}{2}(1-p)\mathbb{E}\left[v-\mu-\alpha w^C(v,\mu)-(1-\alpha)w^C(v,-\mu)\right] \geq \\ \max\left\{\sup_v\left[v-\mu-w^C(v,\mu)\right], \sup_v\left[v+\mu-w_2^C(v,-\mu)\right]\right\}.\end{array} \tag{7}$$

Note that when we allow for the collusive wage w^C to be contingent on m, the firms' payoffs along the collusive path can be higher than the payoffs when w^C depends only on v. That is, making the collusive wage contingent on m helps sustain the collusion. Nevertheless, our key effect of exclusivity enforcement on collusion continues to hold: the higher is the enforcement level p, the harder it is to satisfy the conditions (7). In other words, a higher enforcement p reduces the firms' ability to sustain collusion. Furthermore, following the same argument as discussed in the context of our general model, one can show that for a given $m \in \{-\mu,\mu\}$, the optimal collusive wage, say $\widetilde{w}^C(v,m)$, satisfies the properties of $\widetilde{w}^C(v)$ as specified in Proposition 1, and hence, have qualitatively similar effects on welfare and distribution of surplus.[26]

5.5. **Workers' bargaining power in period one.** We have assumed that the firm has the entire bargaining power with the worker in period one of every generation. But once a worker is revealed to be a star, the balance of power shifts to the worker. This is perhaps a natural assumption for the environment we are studying in this article: there are many "potentially talented" young workers but only a few would indeed become a star. So a young worker is easily replaceable by the firm but a star worker is a scarce resource. However, the assumption that a young worker has no bargaining power is not essential for our findings. The key results of this article continues to hold as long as a young worker does not have too much bargaining power with the firm.[27]

To see this, consider the following modification to the model: in period one of each generation, each firm is randomly assigned to a worker, but once the assignment is realized, the firm enters into a bilateral bargaining with the worker. Specifically, we assume that the firm can extract (subject to the worker's liquidity constraint) at most a fixed share λ of the value generated by the coalition of the firm and its worker whereas the worker appropriates the share $1-\lambda$. A smaller value of λ represents higher bargaining power for the worker. In our model, $\lambda = 1$. In what follows, we argue that the key economic effects we highlight in this article continue to hold even if $\lambda < 1$ as long as λ is not too small.

As before, first consider the stage game. Note that irrespective of the contract agreed between a firm and worker, the value created by their relationship is always $\frac{1}{2}\mathbb{E}v$.[28] Recall

[26]One can also show that $\widetilde{w}^C(v,\mu) \geq \widetilde{w}^C(v,-\mu)$ for all v, and that when $\widetilde{w}^C(v,\mu)$ and $\widetilde{w}^C(v,-\mu)$ are both strictly positive, $\widetilde{w}^C(v,\mu) - \widetilde{w}^C(v,-\mu) = 2\mu$.

[27]In fact, in a setting where even the young workers enjoy substaintial bargaining power, both the issues of exclusivity and collusion are irrelevant. The firm resort to exclusive contracts and/or collusion to extract rents from the star worker in period two that cannot be extracted from a young worker in period one (due to liquidity constraint on the worker). If even the young workers have substaintial bargaining power, then such rent extraction mechanisms are irrelevant because there is little rent available to the firm at the first place.

[28]The coalition worker+firm could create more value by signing a contract with wage $w > v$. This contract would allow them to capture more than v if the worker becomes a star and the rival firm is more efficient in period one. However, such a contract implies a negative expected payoff to the firm. It could be implemented only if a transfer from the worker to the firm in period one was possible. Since workers are liquidity constrained in period one, such transfer is not possible.

that in the stage game the firm's expected payoff from its period one worker under an exclusive contract with $w_i = 0$ is $\frac{1}{2}[p\mathbb{E}v + (1-p)(1-\alpha)\mu]$. So, as long as λ is large enough so that

$$\lambda \frac{1}{2}\mathbb{E}v > \frac{1}{2}[p\mathbb{E}v + (1-p)(1-\alpha)\mu], \tag{8}$$

one obtains the same stage game payoff as in our original model. In order words, when the condition above holds, the worker's bargaining power makes no difference to the analysis since the worker's liquidity constraint already ensures that the worker gets to keep a share of the value. Hence, in this case, the firm's stage game payoff is the same as given in equation (1) above (i.e., $\frac{1}{2}[p\mathbb{E}(v) + (1-p)\mu]$). In contrast, if λ is low enough so that (8) does not hold, the firm's payoff is $\lambda\frac{1}{2}\mathbb{E}v + \frac{1}{2}(1-p)\alpha\mu$.

