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"*With workers in high demand, the most costly mistake they can make is leaving the bargaining table without asking for more.*" *New York Times*, April 15, 2022

1 Introduction

In April 2022, the *New York Times* ran an article on negotiating pay, recounting the job search experience of Sabrina Hill — a single parent with a degree in social sciences. Within a month, she had multiple job interviews and an offer paying $20.000 more in base salary than her old job as a data analyst. At that point, "she asked for perks she had never considered in previous negotiations, like restricted stock units," which she also received.

Sabrina Hill's experience showcases a broader phenomenon. The need to attract talented workers often forces firms to deviate from their preferred compensation design in order to outbid their competitors or accommodate workers' demands. Supporting the importance of such forces for compensation design, Edmans et al. (2022) conclude that: "*directors view labour market forces, and thus the participation constraint, as more important than [...] the incentive constraint.*" This problem has plagued the recruitment of both top executives and rank-and-file employees, with many firms unable to expand or maintain their operations because they cannot attract workers (Dunkelberg, 2022). Indeed, the vast majority of hiring managers expect job candidates to negotiate their compensation, with 30%-55% actually doing so (Hall and Krueger, 2012; Brenzel et al., 2014; RobertHalf, 2019). Reflecting this phenomenon, practical advice on how workers can negotiate higher compensation and handle multiple job offers has proliferated (Knight, 2017; DePaul, 2020). Yet the academic literature has remained largely silent on the topic. Existing work approaches compensation design primarily from the perspective of what is best for firms, focusing on problems such as screening out the best workers and incentivizing effort at the lowest compensation cost.

In this paper, we study how firms need to adjust the compensation they offer in order to attract talent in tight labor markets in which candidates can choose among different employers and negotiate their compensation. While both more-intense competition and negotiations lead to higher compensation *levels*, we show that negotiations are the primary reason for compensation *structure* to be distorted away from that preferred by firm owners. With private information about the value of firm-worker matches, firms prefer competing for workers by raising fixed wages, while workers often prefer negotiating for higher bonuses or option pay. We endogenize the equilibrium compensation structure by determining in which cases workers benefit more from focusing on negotiations rather than from increasing competition by generating additional offers and in which this relation is reversed. Notably, allowing workers to negotiate and firms to compete by choosing not only the level of pay but also its *structure* overturns the unambiguous dominance of higher competition obtained in the seminal work by Bulow and Klemperer (1996).[1]

Our analysis of negotiations and competition with endogenous compensation structure helps explain why in some industries, such as banking, the rise in compensation of scarce talent has mainly been driven by higher performance bonuses or equity-based pay (Bell and van Reenen, 2014); while in other occupations this rise is mainly due to higher fixed pay, such as base salary or sign-on bonuses. These differences in compensation structure matter from a corporate finance perspective, as they determine whether tight labor markets force firms to raise more external financing or share more of their profits with employees. The impact can be significant, as evidenced by the fact that in 2021, the median ratio of compensation expenses to capital expenditures in Compustat firms was 9.8.

We develop a model in which several firms compete to hire a (representative) worker whose skills are in short supply. Competition and negotiations between the worker and firms are plagued by asymmetric information about the productivity of the firms' existing physical and human capital and investment opportunities (henceforth, "productivity"), which determines the firms' private values from hiring the worker. As a result, the worker does not know how much any given firm is willing to pay to hire her but only that these values are identically and independently distributed across firms.[2] To disentangle the effects of competition and negotiations on compensation design and value, we assume that the worker needs to choose between two alternatives (cf., Bulow and Klemperer 1996). The first is to negotiate with the firms already interested in hiring her. Formally, negotiating means that the worker designs the optimal mechanism for "selling" her labor. The alternative is to attract an additional job offer to increase competition among firms, which then compete in a standard fashion by sequentially submitting contract offers in their preferred compensation design until no firm is willing to improve on the last standing offer (akin to an English auction).

The choice between these two alternatives can be interpreted in an applied context as a choice between "depth vs. breadth" in the worker's strategy to "sell" her labor. While outside of our model, negotiating (i.e., exercising bargaining power) requires workers to spend time and effort on obtaining the detailed information needed to formulate optimal compensation demands that firms will not view as "unreasonable," causing them to withdraw.[3]

[1]This conceptual insight has implications also for other settings in which negotiations and payment structure play a prominent role, such as, e.g., mergers and acquisitions. We provide a detailed discussion of the implications for M&A in the conclusion.

[2]Before joining a firm, workers typically have less information about its growth prospects, internal organization, and the quality of internal collaboration, which could give rise to such information asymmetry. We show that the qualitative insights are robust to endowing workers with private information.

[3]For example, the worker may need to obtain information on the firms' precise needs, their growth prospects, (financial) constraints, and compensation practices.

Alternatively, the worker can devote the same time and effort to additional applications or interviews, relying on the higher competition to drive her pay up.

We, first, study the impact of negotiations on compensation design. To build intuition, we initially consider negotiations with a single firm. Then, the optimal negotiation mechanism for the worker is a simple take-it-or-leave-it demand, which trades off rent-extraction and efficiency: While asking for higher compensation allows the worker to extract more rent from firms willing to pay more, it increases the probability that the demand will be rejected by firms at which the worker generates less value. A central insight from our model is that the *structure* of the worker's compensation demand — i.e., whether she negotiates for higher fixed or variable pay — affects the severity of this trade-off by affecting the worker's rent for any given probability with which her offer is accepted.

The central determinant of whether the worker optimally negotiates for higher fixed or variable pay is whether her skills create more value at low- or high-productivity firms.[4] Consider the latter case; for example, an engineer or an executive joins a growth firm at which her expertise *complements* the existing team and is, thus, particularly valuable if the existing team is of high quality. In this case, the worker optimally negotiates for higher variable compensation, such as performance bonuses or equity-based pay. Such compensation geared towards high cash flow states allows the worker to extract higher pay at high-productivity firms, in which she generates the most value. Simultaneously, less productive firms are willing to agree even to aggressive demands for variable pay since, for them, the expected cost of such compensation is low. Notably, negotiating for variable pay may, in some cases, allow the worker to extract the entire surplus without sacrificing efficiency.

The predictions reverse if low-productivity firms have a higher willingness to pay for the worker. This situation can arise if the worker's skills can *substitute* for the firm's lower-quality assets, e.g., when a firm hires a maintenance engineer or an executive with restructuring skills. In this case, the worker optimally negotiates for higher fixed pay, such as higher base pay or sign-on bonuses. Demanding fixed compensation is optimal because it reduces the likelihood that high-productivity firms will reject aggressive compensation demands since fixed wages leave most of the upside of higher productivity to the firm. Simultaneously, fixed wages allow the worker to extract more rent from low-productivity firms that benefit more from hiring. In fact, workers would be even better off if they could negotiate for compensation that pays them more in low- than high-cash-flow states. However, standard financial contracting arguments rule out such compensation, as it may create incentives for the worker to sabotage

[4] One may think of the former case as inducing "adverse selection" when low productivity firms are more likely to accept any given compensation demand; and of the latter case as inducing "advantageous selection" when high productivity firms are more likely to accept.

the firm (Innes, 1990). As a consequence, full rent extraction is never possible in this case.

Suppose, next, that the worker chooses not to negotiate, which leaves compensation design to firms but frees her up to generate an additional job offer. The key difference relative to the case of negotiations is that firms prefer to compete on fixed wages, *regardless* of whether workers generate more value at low- or high-productivity firms. The reason is that, unlike variable pay, the value of which depends on the firm's private information, fixed wages are minimally affected by information asymmetries. Thus, by competing on fixed pay, firms can avoid that workers undervalue their compensation offers.

The worker's optimal choice between the two alternatives of negotiating and generating more offers depends on whether her preferred compensation structure in negotiations differs from the fixed pay structure that firms prefer when competing to hire the worker. Specifically, when the worker generates more value at more productive firms, negotiating for variable instead of fixed pay allows the worker to extract much more of the surplus she generates at the firms interested in hiring her. Sometimes the worker can even achieve (close to) full surplus extraction in negotiations, which is a sufficient condition for negotiating with n firms to dominate competition on fixed wages among $n + 1$ firms. Hence, negotiating can be better than attracting additional competition when the worker's skills complement the firms' existing businesses.

By contrast, preferences over compensation structure are aligned if the worker generates more value at low-productivity firms. In this case, the best the worker can do is to negotiate for higher fixed wages, which is also the type of compensation that firms prefer when competing to hire the worker. Consequently, with the contract space effectively restricted to fixed payments, Bulow and Klemperer's (1996) well-known result applies that focusing on generating an additional offer is preferable to negotiating.

We extend our core insights in several directions. First, we characterize the optimal mechanism for workers to "sell" their human capital when negotiating with multiple firms. We do so by restricting attention to posterior implementable mechanisms under which only the firm with the highest willingness to pay for labor (if any) hires and pays the worker. Under these realistic restrictions, we show that an intuitive modification of a standard two-stage mechanism maximizes the worker's expected compensation: In the first stage, the worker lets firms compete on the level of compensation — e.g., with fixed-wage offers as in a standard English auction — in order to identify the firm with the highest willingness to pay. In the second stage, the worker optimally negotiates only with the last remaining firm by formulating a take-it-or-leave-it compensation demand, specifying both the level and the structure of pay. As discussed, the optimal compensation structure that the worker demands in the last stage then depends on whether or not the worker's skills are complementary to the firm's business.

We extend this simple mechanism to allow firms to freely choose the type of compensation they want to compete on — e.g., any mix of fixed and equity-based pay — in the first stage. We show that the worker can overcome the challenge of ranking different types of offers by posing the following question: "*What would be the compensation contracts' expected values if each firm were indifferent between hiring and not hiring under the contract it offers?*" Ranking offers based on this question guarantees that the worker correctly ranks and values the compensation offer at which the respective firm would drop out from trying to hire the worker, i.e., at which it is indifferent between hiring and not hiring. This ensures that the firm with the highest willingness to pay outbids its competitors; and that the worker can perfectly infer the valuations of all firms that withdraw.

We close our analysis by investigating the interaction between equilibrium compensation and firm financing. Compensation level and structure affect firms' financing needs and whether workers or outside investors join the firms' investor base. In turn, financing constraints affect compensation. Specifically, cash constraints lead firms to inflate their compensation offers when competing for workers that create more value at more productive firms. In this case, investors overestimate the benefit of hiring at the compensation offer at which workers extract the entire surplus. The resulting cheap financing distorts the highest wage that the firm is willing to offer upward. By contrast, when workers create more value at less productive firms, banks tend to underestimate the benefit of hiring. The resulting expensive financing depresses wages.

Related Literature. Our work provides a framework for understanding how competition for talent and compensation negotiations affect the level and the structure of pay both at and below the executive level. The key departure from the standard approach of modeling competition for workers as a sequential auction (Postel-Vinay and Robin, 2002; Cahuc et al., 2006; Bagger et al., 2014) is to investigate the impact of asymmetric information between workers and firms on compensation design.

With asymmetric information, compensation structure becomes a central determinant of how surplus in negotiations is shared. Our paper complements prior work that explains the impact of worker bargaining power on compensation design by focusing on product instead of labor market competition (Bova and Yang, 2017). While we share Bova and Yang's (2017) prediction of the optimality of fixed compensation in the case in which low-productivity firms benefit more from hiring, our model predicts that workers optimally negotiate for option pay in the case in which they create more value at higher-productivity firms. In the latter case, our results are closer to Benabou and Tirole (2016) who show that bonuses can help firms screen out workers' private information. Instead, our negotiation mechanism characterizes optimal compensation design from the worker's perspective.

Our analysis of whether the worker is better off spending her limited time and effort to determine the optimal negotiation mechanism or to increase competition adds to standard models of wage determination in which workers improve their compensation by searching for new offers (e.g., Postel-Vinay and Robin, 2002). While the choice between negotiating and increasing competition has been prominently studied in the auction literature for the case of cash offers (Bulow and Klemperer, 1996), we allow for compensation in the form of fully general state-contingent contracts. By endogenizing the payment structure, we overturn the classical prediction that increasing competition is always better than negotiating. In particular, if the worker's skills are complementary to the firms' business, she is better off negotiating for variable compensation.

Beyond compensation negotiations, our insights have broader implications in the context of M&A, where state-contingent payments and negotiations are also frequently observed (see Section 7 for a discussion). In particular, our analysis highlights the importance of the payment method in negotiations and provides an alternative explanation for target firms' frequent preference for negotiations. Prior explanations of this preference have focused, instead, on asymmetrically informed firms (Povel and Singh, 2006), valuations drawn from different distributions (Eckbo et al., 2020), and the preservation of secrecy (Hansen, 2001).

Another contribution of our paper is to derive the optimal selling mechanism when compensation can be in general state-contingent claims. Deriving such a mechanism is challenging since the standard regularity conditions imposed in the optimal mechanism design literature are not satisfied. Thus, prior work has focused on finding corresponding conditions for linear instruments, such as equity, where optimal mechanisms can be identified (Liu and Bernhardt, 2019, 2021). Instead, our approach is to show optimality within the class of posterior-implementable mechanisms in which only the firm willing to pay most for labor (if any) hires (see Lopomo, 2000). The appeal of the optimal negotiation mechanism we obtain — letting firms compete with any type of compensation they want and negotiating only with the last remaining firm — is that it is simple, intuitive, and "details-free."

More broadly, our paper contributes to the discussion of why firms offer equity-based compensation, even though it often lacks incentive benefits below the top executive level (Holmström, 1982).[5] Our explanation that negotiating for such compensation can increase workers' expected pay conceptually complements theories studying the link between equity-

[5] Prior work has explained this by arguing that equity-based compensation helps by: avoiding wage renegotiations when the firm's equity value is correlated with the workers' outside options (Oyer, 2004); aligning the incentives of managers with the interests of investors (Lazear, 2004); exploiting the overoptimism of boundedly rational workers (Bergman and Jenter, 2007); providing a hedge against not being promoted (Chen, 2020); or hedging Knightian uncertainty (Fulghieri and Dicks, 2019).

based pay and competitive bidding. These theories have used the Linkage Principle to show that equity-based instruments stimulate more competition than cash bids do (DeMarzo et al., 2005). By contrast, competition is *irrelevant* to the optimality of equity-based pay in our analysis. Our explanation is closest to Hansen (1987) who also studies the role of payment structure in mitigating a rent extraction efficiency trade-off. By showing that the preference for equity-based or fixed pay depends on whether workers generate less or more value at more productive firms, our analysis complements and generalizes Hansen's results.

2 Model

We study a parsimonious model investigating the impact of competition for scarce talent and pay negotiations on compensation design. While we frame our analysis in the context of firms competing for workers in tight labor markets, we discuss another application of our theory to mergers and acquisitions — in which acquirers compete for and negotiate with a target — in Section 7.

Our baseline model features two deep-pocketed firms $i = 1, 2$ that are interested in hiring a single worker (she), which could also be thought of as representing a group of workers. We extend the analysis to $n > 2$ firms in Section 4. There are three stages: An application stage, $t = 0$, in which the worker chooses at which firm(s) to apply; a hiring stage, $t = 1$, in which compensation offers are extended and negotiated, and the worker decides which firm (if any) to join; and a final production stage, $t = 2$, in which firms undertake their projects, cash flows are realized, and the worker is compensated. All parties are risk-neutral, and there is no discounting.

Projects and firm types. Each firm i seeks to hire the worker to run a project that can either fail, in which case cash flow is low and equal to $x > 0$, or succeed, in which case cash flow is high, $x + \Delta x > x$.[6] Each firm's probability of success depends on two firm-level factors. First, it depends on the productivity (or quality) of the firm's or the hiring unit's "existing business," which consists of all its tangible and intangible assets. We denote this productivity by θ_i and sometimes refer to as the firm's "type." Productivity is each firm's private information, and outsiders only know that it is drawn, independently for each i, from distribution F_i with support normalized to $[0, 1]$. Second, firm i's success probability depends on the outcome h_i of its hiring efforts, where $h_i = H$ denotes that firm i was successful in hiring the worker and $h_i = N$ indicates that firm i could not hire. Denoting the probability

[6] The binary cash flow assumption is for illustrative purposes only. All results extend to the case of continuous cash flows, given standard assumptions on the production technology similar to Nachman and Noe (1994).

of firm i realizing high cash flow by $p_{h_i}(\theta_i)$, we assume that $p_{h_i}(\theta_i)$ is strictly increasing in θ, i.e., $\frac{\partial}{\partial\theta}p_{h_i}(\theta) > 0$ for all h_i, and that hiring benefits the firms, i.e., $p_H(\theta_i) > p_N(\theta_i)$ for all θ_i.

While hiring always increases firm value, the value of hiring can be higher or lower for more productive firms. The case in which hiring creates more value at more productive firms, $\frac{\partial}{\partial\theta_i}\left[p_H\left(\theta_i\right) - p_N\left(\theta_i\right)\right] \geq 0$, arises when the worker's skills are complementary to the firm's existing business (as is often the case with high-skilled workers). The opposite case in which hiring creates less value at more productive firms, $\frac{\partial}{\partial\theta_i}\left[p_H\left(\theta_i\right) - p_N\left(\theta_i\right)\right] < 0$, arises in the case of substitutes (as documented for low-skilled labor; jobs at risk of automation; or jobs in which the worker's skills substitute for lower-quality assets, such as in the examples of a maintenance engineer or an executive with restructuring skills). To simplify the presentation in the main text, we will rely on a simple linear specification of the probability of success,

$$p_h\left(\theta_i\right) = p_h + \Delta_h\theta_i, \text{ for } h \in \{H, N\}, \ \theta_i \in [0,1], \tag{1}$$

where $p_h, \Delta_h > 0$, $p_h + \Delta_h \leq 1$, and $p_H + \Delta_H\theta_i > p_N + \Delta_N\theta_i$ for all θ_i. Given the specification in (1), the worker generates more value at higher-productivity firms if $\Delta_H/\Delta_N \geq 1$ and more value at lower-productivity firms if $\Delta_H/\Delta_N < 1$. It is important to note, however, that our qualitative results do not depend on the concrete functional form in (1) and we will comment throughout on how our results extend beyond the linear case.[7]

Compensation Contracts. Upon successful hiring by firm i, its owners split cash flow with the worker according to a compensation contract $\{w_i, \Delta w_i\}$ that stipulates a payment to the worker of w_i in the low cash flow state and of $w_i + \Delta w_i$ in the high cash flow state. We refer to w as fixed pay and to Δw as variable pay, where we drop the subscript i where it does not lead to confusion. The worker has an outside option of $\underline{w} \geq 0$, which can be thought of as expected compensation in her current employment, in unemployment, or from restarting the job search. We stipulate that all n firms are "serious employers," in the sense that their willingness to pay for the worker exceeds the worker's outside option, i.e., $\left(p_H\left(\theta\right) - p_N\left(\theta\right)\right)\Delta x \geq \underline{w}$ for all θ. Furthermore, we assume that the worker is protected by limited liability and that contracts are monotone, $w, \Delta w \geq 0$. Intuitively, the latter assumption means that the worker should have no incentives to sabotage the project in the high cash flow state (Innes, 1990). Contract offers are determined in a competitive negotiation process that we describe next.

[7] Our insights extend to a formulation of the expected cash flows from production nesting both binary as well as continuous cash flows: $\Pi(K, L, \theta) := \Pi\left(\left(v\left(\theta K\right)^{\sigma} + \left(1-v\right)L^{\sigma}\right)^{\frac{1}{\sigma}}\right)$, where K and L stand for the level of capital and labor investments, and θ captures the firm's capital productivity. The sign of the cross partial of the production function with respect to labor and capital (productivity), which in our formulation corresponds to $\frac{\partial}{\partial\theta_i}\left[p_H\left(\theta_i\right) - p_N\left(\theta_i\right)\right]$, captures whether the worker's skills and firms' existing capital are complements or substitutes.

Negotiations and Competition. We differentiate between competition, as captured by the number of firms attempting to hire the worker in $t = 1$, and negotiations (bargaining power), which is captured by whether the worker can choose the optimal way to "sell" her labor. While both negotiating and generating higher competition benefit the worker, we are interested in the trade-off between the two in the process of finding new employment. In particular, following Bulow and Klemperer (1996), at $t = 0$ the worker has to decide whether "...to devote resources to expanding the market than to collecting the information and making the calculations required to figure out the best mechanism (p.108)."[8] Our key addition is to allow for general state-contingent payments.

In our baseline model, if the worker chooses to negotiate, she faces only one firm in $t = 1$ such that the optimal negotiation mechanism consists of a take-it-or-leave-it contract offer of the form $\{w, \Delta w\}$ including menus of such contracts.[9] If instead, the worker chooses to increase competition, she faces two firms in $t = 1$. In this case, the firms compete via alternating offers of the form $\{w_i, \Delta w_i\}$ $i = 1, 2$ until one firm is no longer willing to improve on the competitor's last standing offer. Notably, in this case, it is firms that decide on the level and structure of their compensation offers, while the worker can only decide whether to accept or reject the last standing offer. This way of modeling competition when firms compete on fixed compensation is akin to a standard English auction. In our analysis, we also discuss how the worker compares offers when they differ in structure (e.g., equity offers with fixed wages) and show that the way we model competition is without loss of generality. Once we have analyzed the model described above, we extend it to multiple firms ($n \geq 2$).

Once we have characterized the impact of competition and negotiations on compensation, we turn to the question of how competition and negotiations interact with cash constraints. We do so in Section 5, where we also investigate the implications for external financing.

3 Competition, Negotiations, and Compensation

We solve the model backward. First, we characterize the equilibrium compensation design arising in the different regimes of the baseline model at $t = 1$ — i.e., under negotiations with

[8] Intuitively, negotiating means that workers place demands to firms about their compensation levels or compensation structure that firms might not have offered otherwise. Formulating "reasonable" demands that will not lead firms to withdraw interest involves spending time on learning more about the firms' needs, teams, growth prospects, constraints, or other information to be used in negotiations. The alternative to negotiations is that the worker devotes the same time to more applications and interviews to find one more firm willing to hire her, thereby increasing competition.

[9] More generally, the idea is that "learning how to negotiate" allows the worker to exercise bargaining power in compensation negotiations. However, analyzing intermediate distributions of bargaining power is challenging, as there is no universally accepted solution concept, such as Nash bargaining, when information is asymmetric.

one firm (Section 3.1) and competition among two firms (Section 3.2), respectively. Subsequently, we derive the expected value of compensation under negotiation and competition, which determines the worker's optimal choice between the two regimes at $t = 0$ (Section 3.3).

3.1 Compensation Design in the Negotiation Regime

Suppose that the worker has chosen to (devote her limited resources to learning how) to negotiate at $t = 0$. As a result, the worker can exercise the bargaining power to make a take-it-or-leave-it offer at $t = 1$ to the single firm that has expressed interest in hiring her. This offer consists of the compensation package the worker "demands" in order to join the firm.[10] The advantage of initially restricting attention to negotiations with one firm is that the optimal negotiation mechanism is simple (it is a single take-it-or-leave-it offer), which allows us to focus on the implications for compensation design.

If information were symmetric, the worker could condition her compensation demand on the firm's productivity θ. That is, for any given θ, the worker can demand a contract that makes the firm indifferent between hiring and not hiring

$$x - w + p_H(\theta)(\Delta x - \Delta w) = x + p_N(\theta)\Delta x. \tag{2}$$

This contract extracts all surplus that the worker generates at the firm. Moreover, it ensures that the worker is hired, which from our "serious employer" assumption, is efficient since it maximizes the joint surplus of the worker-firm pair.

The problem under asymmetric information about the firm's type is that the worker does not know how much value she creates at the firm. In particular, the contract cannot condition on θ, and the first-best outcome of efficiency with full surplus extraction can be achieved if and only if there exists a feasible contract $\{w, \Delta w\}$ under which the firm's participation constraint is binding regardless of the firm's productivity type θ. From condition (2), such a first-best contract $\left\{w^{fb}, \Delta w^{fb}\right\}$ would stipulate that

$$\Delta w^{fb} = \left(1 - \frac{\Delta_N}{\Delta_H}\right)\Delta x, \tag{3}$$

$$w^{fb} = p_H\left(\frac{\Delta_N}{\Delta_H} - \frac{p_N}{p_H}\right)\Delta x, \tag{4}$$

[10] Under asymmetric information about the firm's type, θ, both firms are ex-ante identical from the worker's perspective, and it is irrelevant which firm $i \in \{1, 2\}$ has expressed interest in hiring the worker. Accordingly, we will drop the index i in the respective analysis.

where we have used the functional form of p_{h_i}, given by expression (1). This first-best contract is feasible if $w^{fb}, \Delta w^{fb} \geq 0$, which requires that $1 \geq \frac{\Delta_N}{\Delta_H} \geq \frac{p_N}{p_H}$ or, equivalently (for use below) that $1 \leq \frac{\Delta_H}{\Delta_N} \leq \frac{p_H}{p_N}$. That is, a necessary condition for the existence of a feasible first-best contract is that the worker generates more value at more productive firms. Clearly, if it is feasible, the first-best contract is optimal.

For the case in which first-best is not feasible, let W denote a (possibly degenerate) menu of contracts and let $\Omega_W \subseteq [0,1]$ be the set of types accepting a contract from this menu. Given the application, we restrict attention to deterministic mechanisms in which the worker joins the firm with probability one if a contract is accepted. Denote the contract accepted by a firm of type $\theta \in \Omega_W$ by $\{w_\theta, \Delta w_\theta\}$. The worker's problem is to choose W to maximize her expected payoff

$$\int_{\Omega_W} \left(w_\theta + p_H\left(\theta\right) \Delta w_\theta\right) dF\left(\theta\right) + \int_{[0,1]\setminus\Omega_W} \underline{w} dF\left(\theta\right) \tag{5}$$

subject to feasibility, $w_\theta, \Delta w_\theta \geq 0$, individual rationality, and incentive compatibility:

$$\begin{aligned} x + p_N\left(\theta\right) \Delta x &\leq x - w_\theta + p_H\left(\theta\right)\left(\Delta x - \Delta w_\theta\right) \\ &= \max_{\{w,\Delta w\}\in W} \left\{x - w + p_H\left(\theta\right)\left(\Delta x - \Delta w\right)\right\} \text{ for } \theta \in \Omega_W, \\ x + p_N\left(\theta\right) \Delta x &> \max_{\{w,\Delta w\}\in W} \left\{x - w + p_H\left(\theta\right)\left(\Delta x - \Delta w\right)\right\} \text{ for } \theta \notin \Omega_W. \end{aligned}$$

Whenever $\Omega_W \neq [0,1]$, the worker sacrifices efficiency to achieve higher rent extraction. In what follows, we solve this problem for the case in which the worker's skills and the firm's business are complements. Subsequently, we turn to the case in which they are substitutes.

3.1.1 The Case of Complements

Suppose, first, that workers create more value at more productive firms, i.e. $\frac{\Delta_H}{\Delta_N} \geq 1$. In this case, the first-best contract is not feasible if $\frac{\Delta_H}{\Delta_N} > \frac{p_H}{p_N}$. Then, this contract would require paying the worker a negative fixed wage, $w^{fb} < 0$ (see (4)). Intuitively, to extract the value generated by her labor, the worker demands compensation that pays her more in the high cash flow state (i.e. has a large upside Δw). Such compensation allows the worker to extract more value from more productive firms, as they are more likely to generate high cash flows. However, granting the worker too much of the upside can make hiring unprofitable for the firm (unless the worker's fixed pay is negative). Hence, the worker faces a trade-off between rent extraction and efficiency: more aggressive demands for compensation can extract more of the value she generates for a high-type firm, but such demands are more likely to be rejected. In what follows, we formalize this trade-off.

Let $\{w, \Delta w\} \in W$ and define $\widetilde{\theta}(w, \Delta w)$ as the type indifferent between hiring and not hiring for this contract. From the binding participation constraint in (2) it holds that

$$\widetilde{\theta}(w, \Delta w) \equiv \frac{w + p_N \Delta x - p_H (\Delta x - \Delta w)}{\Delta_H (\Delta x - \Delta w) - \Delta_N \Delta x}. \tag{6}$$

Since the firm's expected payoff from hiring compared to non-hiring increases in its type, all types $\theta \geq \widetilde{\theta}(w, \Delta w)$ prefer hiring under contract $\{w, \Delta w\}$ to not hiring.[11] Hence, all such types will choose a contract from W (as they can always choose $\{w, \Delta w\}$). Now take $\widetilde{\theta}$ – in a slight abuse of notation – to be the lowest type that accepts a contract from W, such that we have $\Omega_W = [\widetilde{\theta}, 1]$. The rent extraction-efficiency trade-off is readily apparent: demanding higher compensation (higher w or Δw) will raise $\widetilde{\theta}$ and, thus, reduce the set of types that choose to hire.