Next, consider the payoffs on the collusive path. Recall that on the collusive path the firm's expected payoff from its period one worker under an exclusive contract with $w_i = 0$ is $\frac{1}{2}\mathbb{E}\left[v - (1-p)w^C(v)\right]$. So, as long as λ is large enough so that

$$\lambda \frac{1}{2}\mathbb{E}v > \frac{1}{2}\mathbb{E}\left[pv + (1-p)\left(v - w^C(v)\right)\right], \tag{9}$$

one obtains the same collusive path payoff as in our original model (i.e., the firm's payoff on the collusive path is $\frac{1}{2}\mathbb{E}\left[v - (1-p)w^C(v)\right]$). In contrast, if λ is low enough so that (9) does not hold, the firm's payoff is simply $\lambda\frac{1}{2}\mathbb{E}v$.

So, we can conclude the following: as long as the workers' bargaining power is not too high (i.e., as long as λ is large enough) such that (8) and (9) hold, all our results continues to hold. Moreover, if λ is such that (8) holds but (9) is violated, then the collusion payoff does not depend on exclusivity enforcement (p), whereas the punishment payoff increases with stronger exclusivity enforcement. Thus the qualitative nature of our results still holds. The case where (8) is violated but (9) holds cannot occur in any collusive equilibrium since this would imply that firms' prefer competition to collusion. Similarly, if both (8) and (9) are violated then firms' payoff are higher under competition than under collusion. This case speaks to the situation where even the young workers have considerable bargaining power, and there is little rent left for the firm to extract (by means of exclusive contracts or collusion). Thus, collusion does not help the firms to extract rents from the worker but only leads to inefficient matching. Consequently, collusion in the labor market becomes an irrelevant issue.

5.6. **Implications for product market interaction.** The firms that compete in the labor market are likely to interact in the product market as well. In our analysis above, we have abstracted away from the nature of product market competition by treating the firms' profits from each type of workers as parameters that are unaffected by the level of exclusivity enforcement. But the enforcement of exclusivity clause can also affect the firms' product market interaction. In fact, a strong enforcement of exclusive employment contracts also hinders the firms' anticompetitive behavior in the product market.

For example, suppose that the firms colluding in the labor market also collude in the product market. To keep the analysis simple, assume that there is no firm specific matching gains (i.e., $\mu = 0$). Under competition in the product market, the profit from a star worker of productivity v is v but the profit from a regular worker is 0. In contrast, under collusion in the product market, let the profit of a firm from a star worker of productivity v be $\pi^c(v)$ $(> v)$ and that from a regular worker be $\pi^c(0)$ (> 0). Finally, assume that in period two of every generation, the firms set the labor market wages and product market price simultaneously. In this setting, there are two relevant ways of deviation for the colluding firms. First, the firm that initially hired the star may deviate in the product market. Let $\pi^d(v)$ be the associated gains from deviation. So, similar to equation (5), the no-deviation constraint for the firm boils down to

$$\frac{\delta}{1-\delta}\frac{1}{2}\mathbb{E}[\pi^c(v)-(1-p)w^C(v)+\pi^c(0)-pv] \geq \sup_v[\pi^d(v)-\pi^c(v)] \tag{10}$$

Second, the firm that initially hires the regular worker deviates in both the labor and the product market by poaching the star and charging the profit maximizing price conditional on hiring the star worker (this set up is similar to the multi-market contact environment studied by Bernheim and Whinston, 1990). Let $\pi^d_*(v)$ be associated gains from deviation. In this case, the no-deviation constraint for the firm is

$$\frac{\delta}{1-\delta}\frac{1}{2}\mathbb{E}[\pi^c(v)-(1-p)w^C(v)+\pi^c(0)-pv] \geq \sup_v[\pi^d_*(v)-w^C(v)-\pi^c(0)] \tag{11}$$

Since under collusion $\mathbb{E}w^C(v) < \mathbb{E}v$ (else, there is no gains from colluding), a higher p makes both constraints (10) and (11) more binding. That is, a stronger enforcement makes collusion harder to sustain—both in the labor market as well as in the product market.