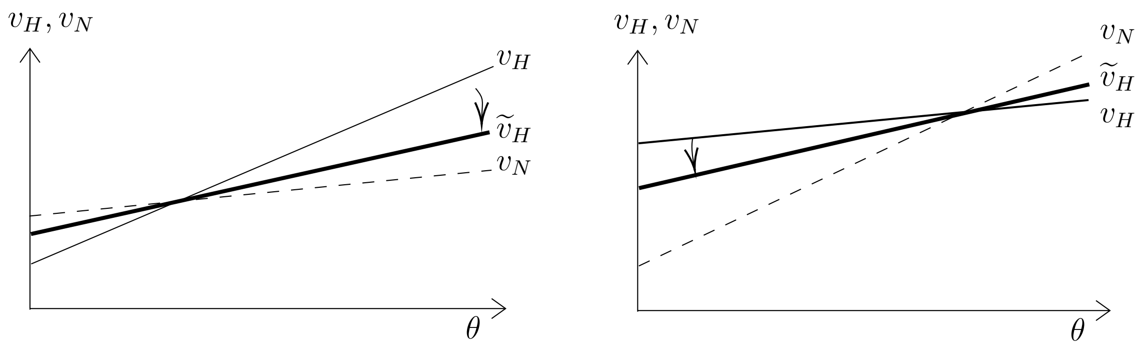
A contract that pays the worker only in the high cash flow state mitigates this trade-off. To see this, consider the compensation design problem of maximizing the worker's expected compensation for a *given* $\widetilde{\theta}$. Since the set of types, $[\widetilde{\theta}, 1]$, that hire is fixed, the total expected surplus from hiring is fixed. Thus, maximizing expected compensation amounts to minimizing types' $\theta \geq \widetilde{\theta}$ information rent, i.e., the share of the surplus that goes to the types accepting the worker's offer. Specifically, a firm's information rent from hiring a worker with compensation contract $\{w, \Delta w\}$ can be expressed as

$$\begin{aligned} & x - w + p_H(\theta)(\Delta x - \Delta w) - x - p_N(\theta)\Delta x \\ = \; & (\theta - \widetilde{\theta})(\Delta_H(\Delta x - \Delta w) - \Delta_N \Delta x). \end{aligned} \tag{7}$$

This rent is strictly positive for all types $\theta > \widetilde{\theta}$ when first best is not feasible. As expression (7) illustrates, extracting more rent from higher types, requires shifting the worker's compensation from the low to the high cash flow state (i.e., minimizing $\Delta x - \Delta w$: see Panel A in Figure 1). That is, the optimal contract offer for which types $[\widetilde{\theta}, 1]$ accept stipulates $w = 0$. The variable compensation is pinned down by the participation constraint for type $\widetilde{\theta}$ as $\Delta w(\widetilde{\theta}) = \left(1 - \frac{p_N(\widetilde{\theta})}{p_H(\widetilde{\theta})}\right)\Delta x$. One implementation of such a contract that pays the worker only in the high cash flow state is via call options. No menu of contracts can improve on this offer, as any non-degenerate menu would have to include a compensation contract with $w > 0$ and would leave more of the surplus to the firm.

The final step in solving the worker's problem is to determine the optimal cutoff type

[11] To see this, suppose to a contradiction that $\frac{\partial}{\partial \theta} p_H(\theta)(\Delta x - \Delta w) < \frac{\partial}{\partial \theta} p_N(\theta)\Delta x$ at $\widetilde{\theta}$, i.e., that $\Delta w \geq \left(1 - \frac{\Delta_N}{\Delta_H}\right)\Delta x$. Plugging into (6), we obtain that $w \leq p_H\left(\frac{\Delta_N}{\Delta_H} - \frac{p_N}{p_H}\right)\Delta x < 0$, violating feasibility.



Panel A: Complements. **Panel B**: Substitutes.

Figure 1: **Rent extraction via compensation design.** In both panels, the dashed line depicts the firm's expected payoff if it does not hire $v_N(\theta)$, while the solid lines illustrate the firm's expected payoff if it hires under a suboptimal contract $v_H(\theta)$ (thin solid line) and under the optimal contract $\tilde{v}_H(\theta)$ (thick solid line) for the same cutoff type $\widetilde{\theta}$.

$\widetilde{\theta}^*$. Doing so is straightforward: $\widetilde{\theta}^*$ can be obtained as the maximizer of the worker's expected compensation in (5) by using that $w = 0$, $\Delta w = \left(1 - \frac{p_N(\widetilde{\theta})}{p_H(\widetilde{\theta})}\right) \Delta x$ and $\Omega_W = [\widetilde{\theta}, 1]$. The following Proposition characterizes the solution of the worker's problem for the case of complements.

Proposition 1 *Suppose that the worker creates more value at more productive firms, i.e., $\frac{\Delta_H}{\Delta_N} \geq 1$, and can make a take-it-or-leave-it offer to the firm. Then, if the first-best contract is feasible ($\frac{\Delta_H}{\Delta_N} \leq \frac{p_H}{p_N}$), the worker demands $\left\{w^{fb}, \Delta w^{fb}\right\}$ as characterized in (3) and (4). Else, the worker demands a contract with only variable but no fixed pay ($\Delta w(\widetilde{\theta}^*) > 0$, $w = 0$). No menu can improve on these contracts.*

We close this section by noting that the optimal cutoff $\widetilde{\theta}^*$, chosen under the optimal compensation design, is lower and, thus, more efficient than the cutoffs the worker would choose when restricted to any other compensation design. Intuitively, call options allow workers to demand compensation that is affordable to low-productivity firms while simultaneously helping workers extract high compensation from high-productivity firms.

3.1.2 The Case of Substitutes

If the worker creates more value at less productive firms, i.e., $\frac{\Delta_H}{\Delta_N} < 1$, she faces the opposite problem: extracting all surplus from both low- and high-productivity firms requires that the worker's expected compensation decreases in the firm's productivity. This is not feasible, as it would require that the worker is paid less in the high cash flow state than in the low cash flow state, i.e., $\Delta w^{fb} < 0$, which violates the monotonicity requirement that $\Delta w \geq 0$. Thus, there is again a trade-off between rent extraction and efficiency. However, in this case, it is the higher types that are more likely to reject the worker's offers, as they have a lower willingness to pay for labor. That is, efficiency losses arise at the top, i.e., $\Omega_W = [0, \widetilde{\theta}]$, where $\widetilde{\theta}$ is the highest type that accepts an offer from W.

Analogous to the expression in (7), we can write the firm's information rent as

$$(\widetilde{\theta} - \theta)\left(\Delta_N \Delta x - \Delta_H \left(\Delta x - \Delta w\right)\right), \tag{8}$$

which is strictly positive for all $\theta < \widetilde{\theta}$, since $\Delta w \geq 0$. As expression (8) illustrates, extracting more rent from lower types, while keeping the set of types $[0, \widetilde{\theta}]$ that accepts the worker's offer unchanged, requires shifting the worker's compensation from the high to the low cash flow state (i.e., her claim on the upside Δw decreases: see Panel B in Figure 1). Hence, a simple fixed-wage contract (for which $\Delta w = 0$) is optimal. Once again, no menu of contracts can improve on this offer, as any non-degenerate menu would have to include a compensation contract with $\Delta w > 0$ and would leave more of the surplus to the firm. Intuitively, when low productivity firms benefit more from hiring, extracting a higher expected compensation from such firms requires shifting compensation to the (low) cash flow states that such firms are more likely to generate.

Proposition 2 *Suppose that the worker creates more value at less productive firms, i.e.,* $\frac{\Delta_H}{\Delta_N} < 1$ *and the worker can make a take-it-or-leave-it offer to the firm. Then, the worker demands a contract with only fixed and no variable pay* ($w(\widetilde{\theta}^*) > 0$, $\Delta w = 0$)*. No menu can improve on this contract.*

Finding the optimal cut-off type $\widetilde{\theta}^*$ is again straightforward: It is determined from program (5) by using that $\Delta w = 0$, $w = (p_H(\widetilde{\theta}) - p_N(\widetilde{\theta}))\Delta x$, and $\Omega_W = [0, \widetilde{\theta}]$. Once again, the ability to extract more rent for any given cutoff mitigates the worker's rent-extraction efficiency trade-off and leads her to choose a more efficient (higher) cutoff.

We close the discussion of equilibrium compensation when the worker negotiates with one firm by noting that both Propositions 1 and 2 extend beyond the case of linear success probabilities, $p_H(\theta)$ and $p_N(\theta)$. If the case of complements, the only requirement we need is that for all compensation contracts, the firm's expected value from hiring $v_H(\theta) = x - w + p_H(\theta)(\Delta x - \Delta w)$ crosses its expected payoff from not hiring $v_N(\theta) = x + p_N(\theta)\Delta x$ only once from below (see Panel A in Figure 1). For the case of substitutes, the requirement is that $v_H(\theta)$ crosses $v_N(\theta)$ only once from above (Panel B in Figure 1) — a condition that is always satisfied in this case.

Taken together, Propositions 1 and 2 provide a novel rationale for why and when firms use (broad-based) option pay. Such compensation is optimal to attract workers with strong a bargaining position when workers create more value at more productive firms but not when workers create more value at less productive firms (possibly substituting for lower-quality assets).

3.1.3 Robustness: Private Information on Workers' Instead of Firms' Side

The qualitative compensation design results of Propositions 1 and 2 do *not* depend on whether the worker or the firm is better informed. In Proposition B.1 in Appendix B.1, we solve for a version of the model in which the worker has private information about the firm's true productivity type — possibly because she is an expert in the field, and the firm lacks such experts.[12] Then, we have a game of signaling in which the worker's choice of compensation can signal information about the quality of the worker-firm match. We show that in the equilibrium of this game, the worker chooses compensation in call options if her skills are complementary to the firm's business. By contrast, she chooses fixed wages if her skills generate more value at less productive firms. We relegate a detailed discussion of the intuition behind these results as well as all formal derivations to Appendix B.1.

3.2 Compensation Design in the Competition Regime

We discussed above the case in which the worker chooses to negotiate. Next, we discuss the case in which the worker chooses to devote her limited resources at $t = 0$ to find another firm interested in hiring, which increases competition among firms at $t = 1$ but comes at the expense of leaving bargaining power with firms. Specifically, it is now firms that decide both on the level as well as on the structure of compensation they want to offer facing competition for the worker. In order to disentangle the effects of differences in competition and bargaining power, we, first, solve the problem in which a single firm makes a take-it-or-leave-it offer to the worker. Doing so allows us to isolate the effect on compensation design coming from the shift in bargaining power from the worker to the firm. Building on this benchmark case, we subsequently add the effect of increasing competition.

Compensation when a single firm can make a take-it-or-leave-it offer. If the firm can make a take-it-or-leave-it-offer to the worker, the worker accepts if and only if her expected on-the-job compensation at least matches her outside option given her posterior

[12] Alternatively, we could assume that the worker's information, θ, is about her ability. The analysis will then correspond to the case in which the worker's skills complement the firm's business, as it is unlikely that the worker's type affects the firm's outside option of not hiring.

belief about the firm's type θ

$$w + \int_0^1 p_H(\theta)\, d\widetilde{F}(\theta \,|\{w, \Delta w\})\, \Delta w \geq \underline{w}. \tag{9}$$

Here, the cumulative density function $\widetilde{F}(\theta \,|\{w, \Delta w\})$ denotes the worker's posterior over θ after receiving the offer $\{w, \Delta w\}$. We use perfect Bayesian equilibrium as the equilibrium concept for this signalling game of incomplete information. That is, on the equilibrium path, $\widetilde{F}$ is formed using Bayes rule. To deal with potential multiplicity of equilibria, out-of-equilibrium beliefs are refined using Cho and Kreps' (1987) Intuitive Criterion.

For any given contract that the worker accepts, the firm's expected payoff net of its outside option is given by

$$x - w + p_H(\theta)(\Delta x - \Delta w) - x - p_N(\theta)\, \Delta x. \tag{10}$$

The firm's problem is to design the offer $\{w, \Delta w\}$ such as to maximize (10), subject to (9) and $w, \Delta w \geq 0$.[13]

The firm's optimal solution to this problem is to offer a fixed wage. Intuitively, the advantage of a fixed wage w is that its value for the worker is independent of the firm's private information θ, since w is paid in all cash flow states.[14] In contrast, the value of all other compensation contracts depends on θ such that they suffer from misvaluation in equilibrium, increasing compensation costs. In the unique equilibrium, the firm offers the lowest fixed wage that ensures that the worker accepts the contract offer.

Lemma 1 *If a single firm makes a take-it-or-leave-it offer to the worker, the firm hires the worker under a fixed-wage contract with $w = \underline{w}$ and $\Delta w = 0$ for all firm types θ.*

Comparing equilibrium compensation when the firm can make a take-it-or-leave-it offer (Lemma 1) with when the worker can do so (Propositions 1 and 2), we see that the distribution of bargaining power matters not only for the level but also for the structure of compensation. In particular, our simple model of asymmetric information about firm type predicts compensation in fixed pay whenever firms have (all the) bargaining power, independent of whether the worker generates more value at more or less productive firms. By contrast, the latter distinction leads to fundamentally different predictions for equilibrium

[13] The "serious employer" assumption ensures that the firm's willingness to pay for the worker exceeds the worker's outside option. Optimality of hiring for any firm type θ follows from the observation that a fixed wage contract with $w = \underline{w}$ and $\Delta w = 0$ is always accepted by the worker.

[14] This intuition is standard and closely related to the explanation for why firms use debt financing when raising capital under asymmetric information (Nachman and Noe, 1994).

compensation structure if workers have a strong bargaining position. While our focus here is on compensation design, we further note that the distribution of bargaining power also has efficiency implications. While the worker is always successfully hired when bargaining power is in the hands of the firm, this is not generally the case when bargaining power is in the hands of the worker.

It is worth noting that the qualitative result of Lemma 1 also does not depend on whether the worker or the firm is better informed about θ. It is easy to see that a uniform contract of the form $w = \underline{w}$ and $\Delta w = 0$ achieves efficiency and full surplus extraction also in the case in which the worker is privately informed about the value of the worker-firm match.

Compensation under competition. Extending the results of Lemma 1 to the case of competing firms is straightforward. Specifically, consider the case in which the worker faces two firms $i = 1, 2$ that compete for her human capital but can decide on the level and structure of the compensation they want to offer. Following the same line of argument as in Lemma 1, firms will optimally offer fixed-wage contracts. The only difference to Lemma 1 is that the worker's outside option $\underline{w}$ adjusts endogenously in every round of competition. Concretely, firms compete by extending alternating offers of fixed compensation until one firm is no longer willing to improve on its competitor's last standing offer (akin to an English auction).

In the equilibrium of this game (when no firm chooses weakly dominated compensation offers), the worker is hired by the firm with the highest willingness to pay for her human capital at a wage equal to the second-highest valuation of her labor $w = \omega^{(2)} \equiv \min_{\{\theta_i\}_{i=1}^2} \left(p_H\left(\theta_i\right) - p_N\left(\theta_i\right)\right) \Delta x$.[15] To see this, note that each firm is prepared to increase its fixed-wage offer until it breaks even at $w(\theta_i) = \left(p_H\left(\theta_i\right) - p_N\left(\theta_i\right)\right) \Delta x$. Offering more is clearly suboptimal. Dropping out at an earlier point is also suboptimal, as the firm could have hired the worker and generated a positive surplus if its competitor has a lower willingness to pay for labor.

Lemma 2 *Suppose that firms compete in the compensation contract of their choice. Then, firms optimally offer fixed-wage contracts ($w > 0$, $\Delta w = 0$) independent of whether the worker creates more value at more or less productive firms. The worker is hired by the firm with the highest valuation of her labor at a fixed-wage of $w = \omega^{(2)} > \underline{w}$.*

Overall, our analysis so far suggests that competition and negotiations (bargaining power) affect equilibrium compensation differently. Attracting additional competition – while bargaining power remains with firms – affects the level but not the structure of compensation.

[15] Let $\{\omega(\theta_i)\}_{i=1}^n$ be the random sample of the surplus the worker could generate at each of the n firms. We denote by $\omega^{(n)}$ the n-th highest value in $\{\omega(\theta_i)\}_{i=1}^n$.