6. Conclusion

In this article, we offer a stylized model of the labor market for highly talented workers, or "stars." We highlight a scenario where employers groom talented young workers under the threat of having their star employees subsequently poached by rival firms. In such an environment firms may adopt one of two channels of surplus extraction from their future star employees: exclusive employment contract (or "covenant not to compete") and collusion among employers that forbids poaching each others' workers. The key effect we highlight in this paper emanates from the interplay of these two channels of surplus extraction.

We argue that a stricter legal enforcement of exclusive employment contracts may hinder collusive behavior among firms that compete to hire scarce talent in the labor market. This effect has important implications for the optimal enforcement of exclusive contracts and the distribution of surplus between firms and workers. We find that it is socially optimal to enforce the exclusive employment contracts up to the extent that it renders collusion unfeasible. Moreover, a stronger enforcement of such contracts can shift the distribution of surplus in favor of the workers. These findings suggests that neither of the extreme policies of zero enforcement and full enforcement is optimal and they also call into question the oft-cited views of the Court that the enforcement of exclusivity contracts hurts the workers' interest.

Appendix

This appendix contains the proofs omitted in the text.

Proof of Proposition 1. We start by showing that given $p < 1$ and parameters μ, $\underline{v}$ and $\overline{v}$, there exists $\widetilde{\delta}(p)$ such that a collusive equilibrium is sustainable if and only if $\delta \geq \widetilde{\delta}(p)$. We do this in the following three steps.

Step 1.1. For $\delta \simeq 0$, no wage schedule is sustainable. When $\delta \simeq 0$ the left-hand side of (4) is close to zero. Hence, a wage schedule $w^C(\cdot)$ satisfies (4) only if $w^C(v) \simeq v + u, \forall v \in [\underline{v}, \overline{v}]$. But for such $w^C(v)$, the left-hand side of (4) is negative, implying that (4) is violated.

Step 1.2. For $\delta \simeq 1$, wage schedule $w^C(v) = 0, \forall v \in [\underline{v}, \overline{v}]$ is sustainable. First, observe that when $w^C(v) = 0, \forall v \in [\underline{v}, \overline{v}]$, (4) is equivalent to $[\delta/(1-\delta)](1-p)/2 \geq (\overline{v}+\mu)/(\mathbb{E}v - \mu)$.

Next, observe that $\mathbb{E}v > \underline{v} > \mu$, which implies that the right-hand side of the above inequality is finite. Finally, note that $\lim_{\delta \to 1}(\delta/1-\delta) = +\infty$.

Step 1.3. If $w^C(\cdot)$ is sustainable when $\delta = \delta_0$ then it is also sustainable when $\delta = \delta_1$, with $\delta_1 > \delta_0$. This follows by direct observation of (4).

The fact that in the most profitable collusive equilibrium firms offer an exclusive contract with 0 wage is trivial. Simply note that firms gain nothing by committing in period one to a positive wage. Similarly, firms have no loss in offering an exclusive contract. We next show that in the most profitable collusive equilibrium firms bid $\tilde{w}^C(v)$ (as defined in the statement of the Proposition) for a free star. An important observation in finding the optimal $w^C(\cdot)$ is the following. Fix the left-hand side of (4) and call it z. Given z, $w^C(\cdot)$ is optimal if and only if, for each $v \in [\underline{v}, \overline{v}]$, $w^C(v)$ is the lowest (non-negative) value such that $z \geq v + \mu - w^C(v)$. That is, $w^C(v) = 0$ if $z \geq v + \mu$, and $w^C(v) = v + \mu - z$ if otherwise. The remainder of the proof is established in the following steps.