By contrast, the distribution of bargaining power also affects compensation structure (Propositions 1 and 2).

3.3 Negotiations vs. Increasing Competition

Given that the choice between negotiations and competition can have opposite predictions on workers' compensation structure, the question that arises is when workers can extract higher expected pay by negotiating. In this section, we answer this question by comparing the two alternatives at $t = 0$. Our main result is that this choice depends on whether it is optimal for workers to negotiate for fixed or variable pay.

First, consider the case in which the worker creates less value at more productive firms. In this case, the worker optimally negotiates for fixed compensation (see Proposition 2), which is the same contract type that firms offer when they compete for the worker (see Lemma 2). Since in both cases, the equilibrium compensation is in fixed wages we can lean on results from the existing literature, which has studied the choice between competition and negotiations when payments are restricted to be in cash only. For this case, Bulow and Klemperer (1996) show that increasing competition (from n to $n + 1$) is, in expectation, preferable to optimal negotiations with n firms. It is important to stress that, while the restriction to cash payments in Bulow and Klemperer (1996) is by assumption, fixed compensation is the endogenously derived optimal compensation design in our model if the worker generates less value at more productive firms.

The prediction that increasing competition always dominates negotiations does not hold in the second case in which the worker creates more value at more productive firms — i.e., if the worker's skills are complementary to the firm's existing business. The reason is that the optimal compensation structure from the perspective of the worker and the firms differs. In particular, the worker optimally negotiates for variable compensation (such as performance pay or call options), while under competition, firms will offer fixed compensation only.

Our central insight when the worker creates more value at more productive firms is that an optimally designed variable compensation contract allows the worker to extract more of the surplus she generates at the firms interested in hiring her compared to fixed compensation. In some cases, the worker can even extract the entire surplus. In turn, full surplus extraction in negotiations is a sufficient condition for negotiations with n firms to dominate competition among $n + 1$ firms that offer fixed compensation.

As an illustration, consider the case in which θ is drawn from a uniform distribution and $\frac{\Delta_H}{\Delta_N} \in \left[1, \frac{p_H}{p_N}\right]$ such that the worker can extract all surplus generated by her labor under negotiations via the first-best contract. In particular, if the worker negotiates, her expected compensation is

$$U_{neg} = \left(p_H - p_N + \frac{1}{2}\left(\Delta_H - \Delta_N\right)\right)\Delta x.$$

If, instead, the worker attracts competition from a second firm, the worker's compensation corresponds to the valuation of the firm with the second-highest willingness to pay

$$U_{comp} = \left(p_H - p_N + \mathrm{E}\left[\min\left(\theta_1, \theta_2\right)\right]\left(\Delta_H - \Delta_N\right)\right)\Delta x = \left(p_H - p_N + \frac{1}{3}\left(\Delta_H - \Delta_N\right)\right)\Delta x.$$

As is easily seen, negotiations always dominate competition in this case, $U_{neg} - U_{comp} > 0$. The effect can be large: if $p_H \approx p_N$, negotiations lead to 50% higher expected compensation than competition.

Proposition 3 *A sufficient condition that optimal negotiations are better than increasing competition among firms offering fixed wages is that the worker can extract the full surplus under negotiations. Furthermore, it holds that: (i) If the worker creates less value at more productive firms, $\Delta_H/\Delta_N \in [0, 1)$, generating additional competition leads to higher expected compensation than negotiations. (ii) If the worker creates more value at more productive firms, and $\Delta_H/\Delta_N \in [1, T)$, with $T \in (p_H/p_N, \infty)$, optimal negotiations lead to higher expected compensation than adding competition from one more firm.*

As an illustration, Figure 2 plots the difference between the workers' expected payoff under competition and negotiations as a function of complementarity (Δ_H/Δ_N) for a parameterization of the uniform example. For this example, the figure shows that the worker prefers to negotiate whenever her human capital and the firms' business are complements, i.e., $T = \infty$. While we were not able to show that $T = \infty$ for general type distributions, negotiations always dominate competition if Δ_H/Δ_N is close to p_H/p_N.

At a high level, Proposition 3 shows that allowing agents to negotiate not only over the level but also the structure of pay overturns the predictions of prior work that increasing competition is preferable to negotiating when negotiations only affect the level of pay (Bulow and Klemperer, 1996). To the best of our knowledge, this result is new to the general auction literature and has implications beyond our concrete application. In particular, in Section 7, we discuss the implications of our model for mergers and acquisitions, where negotiations for performance payments (e.g., earnouts or choosing equity as a payment method) are also commonly observed. Notably, the sufficient condition for negotiations to dominate competition — that the worker can extract all surplus — is satisfied not only in the linear setting we solve for explicitly. Similar to Liu and Bernhardt (2021), it can be shown that a sufficient condition for extracting all surplus (in the case of complements) is that the value of hiring is concavely related to the firm's existing business.

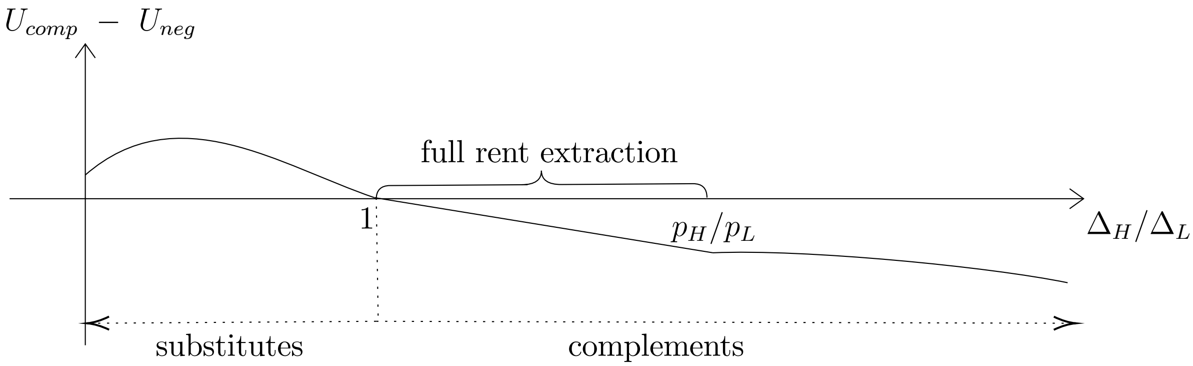


Figure 2: **Competition vs. negotiations.** The figure plots the ratio of the worker's expected compensation under optimal negotiation U_{neg} over expected compensation under competition U_{comp} as a function of the degree of complementarity between capital and labor Δ_H/Δ_N for the case of uniformly distributed firm types.

4 Optimal Negotiations With Multiple Firms

We, now, extend the analysis to a general number of firms. That is, we will compare equilibrium compensation design as well as expected compensation when the worker can design the optimal mechanism to "sell" her labor to $n \geq 1$ firms (negotiation regime) with the respective outcomes when the worker increases competition and, thus, faces $n+1$ firms that compete for her human capital in the sequential offers game described above (competition regime).

Extending our competition results to a general number of firms is straightforward. Lemma 2 continues to apply. That is, the firm with the highest willingness to pay for human capital hires the worker under a fixed-wage contract with $w = \omega^{(2)}$, which corresponds to the second-highest willingness to pay for the worker among all $n+1$ firms. It is worth noting that, by Myerson's (1981) revenue equivalence result, any mechanism in which the firm with the highest valuation hires the worker and compensates her in cash, leads to the same expected payoffs for firms and the worker.[16]

The open problem to which we turn next is characterizing the optimal way for the worker to "sell" her human capital (i.e., the equilibrium in the negotiations regime) when she can negotiate with *multiple* firms. In what follows, we characterize a simple mechanism that maximizes the worker's expected compensation when facing $n \geq 2$ firms and quantify its outperformance relative to standard mechanisms discussed in prior work.

[16] This insight applies to our private values setting since offering fixed payments is optimal for firms also in other standard mechanisms, such as the first-price auction (DeMarzo et al., 2005).

4.1 The Optimal Negotiation Mechanism

If offers are in cash only, the optimal selling mechanism is well-understood and can be implemented by a simple two-stage mechanism comprising of an English auction followed by a take-it-or-leave-it offer to the last remaining firm (Myerson, 1981). Allowing for payments to be state-contingent, we show that a modification of this implementation maximizes the worker's expected compensation under several realistic restrictions to the set of admissible mechanisms. In particular, we define a mechanism as admissible if it satisfies the following standard restrictions (Lopomo, 2000): (i) if the worker is hired, she is hired by the firm willing to pay most for her labor; (ii) only the hiring firm compensates the worker; and (iii) no firm regrets its decisions after observing the behavior of its competitors, i.e., the offered compensation is posterior implementable in that it is ex-post incentive compatible and individually rational.[17]

Among the class of admissible mechanisms, we show the optimality of the following two-stage mechanism: In the first stage, the worker approaches firm $i = 1$ demanding a fixed-wage offer higher than her outside option $\underline{w}$.[18] If the firm does not make such an offer, it drops out. If it does, the firm's offer replaces the worker's outside option as the highest standing offer. The worker then approaches firm $i = 2$ and asks her to improve on the highest-standing offer or drop out, and so on until all n firms have been approached once. In the next round, all remaining firms need to decide again sequentially on whether to improve on the last-standing offer or drop out. The game continues in this fashion until only one firm remains. We denote the last remaining firm's offer (that no other firm is willing to improve upon) by $\underline{w}^*$. We stress that the restriction to fixed-wage offers in this competitive process is for ease of exposition only. In the next section, we will show that expected compensation, as well as equilibrium compensation design, are identical when allowing firms to make general compensation offers.

In the second stage of the mechanism, the worker negotiates with that last remaining firm by making a take-it-or-leave-it offer as in the case in which she faces a single firm — i.e., as dictated by Proposition 1 when the worker's skills and the firm's existing business are

[17] Deriving the optimal mechanism when workers can choose their compensation structure is challenging, as some of the main assumptions made in the mechanism design literature are not satisfied. Specifically, the bidders' virtual valuation is a complicated object that depends on the contract's structure and is, in general, not monotone in θ. For recent advances, restricting attention to equity auctions, see Sogo et al. (2016), Liu (2016), Liu and Bernhardt (2021). Prior approaches, such as DeMarzo et al. (2005), restrict attention to efficient symmetric mechanisms without optimally designed reserve prices. Note that the final take-it-or-leave-it offer in our mechanism can be interpreted as a reserve price, optimally chosen once only one firm remains. Further note that we do not require that the mechanism be efficient, as it can be that the worker is not hired by any of the firms.

[18] We assume that the requested increments are small.

complements and by Proposition 2 in the case of substitutes. The only difference relative to the single firm case arises in the determination of the optimal cut-off type $\widetilde{\theta}^*$, which now takes into account the information acquired in the sequential offers game. In particular, since the last remaining firm must have a willingness to pay for the worker that is weakly larger than $\underline{w}^*$, its type must satisfy $\theta \geq \frac{\underline{w}^* - (p_H - p_N)\Delta x}{(\Delta_H - \Delta_N)\Delta x}$. Hence, the worker's posterior beliefs in the determination of $\widetilde{\theta}^*$ are now given by the conditional distribution $\widetilde{F}\left(\theta \,\middle|\, \theta \geq \frac{\underline{w}^* - (p_H - p_N)\Delta x}{(\Delta_H - \Delta_N)\Delta x}\right)$ instead of the prior $F(\theta)$.

Just as in the case of competition, it is a weakly dominant strategy for each firm to keep increasing its compensation offer until the workers' expected compensation increases to the point at which the firm would be indifferent between hiring and not hiring. At this point, the firm drops out. Hence, $\underline{w}^*$ corresponds to the value-added from hiring at the firm with the second-highest willingness to pay for the worker $\omega^{(2)}$. Verifying that this mechanism is ex post incentive compatible and individually rational is straightforward:

Proposition 4 *Consider the class of admissible posterior implementable mechanisms in which only the highest type firm (if any) hires and pays the worker. Then the following two-stage mechanism maximizes the worker's expected compensation: In the first stage, firms compete on compensation levels by sequentially improving on each other's fixed compensation offers as in an English auction, with the highest bid denoted by* $\underline{w}^*$. *In the second stage, the worker negotiates her compensation structure and level with the last remaining firm by making a take-it-or-leave-it offer of the form* $\{w, \Delta w\}$ *as characterized by Proposition 1 if the worker generates more value at more productive firms and Proposition 2 if the worker generates more value at less productive firms. In the determination of* $\widetilde{\theta}^*$ *in the second stage, the worker's posterior beliefs are given by the conditional distribution* $\widetilde{F}\left(\theta \,\middle|\, \theta \geq \frac{\underline{w}^* - (p_H - p_N)\Delta x}{(\Delta_H - \Delta_N)\Delta x}\right)$.

The conditions imposed in Proposition 4 on the set of admissible mechanisms are the same as those required to show that an English auction followed by a final take-it-or-leave-it offer implements the optimal selling mechanism in an affiliated values setting in which offers are in cash only (Lopomo, 2000). While we obtain our result in a private values setting, we do not restrict attention to cash offers, making our mechanism optimal within a class of mechanisms that allow for offers in any type of state-contingent claim. We believe that the simplicity and familiarity of this mechanism are key to its appeal. Another advantage is that the mechanism is almost details free, as the worker only needs to learn how to negotiate with the last remaining firm.

	Expected compensation	
	Fixed wages	Call options
Sequential competition + final TIOLI offer	$0.25\Delta x$	$0.28\Delta x$
First-price auction w/o final TIOLI offer	$0.20\Delta x$	$0.24\Delta x$
Second-price auction w/o final TIOLI offer	$0.20\Delta x$	$0.24\Delta x$

Table 1: **Expected Compensation for Different Mechanisms.**

4.2 Quantifying Expected Compensation under Optimal Negotiation

Given the characterization of the optimal negotiation mechanism in Proposition 4, we next ask the question of how expected compensation under this mechanism compares to that under alternative negotiation mechanisms. In related work, DeMarzo et al. (2005) compare seller revenues in security auctions in which the seller restricts the security design to an ordered set and uses a first- or second-price auction as the auction format. They find that a first-price auction with bidding in call options yields the highest expected revenues among this class of efficient mechanisms. As the following example shows, the simple two-stage mechanism characterized in Proposition 4 presents a substantial improvement on this and other standard mechanisms discussed in prior work.

Example 1 ***(comparing negotiation mechanisms)*** Let $p_H = p_N = \frac{c}{c+1}$, $\Delta_H = \frac{1}{c+1}$, and $\Delta_N = 0$ with $c = 0.7$, such that hiring creates more value at better firms, with the surplus being positive for all $\theta \in [0, 1]$. Further assume that there are two firms trying to hire the worker and that θ is uniformly distributed on $[0, 1]$. Table 1 compares the expected compensation from the optimal two-stage mechanism in Proposition 4 in which the final offer is in call options (complements case) with the following alternatives: (i) sequential competition with a final take-it-or-leave-it (TIOLI) offer in (suboptimal) fixed wages; (ii) a first-price auction in which bidders are restricted to either fixed wage bids or to call option bids; (iii) a second-price auction (equivalent to an English auction) in which bidders are again restricted to either fixed wage bids or to call option bids. The optimal strategies for each of these mechanisms are derived in Appendix B.3.