Step 2.1. If $[\delta/(1-\delta)](1-p)/2 \geq (\overline{v}+\mu)/(\mathbb{E}v - \mu)$, then optimal schedule is $w^C(v) = 0, \forall v \in [\underline{v}, \overline{v}]$. As shown above this wage schedule is sustainable in this case. Clearly, if this wage schedule is sustainable, then it is the most profitable. In the definition of $\widetilde{w}^C(v)$ in statement of the proposition, this corresponds to the case where $v^* = \overline{v}$.

Step 2.2. If $(\underline{v}+\mu)/(\underline{v}-\mu) \leq [\delta/(1-\delta)](1-p)/2 < (\overline{v}+\mu)/(\mathbb{E}v-\mu)$ then the optimal wage schedule is given by $\widetilde{w}^C(v)$ with $v^* \in (\underline{v}, \overline{v})$. Given z, let $\widehat{v}$ denote the maximum type of star such that wage 0 can be sustained. That is, $\widehat{v}$ is such that

$$\widehat{v} + \mu = z. \tag{12}$$

The optimal wage schedule must specify $w^C(v) = 0$ if $v \leq \widehat{v}$ and

$$v + \mu - w(v) = z \tag{13}$$

if $v > \widehat{v}$. But given such schedule the left-hand side of (4) is determined. Thus, $w^C(v)$ as defined above is indeed optimal if it induces a left-hand side of (4) that is identical to z. That is, we need to show that there is a fixed point. Define,

$$Z(\widehat{v}) = \frac{1}{2}\frac{\delta}{1-\delta}(1-p)\left[\int_{\underline{v}}^{\widehat{v}}(v-\mu)dF(v) + (1-F(\widehat{v}))(\widehat{v}-\mu)\right].$$

$Z(\widehat{v})$ is the left-hand side of (4) given wage schedule with cutoff $\widehat{v}$. The second term inside the square brackets is obtained by using (12) and (13) to obtain $w^C(v) = v - \widehat{v}$, and then noting that $v - \mu - w^C(v) = \widehat{v} - \mu$. To find the fixed point, we use (12) and $Z(\widehat{v})$ to define $h(\widehat{v}) = \widehat{v} + \mu - Z(\widehat{v})$ and look for a 0 of this function. Note that

$$h(\underline{v}) = \underline{v} + \mu - \frac{1}{2}\frac{\delta}{1-\delta}(1-p)(\underline{v}-\mu) \leq 0$$

and

$$h(\overline{v}) = \overline{v} + \mu - \frac{1}{2}\frac{\delta}{1-\delta}(1-p)(\mathbb{E}v-\mu) > 0,$$

where the inequalities follow from the fact that in this step we focus on the case where $(\underline{v}+\mu)/(\underline{v}-\mu) \leq [\delta/(1-\delta)](1-p)/2 < (\overline{v}+\mu)/(\mathbb{E}v-\mu)$. Continuity of h immediately implies that h has a zero in $[\underline{v}, \overline{v})$. v^* in the definition of $\widetilde{w}^C(v)$ is the largest zero of h in $[\underline{v}, \overline{v})$. Note that $v^* > \underline{v}$ even if $h(\underline{v}) = 0$. This is because $h'(\underline{v}) = 1 - \delta/(1-\delta)(1-p)/2 < 0$, where the inequality follows from the fact that $1 < (\underline{v}+\mu)/(\underline{v}-\mu) \leq [\delta/(1-\delta)](1-p)/2$.

Step 2.3. If $1 < [\delta/(1-\delta)](1-p)/2 < (\underline{v}+\mu)/(\underline{v}-\mu)$, the optimal wage schedule if it exists is given by $\widetilde{w}^C(v)$ with $v^* \in (\underline{v}, \overline{v})$. The analysis developed in the previous step applies here. In this case $h(\underline{v}) > 0$ and as before $h'(\underline{v}) < 0$. While a zero of h is not guaranteed, $h'(\underline{v}) < 0$ implies that if it exists then it is larger than $\underline{v}$.