The key insight from Example 1 is that the choice of the selling mechanism is at least as important as that of compensation structure. In particular, in this example, sequential competition followed by a TIOLI offer dominates all alternative mechanisms, *regardless* of whether the worker negotiates for call options (as is optimal) or fixed wages with the last remaining firm.[19] Furthermore, for all standard selling mechanisms, there is a substantial gain in expected compensation arising from choosing the optimal compensation structure.

Having established the maximal expected compensation the worker can achieve when optimally negotiating with $n \geq 2$ firms, we are now ready to compare whether the worker is better off negotiating with n firms or letting $n+1$ firms compete for her human capital. To do so, note that the optimal two-stage negotiation mechanism of Proposition 4 simply adds a final take-it-or-leave-it offer to the outcome under competition with n firms. That is, just as in our baseline case of Section 3, the comparison amounts to whether the worker benefits more from being able to make a take-it-or-leave-it offer to one firm (here the firm with the highest valuation among n firms) or adding another firm (the $n+1^{st}$ firm) competing as in an English auction. This trade-off is again resolved as described in Proposition 3, which we prove for general n. In particular, whenever $\Delta_H/\Delta_N \in [1, \frac{p_H}{p_L}]$, the worker can extract from the firm with the highest valuation out of n firms by negotiating. In expectation, this leads to higher expected compensation than when $n+1$ firms compete on fixed wages.

4.3 General Offers

The first stage of the optimal negotiation mechanism of Proposition 4 restricts firms to compete in fixed-wage contracts as in an English auction until only one remains. While this mechanism is without loss of generality in terms of optimality (i.e., the maximally achievable expected compensation), the mechanism is not uniquely optimal. In what follows, we characterize the set of optimal mechanisms that allow firms to make *any* type of compensation offers in the first stage in which the worker identifies the firm with the highest willingness to pay. In practical terms, this means that firms, anticipating that the worker will negotiate for call options in the second stage, may offer call options from the outset even if the worker is not explicitly demanding that in the first stage.

When firms are allowed to compete by making general offers of the type $\{w, \Delta w\}$, the main challenge for the worker is to rank offers that differ in compensation structure, e.g., to establish whether the fixed-wage offer by one firm dominates the equity offer of another firm. The key difficulty here is that the value of any compensation offer that features $\Delta w \neq 0$ depends on the firm's unknown type.

In the following, we specify a simple rule according to which the worker can rank general compensation offers, allowing her to identify the firm willing to pay most for her human

[19] The first-price auction in call options outperforms the second-price auctions in call options, but the difference is indistinguishable when rounding to the second decimal. The worker's expected compensation with any other type of compensation (e.g., fixed wages plus equity) is in between the cash and call options alternatives.

capital. Recall that at any point in this competition stage, the worker approaches the next firm asking for an improvement on the highest standing offer. Thus, the key challenge is to determine the set of offers the worker is willing to accept as an improvement over the highest standing offer.

This problem can be solved as follows. Assume firm A has extended the highest standing offer which we denote by $\{w_a, \Delta w_a\}$. For a firm B to beat this offer, the worker requires that it chooses a contract $\{w_b, \Delta w_b\}$ from the set of all contracts for which it holds that

$$w_b + p_H\left(\widetilde{\theta}\left(w_b, \Delta w_b\right)\right)\Delta w_b > w_a + p_H\left(\widetilde{\theta}\left(w_a, \Delta w_a\right)\right)\Delta w_a, \tag{11}$$

where $\widetilde{\theta}\left(w, \Delta w\right)$ is defined in (6). Intuitively, condition (11) states that the worker ranks compensation offers based on the answer to the following question: *"What would be the compensation contract's expected value if the firm was indifferent between hiring and not hiring at that compensation?"* This ranking effectively undervalues all contracts for which the firm makes a profit from hiring but ranks those for which the firm is indifferent between hiring and not hiring based on their true value. Hence, a firm drops out from competing to hire the worker only after all firms with lower valuations have dropped out. Furthermore, by following this rule, the worker can perfectly infer the types of all firms that drop out, which allows her to obtain a lower bound on the winning firm's type. That is, just as in Proposition 4, the worker knows at the end of the competition stage that the type of the last remaining firm satisfies $\theta \geq \frac{\underline{w}^* - (p_H - p_N)\Delta x}{(\Delta_H - \Delta_N)\Delta x}$, where $\underline{w}^*$ is given by $\underline{w}^* = w^* + p_H\left(\widetilde{\theta}\left(w^*, \Delta w^*\right)\right)\Delta w^*$ and $\{w^*, \Delta w^*\}$ denotes the last-standing offer in the first stage.

Proposition 5 *The worker can identify the firm willing to pay the most for her fixed-wage c extracting the maximum information about its valuation, by demanding that firms improve sequentially on each other's offers as dictated by condition (11) or drop out. The optimal final take-it-or-leave-it offer to the last remaining firm is as in Proposition 4.*

It is worth noting that the basic insights of Propositions 4 and 5 extend to the case in which the worker has bargaining power only vis-à-vis a subset of firms $B \subset \{1, ..., n\}$. In particular, consider the case in which the worker is able to make a take-it-or-leave-it offer only if the winning firm satisfies $i \in B$, whereas she cannot negotiate with the winning firm if $i \notin B$. Then, the optimal selling mechanism consists of a competition stage as described in Propositions 4 and 5, with firms with strong bargaining power offering fixed-wage contracts (see Section 3.2). If for the last remaining firm it holds that $i \in B$, the worker makes a final take-it-or-leave-it offer as characterized in Propositions 4 and 5. Else, if $i \notin B$, the worker is hired at the last-standing fixed-wage offer.[20]

In salary negotiations in practice, employers typically ask prospective employees about their salary expectations, and the standard advice is to respond by offering a salary range. Offering such a range can be seen as the first offer made by workers to firms. A firm then typically responds with an offer, and workers can then negotiate based on this offer or use the offer to ask for higher compensation at another firm interested in hiring them. In a nutshell, the mechanism we described can be seen as the optimal way to lead such sequential negotiations.

5 Cash Constraints and Wage Distortions

The structure of workers' compensation has first-order importance from a corporate finance perspective because it determines firms' financing needs. In turn, the terms at which firms can raise capital affect the compensation that they can offer. In this section, we study this interdependence by dispensing with the assumption that firms have deep pockets and, instead, considering the case in which firms are penniless. Such cash constraints are never binding if the worker's equilibrium contract stipulates payments only in the high cash flow state (call options). However, if the firm wants to offer fixed compensation, cash constraints become binding when the firm seeks to offer fixed wages of $w > x$ in the low cash flow state. That is, fixed-wage offers of $w > x$ are either risky — i.e., it is commonly known that the firm can only pay the worker x in the low cash flow state — or have to be secured by external financing.

To study the impact of cash constraints on compensation, we initially limit the discussion to the case of competition, as then the workers' equilibrium compensation (absent cash constraints) is a fixed wage, suggesting that cash constraints are potentially binding. We assume that if firm i secures external financing to guarantee its fixed wage promises, it does so at competitive terms. Specifically, the firm makes a take-it-or-leave-it offer to financiers, together with the offer it makes to the worker where we assume that all offers are commonly observable.[21]

An external financing contract $\{S_i, \Delta S_i\}$ stipulates that firm i pays the financiers S_i in the low cash flow state and $S_i + \Delta S_i$ in the high cash flow state at $t = 1$, with a negative value for S_i or $S_i + \Delta S_i$ meaning that there is a transfer from the financiers to the firm. As before, the subscript i, denoting the firm's identity, is dropped whenever doing so does

[20] Excluding firms against which the worker has no bargaining power is never optimal if these firms' participation does not affect the workers' bargaining power vis-à-vis the other firms.

[21] A previous working paper version shows that the results do not qualitatively depend on whether financing is arranged before or after the firm hires the workers.

not lead to confusion. As it is standard, we assume that all parties are protected by limited liability and that all contracts are monotone (Nachman and Noe, 1994). Formally, it should hold that $0 \leq w + S \leq x$ and $0 \leq \Delta w + \Delta S \leq \Delta x$. Financiers require to break even when guaranteeing the worker's compensation:

$$S + \int_0^1 p_H(\theta)\, d\widetilde{F}(\theta)\, \Delta S \geq 0, \tag{12}$$

where $\widetilde{F}$ is the financiers' posterior belief over θ after receiving an offer $\{S, \Delta S\}$. Note that since financiers and the worker have the same information, they share the same posterior $\widetilde{F}$. In what follows, we show that cash constraints distort the firms' willingness to pay for labor *upward* if the worker creates more value at higher productivity firms (the case of complements). However, the distortion is downward if the worker creates more value at less productive firms (the case of substitutes).

The argument proceeds in two steps. The first is to establish that offering fixed wages secured by external financing is an equilibrium strategy for the firms. Indeed, this is the most beneficial equilibrium for the firm that can be supported. Despite the complication that there are two types of investors (external financiers and the worker who invests by forgoing her outside option), the analysis of this step is largely standard and relegated to the appendix. A sketch of the intuition is as follows. Let $\underline{w}' > x$ be the minimum expected compensation that the worker will accept over her outside option. The firm whose turn it is to make an offer then optimally offers the worker a fixed-wage of $w = \underline{w}'$ (and $\Delta w = 0$), with external financing filling the gap of $\underline{w}' - x$. The reason that no other equilibrium can be supported is that high types would have an incentive to deviate to a debt-financed fixed compensation contract of $w = \underline{w}'$ that minimizes the cross-subsidization to lower types. When out-of-equilibrium beliefs are refined with the Intuitive Criterion, such deviations will be perceived to come, indeed, from higher types, making it optimal for the worker and financiers to accept the deviation. The main difference from the standard analysis (Nachman and Noe, 1994) is that the firm does not actually need to raise $\underline{w}' - x$ at $t = 0$. Instead, it can sign an insurance contract allowing it to raise capital at $t = 1$ in the low cash flow state in return for paying a premium in the high cash flow state. One interpretation of this insurance contract is as a credit line.

It is important to note that the worker could also be interpreted as a financier. For example, a risky fixed-wage contract w' that the firm pays partially in the low cash flow state at $t = 1$ effectively means that the worker is offering her human capital in return for a risky debt contract with a face value of $\underline{w}'$. Since the worker and external financiers share the same information and bargaining power, the financing terms they will offer are the same.

All that matters for the firm is the joint claim $R = S + w$ and $\Delta R = \Delta S + \Delta w$ offered to the worker and financiers, where in any equilibrium, it should hold that $R = x$. In practice, this means that the worker may agree to be paid a fixed-wage of $w \in [x, \underline{w}')$ in return for a variable component paid in the high cash flow states. In the equilibrium with $w = x$, the firm would not even need access to external financing.

The second step in our equilibrium characterization is to show the distortive effects of cash constraints. To see these effects, note that a firm stays in the competition to hire the worker until its final fixed-wage offer, $w(\theta)$, exhausts its benefit from hiring

$$(p_H(\theta) - p_N(\theta))\,\Delta x - w(\theta) - (S + p_H(\theta)\,\Delta S) = 0. \tag{13}$$

Since in the discussed equilibrium, a firm seeking financing for $w(\theta)$ cannot signal its type through its choice of contracts, financing will entail cross-subsidization from high to low types.

Consider, now, the case in which the worker creates more value at higher-productivity firms (the case of complements). When a type θ^* makes the highest compensation offer it can afford, i.e., $w(\theta^*)$, the financiers overvalue its type, as they form their expectation over all types $[\theta^*, 1]$ that make a weakly positive profit from hiring at this wage. In particular, the financier's break-even condition is

$$\int_{\Omega} (S + p_H(\theta)\Delta S)\, d\widetilde{F}(\theta) = 0, \tag{14}$$

where $\Omega = [\theta^*, 1]$. Due to the monotonicity of $p_H(\theta)$, this directly implies that investors make a loss at type θ^*, i.e., $S + p_H(\theta^*)\Delta S < 0$. Put differently, the favorable financing conditions of low types in $[\theta^*, 1]$ are cross-subsidized by high types with which investors make a profit. Because of this cross-subsidization, type θ^* is willing to increase its compensation offer up to a value $w(\theta^*)$ that is higher than the expected surplus from hiring. Specifically, from $S + p_H(\theta^*)\Delta S < 0$ and expression (13), it holds that $w(\theta^*) > (p_H(\theta^*) - p_N(\theta^*))\,\Delta x$.

In the case in which the worker creates more value at lower-productivity firms (the substitutes case), the argument is reversed. In this case, the set of types that can afford a wage offer of $w(\theta^*)$ is $\Omega = [0, \theta^*]$. Hence, type θ^* is pooled with lower types, implying that $S + p_H(\theta^*)\Delta S > 0$ and $w(\theta^*) < (p_H(\theta^*) - p_N(\theta^*))\,\Delta x$. These distortions do not depend on whether the worker co-finances her compensation or not.

Proposition 6 *Cash constraints distort the highest fixed wage that the firm is prepared to offer upward if the worker creates more value at higher-productivity firms; and downward if the worker creates more value at lower-productivity firms.*

Though cash constraints do not distort the efficient allocation of workers to firms, they distort the compensation at which the worker joins the last-standing firm for two reasons. In the case of complements, these reasons are: (i) the cash constraint distorts the firms' willingness to pay upward; (ii) the risky wage promised by the firm with the second-highest valuation is worth more when it ends up being paid by the firm with the highest valuation that is more likely to pay the wage in full (see Hansen, 1985). Once again, all this reasoning reverses in the case of substitutes.

It follows that negotiating is less attractive than attracting one more job offer when firms are cash-constrained and the worker generates more value at more productive firms. The difference to the competition regime is that cash constraints are not relevant in negotiations, since the worker's demand for a contract with $w = 0$ (call options) is not affected by such constraints.[22] In the case of substitutes, the implications are ambiguous. In this case, the worker negotiates for fixed-wage contracts which are restricted by cash constraints. Hence, the worker's expected compensation under both negotiations and competition declines.[23]

6 Empirical Implications

In what follows, we summarize the main empirical predictions of our analysis and relate them to empirical evidence. A key distinction in our analysis is whether workers generate more value at high- or low-productivity firms. An example of the former case is a marketing expert joining a high-growth start-up. Empirically, this case of "complements" is often associated with high-skilled workers. The opposite case is when workers generate more value at lower-productivity firms, as in the examples of a maintenance manager or an executive with restructuring skills whose skills substitute for the firm's lower-quality assets. The case of substitutes is also often associated with lower-skilled workers or jobs at risk of being automated away (Krusell et al., 2000; Larrain, 2015; Fonseca and van Doornik, 2022). For brevity, we will refer to these two cases as "complements" and "substitutes," respectively.

Negotiation vs. Competition. The relative importance of competition versus bargaining power for the level of workers' wages is debated in the literature, with some studies

[22] Cash constraints also do not distort the efficient ranking of compensation offers in the first stage of the optimal mechanism. In that stage, the worker only uses the firms' offers to elicit the second-highest valuation, so her final take-it-or-leave-it offer is based on the same information as in the case without cash constraints.

[23] Another setting in which the difference between negotiating and attracting additional offers is likely to be smaller is when the firms' values from hiring share are common component. The reason is that then the worker's benefit of negotiating for call options is muted by the fact that firms may also prefer competing on call options to mitigate the risk of a winner's curse (Yuan, 2021).

finding that competition is more important (Cahuc et al., 2006), while others finding that bargaining power plays a substantial role (Bagger et al., 2014; Di Addario et al., 2021). Our model sheds light on such differing findings by arguing that the importance of negotiations (and, thus, bargaining power) versus competition will endogenously depend on whether workers create more or less value at more productive firms. Empirically, negotiations are common for about 30%-55% of jobs (Hall and Krueger, 2012; Brenzel et al., 2014; RobertHalf, 2019). Our analysis shows that this will particularly be relevant for jobs in which workers' skills are complementary to firms' businesses.

Implication 1 *Workers will be more likely to negotiate their compensation when their skills complement a firm's existing business, creating more value at better firms. In the case of substitutable skills, in which workers create more value at lower-productivity firms, workers will prefer generating additional offers.*

Compensation Structure. Larger firms with rigid salary scales may be limited to offering compensation only within these scales. For this reason, compensation consultants advise negotiating also over types of compensation about which firms might have more flexibility, such as performance bonuses, equity-based pay, or signing bonuses. Our next implication describes when workers do better by negotiating for higher fixed or variable pay.

Implication 2 *(i) If workers' skills are complementary to the firm's business, workers can increase their expected compensation by negotiating for variable pay, such as equity-based pay or performance bonuses. (ii) By contrast, in the case of substitutes, workers are better off negotiating for higher fixed pay, such as salary or signing bonuses. (iii) When bargaining power is with firms, they prefer to match/beat competing offers by offering higher fixed pay regardless of whether workers' skills are substitutable or complementary to their business.*

Implication 2 is consistent with anecdotal evidence that lower-skilled workers (whose skills are typically considered substitutable), such as warehouse managers, grocery store employees, or truck drivers who have seen pay increases during hot labor markets in the form of higher hourly wages and sign-on bonuses.[24] By contrast, workers whose skills are typically complementary to firms, such as bankers or IT engineers, have seen pay increases in tight labor markers primarily in the form of variable pay such as performance bonuses and equity-based pay (Bell and Van Reenen, 2014; Giannetti and Metzger 2015). More generally,

[24] See "Companies you'd never expect are offering signing bonuses to new employees" (CNN, June 7, 2021)". Our competition-driven explanation for the use of signing bonuses complements other motivations pointed out in the literature, such as firms signaling their belief in the quality of the match with workers (Van Wesep, 2010) or compensating employees for forgoing pay at their current employers.

Kedia and Rajgopal (2005) find that firms are more likely to offer equity-based compensation when they compete against similar nearby firms, and Mehran and Tracy (2001) find that more competition for workers in the 1990s is associated with an increase in stock-based compensation. A common caveat is that these studies do not differentiate between stronger worker bargaining power and higher levels of competition.[25]

To differentiate Implication 2 from alternative explanations in which firms offer equity for retention purposes (Oyer, 2004), one could test whether the evidence we cite above is stronger for firms about whose growth options there is more information asymmetry. Younger firms and firms about which there is more dispersion in analysts' forecasts are likely to fit this description. Notably, we show that asymmetric information should have the *opposite* effect when incorporated into models in which firms can dictate terms — then, information asymmetry will lead to less equity-based compensation (Lemma 1). Furthermore, one could test whether firms with decreasing stock prices also offer equity-based compensation to workers with stronger bargaining power. Such evidence would be less-consistent with alternative explanations that equity-based compensation helps retain workers when stock prices increase (Oyer, 2004; Bergman and Jenter, 2007).

External Financing. Implications1 and 2 have clear implications about how competition and negotiations distort firms' financing needs.

Implication 3 *In tight labor markets, firms hiring workers with complementary skills to their business will be less pressured to raise external financing to pay wages but will be forced to share more of their profits with employees in the form of performance bonuses or stock-based pay. By contrast, in the case of substitutes, firms will be forced to raise more external financing to guarantee their wage promises.*

Another insight from the paper is that, when external financing for fixed wages is easily available, it distorts the firms' willingness to pay for labor upward when workers create more value at more productive firms but downward when workers create more value at less productive firms (Lemma 6). That is, in the case of complements, there is a mitigating force to concerns that compensation may be lower if external financing is hard to come by — as, for example, during a financial crisis. By contrast, the effects are reinforcing each other in

[25] Note that our model is not about how the *level* of competition (n) correlates with workers' willingness to negotiate. Instead, Implication 2 studies whether for a *given* level of competition, n, negotiations are better than attracting interest from one more firm. Higher levels of n are likely to be associated with higher worker bargaining power also in our model. In particular, workers are more likely to negotiate their pay when their outside option of restarting their job search ($\underline{w}$ in our model) is higher or when it is easier to learn how to negotiate. Both are more likely when the level of competition to hire a worker is high.

the case of substitutes.[26]

Implication 4 *Compared to unconstrained firms, cash-constrained firms compete more aggressively for workers whose skills are complementary to their business but less aggressively in the case of substitutes.*

7 Conclusion and Discussion of M&A Application

Attracting talented workers is key for firm success but extremely challenging in tight labor markets. In particular, firms have to be willing to deviate from their preferred compensation design in order to accommodate workers' demands and to outbid the compensation offers of their competitors. Yet the literature is largely silent on how competition and negotiations in talent acquisition affect the structure of workers' compensation. This paper addresses this gap. From a corporate finance perspective, workers' compensation structure matters because it affects firms' external financing needs, whether workers become part of the firm's investor base, and more fundamentally, whether the firm can attract the human capital needed to realize its growth prospects.

An alternative application of our model is competition for and negotiations with a target in mergers and acquisitions. In this case, the firms in our model can be interpreted as the "acquirers" and the worker as the "target."[27] The distinction of whether a target adds more value to more productive acquirers (case of complements) or less productive ones (case of substitutes) is also relevant in this context. For example, the case of complements could capture situations in which a healthy strategic acquirer bids for a growth firm. By contrast, the case of substitutes may capture a mature firm buying the competencies it is lacking to replace or improve an ailing business.

In this interpretation of our model, a target's preference for cash or equity as a payment method depends on whether or not its business is complementary to that of interested

[26] Our results that competition among financially constrained firms can lead to overly aggressive or depressed compensation depending on whether workers' skills are substitutable or complementary to the firm's business provides a new angle to the literature investigating the effect of cash constraints on employment. Prior work has focused, instead, on three other aspects: that financing constraints may prevent efficient retention (Falato and Liang, 2016; Caggese et al., 2018); that higher leverage may strengthen firms' bargaining power in negotiations with unions (Perotti and Spier, 1993; Matsa, 2010; Chava, Danis, and Hsu, 2020); and that high labor protection may increase operating leverage, thus, crowding out financial leverage (Simintzi, Vig, and Volpin, 2018; Woods, Tan, Faff, 2019).

[27] The reason we interpret the worker as the target is that it will typically be the target's choice whether it wants to negotiate with one acquirer or organize an auction. Interpreting the worker as the acquirer is also possible, where now the target has private information. Taking the latter interpretation, our results generalize Hansen's (1987) predictions about the optimal payment method choice and show that the predictions are reversed depending on whether the target and acquirer are complements or substitutes.

acquirers. Negotiating for equity allows the target to extract more of the synergies generated by the merger if its business is complementary to that of the acquirers. By contrast, cash payments will be the preferred choice in cases in which the businesses of the target and the acquirers are substitutes.[28] Notably, when acquirers are in a position to dictate terms, our model with asymmetric information about the acquirers' types predicts that they will unambiguously prefer paying in cash.

In the context of mergers and acquisitions, the main novel prediction of our analysis then is that a target is better off focusing on negotiations with a limited number of acquirers when it prefers negotiating for equity as the payment method. By contrast, organizing an auction with an additional bidder is the better choice if the target prefers cash as the payment method. Hence, our theory predicts that negotiations are more likely to be observed in the context of transactions involving a higher proportion of equity payment, which is consistent with the evidence (Aktas et al., 2010).

Whether the acquirers' and target's businesses are complements or substitutes also matters for the impact of cash constraints on takeover premia. Our model implies that the takeover premia offered by cash-constrained acquirers will be higher if they are bidding in cash and the target's business complements their own. However, in the case of substitutes, cash constraints will depress acquirers' cash bids. This difference in predictions adds to prior work showing that the option to declare bankruptcy could make (in particular, poorer) bidders more aggressive (Zheng, 2001; Board, 2007). In particular, our theory suggests a countervailing force if the acquirer's and target's business are substitutes.

A key normative contribution of our paper is to characterize the optimal negotiation mechanism when payments can be in state-contingent claims. We show that the optimal mechanism is simple and almost details free. In an M&A context, it involves acquirers competing in whatever payment method they wish, with the target negotiating about its preferred payment method (and level) only with the highest bidder. Notably, if acquirers have different bargaining power and make different types of offers, targets can still efficiently compare offers and successfully identify the acquirer willing to pay the most.

Overall, our paper highlights the importance of competition and negotiations for corporate financing decisions, the structure of payments, and the efficient matching between negotiating parties. The predictions extend beyond the specific application of workers ne-

[28] As mentioned above, these predictions generalize and extend Hansen (1987) and show that the results reverse depending on whether or not the target's business complements that of the acquirer. Furthermore, our predictions complement Fishman (1989), who shows that cash bids can preempt competition from other bidders, and Eckbo et al. (1989), Gorbenko and Malenko (2018), and Liu and Bernhardt (2021) who show that "high-type" acquirers will use more cash in their mix of cash and equity bids. See Eckbo et al. (2020) for a recent overview of the literature.

gotiating their compensation to other settings in which the choice between auctions and negotiations is relevant, such as mergers and acquisitions. Corporate and public procurement present other possible applications.

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Appendix A Proofs

Proof of Proposition 1 and 2. Suppose initially that a worker offers a single take-it-or-leave-it contract. At the end of the proof, we show that offering a menu will always be dominated. Let

$$\begin{aligned} u(\boldsymbol{\omega},\theta) &= w + p_H(\theta)\,\Delta w \\ v(\boldsymbol{\omega},\theta) &= x - w + p_H(\theta)\,(\Delta x - \Delta w) \end{aligned}$$

be the worker's and the firm's expected payoffs when the firm hires that worker with a compensation contract $\boldsymbol{\omega}=\{w, \Delta w\}$.

Claim 1: *In the case of complements the worker optimally demands the first-best contract if this is feasible; else she demands a contract with variable compensation only, i.e., with* $w = 0$.

Proof. The case of complements arises if $\frac{\Delta_H}{\Delta_N} \geq 1$. Feasibility and optimality of the first-best contract for $\frac{\Delta_H}{\Delta_N} \leq \frac{p_H}{p_N}$ is shown in the main text. So, assume now that the first-best contract is not feasible, i.e., $\frac{\Delta_H}{\Delta_N} > \frac{p_H}{p_N}$. We will show that for any given level of rationing, as captured by a given cutoff $\widetilde{\theta} < 1$, the worker's expected compensation is maximized under a contract with variable compensation only.[29] The case of the optimal cutoff $\widetilde{\theta}^*$ is then a special case. So, suppose to a contradiction that a compensation contract $\boldsymbol{\omega}'=\{w', \Delta w'\}$ with $w' > 0$ was optimal and accepted by types $\theta \geq \widetilde{\theta}$. Consider now a perturbation of contract $\boldsymbol{\omega}'$ given by $\boldsymbol{\omega}'' = \left\{w' - \zeta, \Delta w' + \frac{\zeta}{p_H(\widetilde{\theta})}\right\}$, where $\zeta > 0$ is chosen small enough such as to ensure that $w'' = w' - \zeta \geq 0$. By construction $\boldsymbol{\omega}''$ is feasible and implements the same cutoff $\widetilde{\theta}$, that is the set of types accepting contracts $\boldsymbol{\omega}'$ and $\boldsymbol{\omega}''$ is the same. However, the worker's expected compensation is higher under $\boldsymbol{\omega}''$ than under $\boldsymbol{\omega}'$, contradicting the optimality of the latter. To see this note that $u(\boldsymbol{\omega}'', \theta) - u(\boldsymbol{\omega}', \theta) = -\zeta + p_H(\theta)\,\frac{\zeta}{p_H(\widetilde{\theta})}$ which is positive for all types $\theta \geq \widetilde{\theta}$ accepting the contract, strictly so for all $\theta > \widetilde{\theta}$. ■

Claim 2: *In the case of substitutes, the worker optimally demands a fixed wage, i.e., a contract with* $\Delta w = 0$.

Proof. The proof follows the same line of argument as in the case of complements with the main difference that with substitutes it is now lower types that have a higher willingness to pay. We will show that for any given level of rationing, as captured by a given cutoff $\widetilde{\theta} > 0$, the worker's expected compensation is maximized under a contract with fixed compensation

[29] Compensation design is clearly irrelevant in the case in which the worker is never hired, i.e., when $\widetilde{\theta} = 1$.

only.[30] So, suppose to a contradiction that a compensation contract $\boldsymbol{\omega}' = \{w', \Delta w'\}$ with $\Delta w' > 0$ was optimal and accepted by types $\theta \leq \widetilde{\theta}$. Consider now a perturbation of contract $\boldsymbol{\omega}'$ given by $\boldsymbol{\omega}'' = \left\{ w' + \zeta, \Delta w' - \frac{\zeta}{p_H(\widetilde{\theta})} \right\}$, where $\zeta > 0$ is chosen small enough such as to ensure that $\Delta w'' = \Delta w' - \frac{\zeta}{p_H(\widetilde{\theta})} \geq 0$. By construction $\boldsymbol{\omega}''$ is feasible and implements the same cutoff $\widetilde{\theta}$, that is the set of types accepting contracts $\boldsymbol{\omega}'$ and $\boldsymbol{\omega}''$ is the same. However, the worker's expected compensation is higher under $\boldsymbol{\omega}''$ than under $\boldsymbol{\omega}'$, contradicting the optimality of the latter. To see this note that $u(\boldsymbol{\omega}'', \theta) - u(\boldsymbol{\omega}', \theta) = \zeta - p_H(\theta) \frac{\zeta}{p_H(\widetilde{\theta})}$ which is positive for all types $\theta \leq \widetilde{\theta}$ accepting the contract, strictly so for all $\theta < \widetilde{\theta}$. ■

Claim 3: *Offering a menu is not optimal.*

Proof. The result follows since we restrict attention to deterministic mechanisms in which the worker joins the firm with probability one if a contract is accepted. Consider any non-degenerate menu W. Let $\boldsymbol{\omega}' \in W$ be the contract chosen by (i) the lowest type, $\widetilde{\theta}$, that accepts a contract from the worker's menu offer in the case of complements, or (ii) the highest type $\widetilde{\theta}$ that accepts a contract from the worker's menu offer in the case of substitutes. Consider now a uniform contract offer, in which the worker just offers contract $\boldsymbol{\omega}'$, that is drops all other contracts from the menu. Note then that if a type prefers $\boldsymbol{\omega}'$ to its outside option of not hiring, the same holds for (i) all higher types in the case of complements, and (ii) all lower types in the case of substitutes. Thus, the set of types, Ω_W, that accept the worker's offer remains unchanged and so does, hence, the total surplus. The result then follows since for any type θ that accepts a contract $\boldsymbol{\omega}'' \in W$ other than $\boldsymbol{\omega}'$ under the original menu offer it must hold that $v(\boldsymbol{\omega}'', \theta) \geq v(\boldsymbol{\omega}', \theta)$ by revealed preferences. Since total surplus is unchanged, this means that $u(\boldsymbol{\omega}'', \theta) \leq u(\boldsymbol{\omega}', \theta)$, and the worker is better off offering only contract $\boldsymbol{\omega}'$. ■

For completeness, we also provide conditions characterizing the optimal cutoff $\widetilde{\theta}^*$. We will do so for the case of complements, the case of substitutes is analogous. So, take the optimal contract for any cutoff $\widetilde{\theta} < 1$ given by $w = 0$ and $\Delta w = 1 - \frac{p_N(\widetilde{\theta})}{p_H(\widetilde{\theta})} \Delta x$ under which $\Omega_W = \left[\widetilde{\theta}, 1\right]$. Substituting into (5) we get that[31]

$$\widetilde{\theta}^* = \arg\max_{\widetilde{\theta}} \left\{ \underline{w} F\left(\widetilde{\theta}\right) + \left(1 - \frac{p_N\left(\widetilde{\theta}\right)}{p_H\left(\widetilde{\theta}\right)} \Delta x\right) \int_{\widetilde{\theta}}^{1} p_H(\theta)\, dF(\theta) \right\}.$$

[30] With substitutes the worker is never hired if $\widetilde{\theta} = 0$ in which case compensation design is irrelevant. The case of the optimal cutoff again is a special case.