Step 2.4. If $[\delta/(1-\delta)](1-p)/2 < 1$, no collusion is sustainable.

In this case h is an increasing function. Since $h(\underline{v}) > 0$, h has no zero. So if there is a sustainable collusion wage it must satisfy $v + \mu - w^C(v) = z$ for all v. This implies that $w^C(v) = v + \mu - z$. But given this wage, we can get the right-hand side of (4). Define

$$\widetilde{Z}(z) = \frac{1}{2}\frac{\delta}{1-\delta}(1-p)\mathbb{E}(z-2\mu) = \frac{1}{2}\frac{\delta}{1-\delta}(1-p)(z-2\mu).$$

Again, a fixed point must exist. So we need to find z such that $\widetilde{Z}(z) = z$. Since $[\delta/(1-\delta)](1-p)/2 < 1$, it is clear that such a $z > 0$ does not exist, meaning that collusion is not sustainable.

In all the cases considered in each of the above steps, when collusion is sustainable, the form of the most profitable collusive wage is as specified in the Proposition. ■

Proof of Proposition 2. We can write (4) as

$$\rho\mathbb{E}\left[v - \mu - w^C(v)\right] \geq \sup_v \left[v + \mu - w^C(v)\right], \tag{14}$$

where $\rho = [\delta/(1-\delta)](1-p)/2$. We next prove that there exists $\widetilde{\rho} > 0$ such that collusion is feasible if and only if $\rho \geq \widetilde{\rho}$. This result follows immediately from the following three facts. First, no wage schedule $w^C(\cdot)$ can satisfy (14) if $\rho \simeq 0$. This follows from Step 2.4 of the proof of Proposition 1 or by applying a reasoning analogous to that in Step 1.1 in that proof. Second, for $\rho \geq (\overline{v} + \mu)/(\mathbb{E}v - \mu)$ wage schedule $w^C(v) = 0, \forall v \in [\underline{v}, \overline{v}]$ satisfies (14). This follows from Step 1.2 in the proof of Proposition 1. Third, if a wage schedule $w^C(\cdot)$ satisfies (14) when $\rho = \rho_0$, then it also satisfies (14) when $\rho = \rho_1$, with $\rho_1 \geq \rho_0$. This follows from direct inspection of (14).

Having established the existence of $\widetilde{\rho}$, it is clear that collusion is sustainable if and only if $[\delta/(1-\delta)](1-p)/2 \geq \widetilde{\rho}$, or equivalently, $\delta \geq 2\widetilde{\rho}/(2\widetilde{\rho}+1-p)$ and $p < 1$. From this, it follows immediately that (i) collusion is never sustainable if $\delta < \lim_{p\to 0}[2\widetilde{\rho}/(2\widetilde{\rho}+1-p)] = 2\widetilde{\rho}/(2\widetilde{\rho}+1)$, which is $\widetilde{\delta}(0)$; and (ii) when $\delta > 2\widetilde{\rho}/(2\widetilde{\rho}+1)$, the minimal delta that sustains collusion $\widetilde{\delta}(p)$ is increasing in p. ■

Proof of Proposition 3. In each period, total surplus S corresponds to the production of the star worker. A star of type v produces v if he stays with the initial employer, and produces an extra μ if he joins a better matched employer. When firms collude, a star always stays with the initial employer. So $S = \mathbb{E}v$. When collusion is not sustainable, the star switches to a better matched employer if there is one and exclusivity is not enforced. This event occurs with probability $(1-p)\,\alpha$. So, when firms do not collude, $S = \mathbb{E}v + (1-p)\,\alpha\mu$. Finally, note that for $\delta < \widetilde{\delta}(0)$ collusion is never sustainable. For $\delta \geq \widetilde{\delta}(0)$, collusion is sustainable if and only if $\delta \geq \widetilde{\delta}(p)$. Since $\widetilde{\delta}(p)$ is increasing in p, this implies that when $\delta \geq \widetilde{\delta}(0)$, there exists $\widetilde{p}$ such that collusion is sustainable if and only if $p \leq \widetilde{p}$. Moreover, since $\widetilde{\delta}(p)$ is increasing in p, the cutoff $\widetilde{p}$ increases with δ. ■

Proof of Proposition 4. Suppose that $\delta > \widetilde{\delta}(0)$, so that a collusive equilibrium exists for some values of p. Let $\mathbb{P} \subseteq [0,1]$ denote the set of values of p for which a collusive equilibrium exists and $p_0, p_1 \in \mathbb{P}$ such that $p_1 > p_0$.

As a preliminary result, we start by showing that

$$\frac{\delta}{1-\delta}\frac{1}{2}(1-p_0)\mathbb{E}\left[v - \mu - w^C(v;p_0)\right] > \frac{\delta}{1-\delta}\frac{1}{2}(1-p_1)\mathbb{E}\left[v - \mu - w^C(v;p_1)\right]. \tag{15}$$

By optimality of $w^C(v;p_0)$, $w^C(v;p_0)$ maximizes $\mathbb{E}\left[v - \mu - w^C(v)\right]$ among all the wage schedules $w^C(\cdot)$ that satisfy (4) when $p = p_0$. Similarly, $w^C(v;p_1)$ maximizes $\mathbb{E}\left[v - \mu - w^C(v)\right]$ among all the wage schedules $w^C(\cdot)$ that satisfy (4) when $p = p_1$. This, together with the fact that if a wage schedule satisfies (4) when $p = p_1$ then it necessarily satisfies (4) when $p = p_0$, immediately implies that $\mathbb{E}\left[v-\mu-w^C(v;p_0)\right] \geq \mathbb{E}\left[v-\mu-w^C(v;p_1)\right]$. The inequality in (15) follows trivially from this and the fact that $p_1 > p_0$.

We next show that $w^C(v;p)$ is increasing in p. That is, we show that $w^C(v;p_1) \leq w^C(v;p_0), \forall v \in [\underline{v}, \overline{v}]$. Take an arbitrary $v_0 \in [\underline{v}, \overline{v}]$. Suppose first that $w^C(v_0;p_0) = 0$. The result is trivial in this case: $w^C(v_0;p_1) \geq w^C(v_0;p_0) = 0$ simply because wages must be non-negative. Suppose now that $w^C(v_0;p_0) > 0$. Because $w^C(v;p_0)$ is the most profitable collusive equilibrium and $w^C(v_0;p_0) > 0$, the no cheating condition $\tilde{\Pi}^C - \tilde{\Pi} \geq \left[v+\mu-w^C(v;p_0)\right]$ must bind for $v = v_0$. That is,

$$\frac{\delta}{1-\delta}\frac{1}{2}(1-p_0)\mathbb{E}\left[v-\mu-w^C(v;p_0)\right] = v_0+\mu-w^C(v_0;p_0). \tag{16}$$

Because $w^C(v;p_1)$ is sustainable by definition, $\tilde{\Pi}^C - \tilde{\Pi} \geq \left[v_0+\mu-w^C(v_0;p_1)\right]$. Using this no-cheating condition together with (15) and (16), we can write

$$\begin{aligned} v_0+\mu-w^C(v_0;p_0) &= \frac{\delta}{1-\delta}\frac{1}{2}(1-p_0)\mathbb{E}\left[v-\mu-w^C(v;p_0)\right] \\ &> \frac{\delta}{1-\delta}\frac{1}{2}(1-p_1)\mathbb{E}\left[v-\mu-w^C(v;p_1)\right] \\ &\geq v_0+\mu-w^C(v_0;p_1), \end{aligned}$$

which implies that $w^C(v_0;p_0) < w^C(v_0;p_1)$. This completes the proof that $w^C(v;p)$ is increasing in p.