[31] We note that the determination of $\widetilde{\theta}^*$ in the case of optimal negotiations with more than one firm follows the same line of arguments. In particular, as we will show in Proposition 4, the worker then elicits the type of the firm with the second highest willingness to pay for labor, y, and then offers a call option contract to

We close this proof by establishing that $\widetilde{\theta}^{*}$ is larger than the optimal cutoff the worker would implement when offering any (suboptimal) contract with $w > 0$, as claimed in the main text. So fix $w > 0$ such that, for a given cutoff $\widetilde{\theta}$, we have $\Delta w = 1 - \frac{p_N(\widetilde{\theta})\Delta x + w}{p_H(\widetilde{\theta})}$ from (2). Substituting into (5) and taking the cross-partial with respect to w and $\widetilde{\theta}$ we obtain $\int_{\widetilde{\theta}}^{1} p_H(\theta) \frac{\Delta_H}{(p_H(\widetilde{\theta}))^2} dF(\theta) > 0$. The result then follows from standard monotone comparative statics arguments. **Q.E.D.**

Proof of Lemma 1. Since the proof is standard, we will be brief. Suppose that there is an equilibrium for which the worker's participation constraint is satisfied with equality and in which there is a type θ' that offers a compensation contract with $\Delta w > 0$. A fully separating equilibrium in which $w_\theta + p_H(\theta) \Delta w_\theta = \underline{w}$ for all θ requires that $\Delta w_\theta > 0$ at least for some types, which is not incentive compatible, as low types will mimic types for which $\Delta w_\theta > 0$.

Thus, suppose that multiple types offer the same contract and take θ' to be the highest type in the pool. By deviating to a fixed-wage contract offering the worker $w = \underline{w}$, type θ' benefits from avoiding being pooled with lower types. The worker accepts the deviation, as the deviation contract is a fixed wage (which does not depend on out-of-equilibrium beliefs) that gives her the same value as her outside option.

To see that an equilibrium in which all types offer fixed wages and the worker breaks even can be supported, suppose that the worker observes a deviation to a compensation contract with $\Delta\widetilde{w} > 0$ and $\widetilde{w} \leq \underline{w}$. Since the original fixed-wage contract avoids misvaluation, for any deviation that makes the firm better off, the worker must be worse off compared to the original contract. Thus, for any out-of-equilibrium beliefs that put positive probability only on types that can benefit from deviating, the worker rejects the deviation. **Q.E.D.**

Proof of Lemma 2. See main text. **Q.E.D.**

Proof of Proposition 3. We prove the result for the general case in which the worker needs to choose between the optimal negotiation mechanism with n firms or letting $n+1$ firms compete as described in the main text. The optimal negotiation mechanism for the general case is the one characterized in Proposition 4. For the case with $n = 1$, negotiations are as dictated by Propositions 1 and 2.

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the highest valuation type. That is, $\widetilde{\theta}^{*}$ is then determined as

$$\arg\max_{\widetilde{\theta} \geq y} \int_{y}^{\widetilde{\theta}} \underline{w} \frac{dF(\theta)}{1 - F(y)} + \left(1 - \frac{p_N\left(\widetilde{\theta}\right)}{p_H\left(\widetilde{\theta}\right)} \Delta x\right) \int_{\widetilde{\theta}}^{1} p_H(\theta) \frac{dF(\theta)}{1 - F(y)}$$

Proof of statement (i). We first consider the case of substitutes. In this case the worker optimally negotiates for fixed compensation (see Proposition 2). Since the firm's payments are in cash both when the firm negotiates and when it lets firms compete, the result follows from Theorem 1 in Bulow and Klemperer (1996). ■

Proof of statement (ii). We now turn to the case of complements. We proceed in two steps. First, we show that a sufficient condition for negotiations with n firms to dominate competition among $n+1$ firms that offer fixed wages is that the worker can extract the full surplus with negotiations. In the second step, we use then our characterization of when the first-best contract is feasible to show the claim of the proposition.

Consider, first, the workers' expected payoff when $n+1$ firms compete to hire the workers by incrementally increasing their fixed-wage offers until only one firm remains as in an English auction. From Lemma 2 — which applies for any number of firms greater than two (see arguments in the main text) — the workers' expected payoff is equal to the expected valuation of the firm with the second-highest productivity:

$$\begin{aligned} U_{comp} &= \int_0^1 \left(p_H\left(\theta\right) - p_N\left(\theta\right)\right) \Delta x dF^{(2,n+1)}\left(\theta\right) \\ &= \int_0^1 \left(p_H\left(\theta\right) - p_N\left(\theta\right)\right) \Delta x \left(n+1\right) n \left(1 - F\left(\theta\right)\right) F\left(\theta\right)^{n-1} f\left(\theta\right) d\theta, \end{aligned} \tag{A.1}$$

where $F^{(2,n+1)}$ denotes the distribution of the second-highest-order statistics with $n+1$ firms and we have used that

$$F^{(2,n+1)}\left(\theta\right) = F\left(\theta\right)^{n+1} + \left(n+1\right) F\left(\theta\right)^{n} \left(1 - F\left(\theta\right)\right).$$

Since values are private and independent, and firms are symmetric, it holds that the worker's expected payoff would be the same in any alternative mechanism in which the highest-productivity firm hires the worker and makes fixed wage payments (Myerson, 1981).

Consider, next, the worker's expected payoff when she negotiates with n firms. If $\frac{\Delta_H}{\Delta_N} \in \left[1, \frac{p_H}{p_N}\right]$, the worker can extract all surplus created by her labor (see Propositions 1 and 4). Hence, in this case, the worker's expected compensation from negotiating with n firms corresponds to the surplus she generates at the firm with the highest willingness to pay for her labor, i.e.,

$$U_{neg} = \int_0^1 \left(p_H\left(\theta\right) - p_N\left(\theta\right)\right) \Delta x n F^{n-1}\left(\theta\right) f\left(\theta\right) d\theta, \tag{A.2}$$

where we have used that the distribution of the maximum out of n draws is given by $F^{(1,n)}\left(\theta\right) = F\left(\theta\right)^{n}$.

To show that the difference $D_1 := U_{neg} - U_{comp}$ is strictly positive, let $\widehat{\theta}$ be defined by $F(\widehat{\theta}) = \frac{n}{n+1}$. Then, we have that

$$
\begin{aligned}
D_1 &\equiv \int_0^1 \left(p_H(\theta) - p_N(\theta)\right) \Delta x F^{n-1}(\theta) \left(1 - (n+1)\left(1 - F(\theta)\right)\right) n f(\theta)\, d\theta \\
&= n(n+1) \left(\int_0^{\widehat{\theta}} \left(p_H(\theta) - p_N(\theta)\right) \Delta x F^{n-1}(\theta) \underbrace{\left(F(\theta) - \frac{n}{n+1}\right)}_{-} f(\theta)\, d\theta \right. \\
&\quad \left. + \int_{\widehat{\theta}}^1 \left(p_H(\theta) - p_N(\theta)\right) \Delta x F^{n-1}(\theta) \underbrace{\left(F(\theta) - \frac{n}{n+1}\right)}_{+} f(\theta)\, d\theta \right) \\
&> n(n+1) \left(p_H\left(\widehat{\theta}\right) - p_N\left(\widehat{\theta}\right)\right) \Delta x \int_0^1 F^{n-1}(\theta) \left(F(\theta) - \frac{n}{n+1}\right) f(\theta)\, d\theta \qquad \text{(A.3)} \\
&= n(n+1) \left(p_H\left(\widehat{\theta}\right) - p_N\left(\widehat{\theta}\right)\right) \frac{1}{n+1} \left[F^{n+1}(\theta) - F^n(\theta)\right]_0^1 = 0
\end{aligned}
$$

where the inequality follows from the fact that we are in the case of complements, i.e., $\left(p_H(\theta) - p_N(\theta)\right) \Delta x$ increases in θ.

It remains to show that the worker's expected payoff under negotiation with n firms dominates that under competition among $n+1$ firms also for $\frac{\Delta_H}{\Delta_N} \in \left[\frac{p_H}{p_N}, T\right)$, where the first-best contract is infeasible. We note that $T > \frac{p_H}{p_N}$ can be large or even infinite (see, e.g., the uniform example considered in the main text). To establish the result, note that at the boundary $\frac{\Delta_H}{\Delta_N} = \frac{p_H}{p_N}$, the first best contract is $\left\{w^{fb}, \Delta w^{fb}\right\} = \left\{0, \left(1 - \frac{\Delta_N}{\Delta_H}\right) \Delta x\right\}$, implying that the transitioning to a contract that pays only in the high cash flow state, as dictated by Proposition 1 for all $\frac{\Delta_H}{\Delta_N} > \frac{p_H}{p_N}$, is smooth. In particular, for $\frac{\Delta_H}{\Delta_N} \geq \frac{p_H}{p_N}$, we obtain that the difference in the worker's expected payoff when negotiating with n firms and that under competition among $n+1$ firms can be written as

$$
\begin{aligned}
D_2 &\equiv \int_0^1 \left(\left(\int_y^{\widetilde{\theta}^*} \underline{w} dF(\theta | \theta \geq y) + \int_{\widetilde{\theta}^*}^1 p_H(\theta) \Delta w \Delta x dF(\theta | \theta \geq y) \right) dF^{(2,n)}(\theta) \right. \qquad \text{(A.4)} \\
&\quad \left. - \int_0^1 \left(p_H(\theta) - p_N(\theta)\right) \Delta x dF^{(2,n+1)}(\theta) \right)
\end{aligned}
$$

where Δw is defined as in Proposition 1. Now, since $D_2 = D_1 > 0$ for $\frac{\Delta_H}{\Delta_N} = \frac{p_H}{p_N}$, it holds by continuity of D_2 in Δ_H and Δ_N, that a necessary condition for $D_2 \leq 0$ is that $\frac{\Delta_H}{\Delta_N}$ must be sufficiently larger than $\frac{p_H}{p_N}$, i.e., above a threshold $T > \frac{p_H}{p_N}$. ■

This finishes the proof of the Proposition **Q.E.D.**

Proof of Proposition 4. For $n = 1$ the optimality of the proposed mechanism follows from Propositions 1 and 2. For the remainder of the proof consider the case with $n > 1$. Without loss of generality consider a truthtelling mechanism and let $q(\theta_i, \boldsymbol{\theta}_{-i})$ denote the probability that firm i with type θ_i hires the workers when the other $n-1$ firm type realizations are given by $\boldsymbol{\theta}_{-i}$. Since there are n firms with iid types, we can state the worker's problem as one of finding the optimal menu $W = \{q(\theta_i, \boldsymbol{\theta}_{-i}), w(\theta_i, \boldsymbol{\theta}_{-i}), \Delta w(\theta_i, \boldsymbol{\theta}_{-i})\}$ that maximizes the expected payment by each firm

$$\max_W \sum_{i=1}^{n} \int_{[0,1]^n} q(\theta_i, \boldsymbol{\theta}_{-i}) \left(w(\theta_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i) \Delta w(\theta_i, \boldsymbol{\theta}_{-i}) \right) dF(\theta_i, \boldsymbol{\theta}_{-i}), \tag{A.5}$$

subject to $w(\theta_i, \boldsymbol{\theta}_{-i}), \Delta w(\theta_i, \boldsymbol{\theta}_{-i}) \geq 0$ for all $(\theta_i, \boldsymbol{\theta}_{-i})$; the ex ante (truthtelling) incentive constraints for all $(\theta_i, \boldsymbol{\theta}_{-i})$

$$\begin{aligned} &\int_{[0,1]^{n-1}} \Big(q(\theta_i, \boldsymbol{\theta}_{-i}) \left(x - w(\theta_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i) \left(\Delta x - \Delta w(\theta_i, \boldsymbol{\theta}_{-i}) \right) \right) \\ &\qquad + \left(1 - q(\theta_i, \boldsymbol{\theta}_{-i})\right) p_N(\theta_i) \Delta x \Big) dF(\boldsymbol{\theta}_{-i}) \\ \geq &\int_{[0,1]^{n-1}} \Big(q(z_i, \boldsymbol{\theta}_{-i}) \left(x - w(z_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i) \left(\Delta x - \Delta w(z_i, \boldsymbol{\theta}_{-i}) \right) \right) \\ &\qquad + \left(1 - q(z_i, \boldsymbol{\theta}_{-i})\right) \left(x + p_N(\theta_i) \Delta x \right) \Big) dF(\boldsymbol{\theta}_{-i}) \end{aligned} \tag{A.6}$$

for any possible report $z_i \in [0, 1]$; the no-regret participation constraint requiring that for any *given* realization of $\boldsymbol{\theta}_{-i}$, it holds for each type θ_i that

$$w(\theta_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i) \Delta w(\theta_i, \boldsymbol{\theta}_{-i}) \leq \left(p_H(\theta_i) - p_N(\theta_i) \right) \Delta x; \tag{A.7}$$

and the no-regret incentive constraint requiring that for any *given* realization of $\boldsymbol{\theta}_{-i}$, it holds for each type θ_i that

$$\begin{aligned} & \int \Big(q(\theta_i, \boldsymbol{\theta}_{-i}) \left(x - w(\theta_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i)\left(\Delta x - \Delta w(\theta_i, \boldsymbol{\theta}_{-i})\right)\right) \\ & \qquad + \left(1 - q(\theta_i, \boldsymbol{\theta}_{-i})\right) p_N(\theta_i) \Delta x \Big) dF(\boldsymbol{\theta}_{-i}) \\ \geq & \int \Big(q(z_i, \boldsymbol{\theta}_{-i}) \left(x - w(z_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i)\left(\Delta x - \Delta w(z_i, \boldsymbol{\theta}_{-i})\right)\right) \\ & \qquad + \left(1 - q(z_i, \boldsymbol{\theta}_{-i})\right) \left(x + p_N(\theta_i) \Delta x\right) \Big) dF(\boldsymbol{\theta}_{-i}), \end{aligned} \tag{A.8}$$

for any possible report $z_i \in [0, 1]$. Clearly, the ex-post participation constraint (A.7) ensures ex-ante participation and the ex post incentive constraints (A.8) imply the ex ante incentive constraints (A.6). Furthermore, we require that only the firm with the highest valuation (if any) hires and pays the worker, i.e.,

$$\begin{aligned} & q(\theta_i, \boldsymbol{\theta}_{-i}) = 0 \text{ and } \{w(\theta_i, \boldsymbol{\theta}_{-i}), \Delta w(\theta_i, \boldsymbol{\theta}_{-i})\} = \{0, 0\} \\ & \text{if } \left(p_H(\theta_i) - p_N(\theta_i)\right) \Delta x < \max_{\theta_j \in \boldsymbol{\theta}_{-i}} \left(p_H(\theta_j) - p_N(\theta_j)\right) \Delta x. \end{aligned} \tag{A.9}$$

Without loss of generality, we assume that ties are broken at random.