We next show that $v^*(p)$ is decreasing in p. We do so by showing that $v^*(p_1) \leq v^*(p_0)$. If $v^*(p_0) = \overline{v}$, the result is trivial. So, suppose that $v^*(p_0) < \overline{v}$. By construction, $v^*(p_0)$ is the lowest value of v for which a collusive wage of zero is sustainable when $p = p_0$. Since $v^*(p_0) < \overline{v}$, this implies that

$$\frac{\delta}{1-\delta}\frac{1}{2}(1-p_0)\mathbb{E}\left[v-\mu-w^C(v;p_0)\right] = v^*(p_0)+\mu. \tag{17}$$

Using (17), (15), and the fact that when $p = p_1$ the no-cheating condition $\tilde{\Pi}^C - \tilde{\Pi} \geq [v^*(p_1)+\mu]$ must be satisfied, we can write

$$\begin{aligned} v^*(p_0)+\mu &= \frac{\delta}{1-\delta}\frac{1}{2}(1-p_0)\mathbb{E}\left[v-\mu-w^C(v;p_0)\right] \\ &> \frac{\delta}{1-\delta}\frac{1}{2}(1-p_1)\mathbb{E}\left[v-\mu-w^C(v;p_1)\right] \\ &\geq v^*(p_1)+\mu, \end{aligned}$$

which implies that $v^*(p_0) > v^*(p_1)$. ■

Proof of Proposition 5. Suppose that $\delta > \widetilde{\delta}(0)$, so that a collusive equilibrium exists for some values of p. Let $\mathbb{P} \subseteq [0,1]$ denote the set of values of p for which a collusive equilibrium exists and $p_0, p_1 \in \mathbb{P}$ such that $p_1 > p_0$.

We start by analyzing how workers' (stars) expected payoffs change with an increase of p from p_0 to p_1. Suppose first that $v^*(p_0) = \overline{v}$. Clearly, in this case, all workers' expected payoffs (weakly) increase, as $w^C(v;p_0) = 0\ \forall v \in [\underline{v}, \overline{v}]$ and wages must be non-negative. Suppose now that $v^*(p_0) < \overline{v}$. Workers of productivity $v \in [\underline{v}, v^*(p_1)]$ remain the same, as $w^C(v;p_0) = w^C(v;p_1) = 0\ \forall v \in [\underline{v}, v^*(p_1)]$. Workers of productivity $v \in (v^*(p_1), v^*(p_0)]$ are strictly better off, as $w^C(v;p_0) = 0$ and $w^C(v;p_1) = v - v^*(p_1) > 0\ \forall\ v \in (v^*(p_1), v^*(p_0)]$. Consider now the case of workers of productivity $v \in (v^*(p_0), \overline{v}]$. The change in the payoff of such a worker with productivity v, when p increases from p_0 to p_1, is $(1-p_1)w^C(v;p_1) - (1-p_0)w^C(v;p_0)$

and can be written as

$$(1 - p_1)[v^*(p_0) - v^*(p_1)] - (p_1 - p_0)[v - v^*(p_0)]. \tag{18}$$

Clearly, for $v \simeq v^*(p_0)$ (and $v > v^*(p_0)$), (18) is positive, since $v^*(p_0) - v^*(p_1) > 0$ and $p_1 < 1$ (recall that for $p_1 = 1$ a collusive equilibrium does not exist). If (18) is also positive for $v = \overline{v}$, then all workers are better off. If (18) is negative for $v = \overline{v}$, then by continuity of (18) in v there exists $\widetilde{v} \in (v^*(p_0), \overline{v})$ such that the payoffs of workers with productivity $v \in (v^*(p_0), \widetilde{v})$ increase when p increases from p_0 to p_1 and the payoffs of workers with productivity $v \in (\widetilde{v}, \overline{v})$ decrease when p increases from p_0 to p_1.

Finally, to observe that there are cases in which firms' expected payoffs fall when the enforcement level increases, suppose p_0 is such that $v^*(p_0)$ is smaller than $\overline{v}$ but sufficiently close to it so that $\widetilde{v} = \overline{v}$. If p increases to p_1, workers with ability $v \geq v^*(p_0)$ are better off while workers with ability $v < v^*(p_0)$ are either better off or remain the same. Thus, since some types of workers are better off and no type of worker is worse off, firms' expected payoffs must decrease. ■

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