Observe, now, that conditions (A.7), (A.8), and (A.9) imply that the worker's program when she creates more value at more productive firms can be restated as

$$\int_{[0,1]^{n-1}} \max_{W} \left(\int_{[0,1]} \left(w(\theta_i, \boldsymbol{\theta}_{-i}) + p_H(\theta_i) \Delta w(\theta_i, \boldsymbol{\theta}_{-i})\right) dF(\theta_i | \theta_i \geq \max \boldsymbol{\theta}_{-i}) \right) dF(\boldsymbol{\theta}_{-i}), \tag{A.10}$$

subject to (A.7), (A.8) and $w, \Delta w \geq 0$. If the worker creates more value at less productive firms, we need to replace the conditional distribution with $F(\theta_i | \theta_i \leq \min \boldsymbol{\theta}_{-i})$. Conditional on knowing $\boldsymbol{\theta}_{-i}$, solving for the optimal offer, thus, follows the same steps as Propositions 1 and 2, where we only need to replace the worker's prior in these propositions with the conditional distribution from program (A.10). Crucially, the optimal mechanism cannot condition on the winning firm's truthful report of its type, since this would violate (A.8).

The final step follows from the observation that, as required, the final take-it-or-leave-it offer in the second stage of our mechanism does not use information about the last-remaining firm. Thus, firms essentially compete in an English auction in the first stage of the mechanisms. The arguments that the ex post incentive and participation constraints are satisfied are, thus, standard and omitted for brevity. **Q.E.D.**

Proof of Proposition 5. We show that the ranking proposed in the proposition identifies the firm willing to pay most for labor while extracting the valuations of all other firms. To see the claim, observe that a firm is willing to stay in the race to hire the worker as long as the compensation it needs to offer does not exhaust all surplus from hiring. Let W_b be the menu proposed by the worker to a firm in some given round. It is suboptimal for the firm to refuse to choose a contract $\{w_b, \Delta w_b\} \in W_b$ if there is a contract in this menu for which it holds

$$x - w_b + p_H(\theta)(\Delta x - \Delta w_b) \geq x + p_N(\theta)\Delta x, \tag{A.11}$$

as the firm would lose the possibility of hiring at compensation for which it is still better off compared to not hiring. Conversely, choosing a contract from W_b even though there is no contract in this set for which condition (A.11) is satisfied is also suboptimal, as the firm only retains the option to hire the worker at compensation for which hiring leads to a negative net present value.

Observe that, for any menu of contracts W_b, the firm (Firm B) prefers to choose only among the contracts for which $\widetilde{\theta}(w_b, \Delta w_b)$ is lowest. This is because if the other firm (Firm A) drops out on the next move, Firm B would otherwise unnecessarily give away that its type is higher than $\widetilde{\theta}(w_b, \Delta w_b)$. This would allow the worker to extract more surplus with her final take-it-or-leave-it offer. Firm B is indifferent among all offers that have the same cutoff $\widetilde{\theta}(w_b, \Delta w_b)$, since all these offers communicate the same information to the worker (i.e., that $\theta \geq \widetilde{\theta}(w_b, \Delta w_b)$).

If Firm B chooses a contract from W_b, the game continues with the worker offering a menu W_a to worker A and the same argument applies. The worker chooses the menu so that the minimum $\widetilde{\theta}(w_a, \Delta w_a)$ from the W_a corresponds to the minimum increment above $\widetilde{\theta}(w_b, \Delta w_b)$.[32] Thus, similar to an English auction, we obtain that each firm stays in the race to hire the worker until the minimum $\widetilde{\theta}$ from the respective menu offered to her equals her type. The rest of the proof follows then from Proposition 4. **Q.E.D.**

Proof of Proposition 6. The proof proceeds in two steps. Step 1 shows that the equilibrium proposed in the main text can be supported. Step 2 shows that cash constraints distort the highest fixed wage the firm is prepared to offer. The proof that no other equilibrium survives under the Intuitive Criterion refinement is relegated to Appendix B.

Claim 1: *For any given $\underline{w}'$ at each stage of competition, there is a perfect Bayesian equilibrium with a compensation contract $\{w, \Delta w\}$ and financing contract $\{S, \Delta S\}$ for which the*

[32] For our arguments, we use the standard simplification that the increase (in the minimum $\widetilde{\theta}$) is continuous.

worker's and financiers' participation constraints are binding and it holds that $S + w = x$. This equilibrium survives refining out-of-equilibrium beliefs with the Intuitive Criterion.

Proof. Suppose now that the last standing offer is $\{w, \Delta w\}$, implying that all remaining firms' types are higher than $\widetilde{\theta}(w, \Delta w)$. Consider any feasible combination of compensation and financing contracts, $\{w, \Delta w\}$ and $\{S, \Delta S\}$, such that it holds that $w + S = x$ and the worker's and financiers' participation constraints, (9) and (12), are satisfied with equality, where the expectation in these constraints is form using Bayes rule over types $\theta \geq \widetilde{\theta}(w, \Delta w)$. We argue that any such candidate equilibrium can be supported.

Define $R = w + S$ and $\Delta R = \Delta w + \Delta S$ as the sum of the claims offered to the worker and the financiers. Note that the Intuitive Criterion has no bite for deviations that benefit all types. In such cases, we can assume that the worker's and financiers' out-of-equilibrium beliefs place probability one on the lowest type, prompting the worker and financiers to reject the deviation. Thus, we only need to consider deviations that benefit only some types. Since $R = x$ (and feasibility dictates that $R \leq x$), consider a deviation to $\widetilde{R} = R - \zeta$ and $\Delta\widetilde{R} = \Delta R + \delta$ $(\zeta, \delta > 0)$. Define the threshold type $\widehat{\theta}$ that is indifferent between the original and deviation contracts as

$$x - \widetilde{R} + p_H(\widehat{\theta})(\Delta x - \Delta\widetilde{R}) - x + R - p_H(\widehat{\theta})(\Delta x - \Delta R) = 0.$$

If the firm deviates to $\{\widetilde{R}, \Delta\widetilde{R}\}$, the difference in its expected payoff between the equilibrium and deviation contract is

$$\begin{aligned} & \zeta + p_H(\theta)(\Delta x - \Delta\widetilde{R}) - p_H(\theta)(\Delta x - \Delta R) \\ = & -\left(p_H(\theta) - p_H(\widehat{\theta})\right)\delta. \end{aligned} \tag{A.12}$$

Expression (A.12) is positive for any $\theta < \widehat{\theta}$ and negative otherwise. Thus, by the Intuitive Criterion, the worker should put positive probability mass only on types $\theta < \widehat{\theta}$.

If $\widehat{\theta} < \widetilde{\theta}(w, \Delta w)$, the deviation is rejected as (by the Intuitive Criterion) it can only come from types that should have dropped out. Consider, therefore, deviations for which $\widetilde{\theta}(w, \Delta w) < \widehat{\theta}$ and suppose that the worker and financiers place probability one on the deviation coming from type $\widetilde{\theta}(w, \Delta w)$ (these beliefs do not violate the Intuitive Criterion). Given that the worker and financiers just break even with the original contracts (which pool that type with higher types), they are strictly better off rejecting the deviation for such out-of-equilibrium beliefs. Hence, there is no profitable deviation to $\widetilde{R} < x$, and the proposed equilibrium candidate with $R = x$ can be supported. Moreover, it survives refining out-of-equilibrium beliefs with the Intuitive Criterion. ■

Claim 2. *In the equilibrium from Claim 1, the highest fixed wage that the firm is prepared to offer is distorted upward in the case of complements and distorted downwards in the case of substitutes.*

Proof. Consider the case in which the worker generates more value at higher-productivity firms. Let $w(\theta)$ be the fixed wage at which type θ is indifferent between hiring and not hiring, and let $v(\theta^*) \equiv x + p_N(\theta^*)\Delta x$. Using that $S = x - w$ and $\Delta S = \frac{w-x}{\int_{\theta^*}^{1} p_H(\theta) \frac{f(\theta)}{1-F(\theta^*)} d\theta}$ to plug into (13) and rearranging terms, it holds

$$\begin{aligned} w(\theta^*) &= x + \int_{\theta^*}^{1} \frac{p_H(\theta)}{p_H(\theta^*)} \frac{f(\theta)}{1-F(\theta^*)} d\theta \left(p_H(\theta^*)\Delta x - v(\theta^*)\right) \\ &\geq x + p_H(\theta^*)\Delta x - v(\theta^*). \end{aligned}$$

The inequality follows from the fact that $p_H(\theta^*)\Delta x - v(\theta^*)$ must be positive whenever external financing is needed, i.e., $w(\theta^*) > x$. Furthermore, the inequality is strict for any $\theta^* < 1$.

Next, consider the case in which the worker generates more value at lower-productivity firms. Since $\Omega = [0, \theta^*]$, it holds that $\Delta S = \frac{w-x}{\int_{0}^{\theta^*} p_H(\theta) \frac{f(\theta)}{F(\theta^*)} d\theta}$ and we have

$$\begin{aligned} w(\theta^*) &= x + \int_{0}^{\theta^*} \frac{p_H(\theta)}{p_H(\theta^*)} \frac{f(\theta)}{F(\theta^*)} d\theta \left(p_H(\theta^*)\Delta x - v(\theta^*)\right) \\ &\leq x + p_H(\theta^*)\Delta x - v(\theta^*). \end{aligned}$$

The last inequality is strict for any $\theta^* > 0$. ■

This completes the proof of the Proposition. **Q.E.D.**

Appendix B Internet Appendix

B.1 Robustness of Propositions 1 and 2: It Does Not Matter Who Has Private Information

If the worker creates more value at more productive firms, the privately informed worker will offer an information insensitive claim to the uninformed firm and demand the most information-sensitive claim (i.e., call options). The intuition is that a worker who knows that the quality of the match between her and the firm is high wants to minimize the cost coming from the firm's uncertainty about that match — this uncertainty causes the firm to treat the match with the worker as average, leading it to reject aggressive compensation demands. The best way for the worker to minimize the "undervaluation" cost arising from this concern is by offering to be paid with variable compensation only, as such compensation exposes the worker most (and the firm least) to the true worker-firm match quality. No other type of compensation (involving fixed and variable pay) can survive in equilibrium, as a worker matching with a more productive firm will deviate by offering to be paid with variable pay only and, thus, convincingly indicate (when refining beliefs using the Intuitive Criterion) the high quality of the match.

The key difference when labor and capital are substitutes is that low-productivity firms are willing to pay more to hire the worker. Thus, the strongest incentive to deviate from equilibria pooling high and low types is now for a worker that has matched with a *low* (rather than high) productivity firm. Such a worker can do so by offering a fixed-wage contract that benefits workers facing a low type more than those facing higher types. Intuitively, workers that are matched with a high-productivity firm have more to lose from giving up variable pay, Δw. Thus, contracts offering variable pay cannot be sustained in equilibrium, as workers facing lower-productivity firms will deviate by offering fixed-wage contracts that are more valuable to the worker when she has been matched with a low-productivity compared to high-productivity firm. Such deviations will be successful, as they convince the firm (using the Intuitive Criterion as refinement) of its low capital productivity and, thus, the high value of hiring.

Proposition B.1 *Suppose that the worker is privately informed about the firm's productivity and can make a take-it-or-leave-it offer to the firm. (i) If the worker creates more value at more productive firms, she still demands compensation in call options; (ii) If the worker creates more value at less productive firms, she demands compensation in fixed wages.*

Proof of Proposition B.1. We prove the Proposition in three steps.

Claim 1: *In any candidate equilibrium in which types $\theta', \theta'' \in [0,1]$, where $\theta'' > \theta'$, offer different compensation contracts, it must be that $\Delta w_{\theta''} \geq \Delta w_{\theta'}$.*

Proof. From incentive compatibility, it must be that

$$\begin{aligned} w_{\theta'} + p_H(\theta')\,\Delta w_{\theta'} &\geq w_{\theta''} + p_H(\theta')\,\Delta w_{\theta''} \\ w_{\theta''} + p_H(\theta'')\,\Delta w_{\theta''} &\geq w_{\theta'} + p_H(\theta'')\,\Delta w_{\theta'}, \end{aligned}$$

from which we obtain that

$$(p_H(\theta'') - p_H(\theta'))\,\Delta w_{\theta''} \geq (p_H(\theta'') - p_H(\theta'))\,\Delta w_{\theta'},$$

proving the claim. Note that there can be no separating equilibrium in which two types offer a contract with the same Δw but different w, as such contracts are not incentive compatible. Hence, if there is a type $\underline{\theta}$ that makes the same contract offer as θ'', then all types in $[\underline{\theta}, \theta'']$ make the same offer. ■

Claim 2: *Let θ' and θ'' be the lowest and highest type that get hired and suppose that these types offer different compensation contracts. If the worker creates more value at more productive firms, there is no equilibrium, satisfying the Intuitive Criterion, in which types $[\theta', \theta'')$ offer to be paid in a contract that is different from a fixed wage.*

Proof. Let $\{w_{\theta'}, \Delta w_{\theta'}\}$ and $\{w_{\theta''}, \Delta w_{\theta''}\}$ be the contracts offered by types θ' and θ'', respectively. First, we show that type θ' must offer a contract with $\Delta w_{\theta'} = 0$. Extending the argument to all types $\theta < \theta''$ is then straightforward.

If there is a type that makes the same offer as θ'', let $\underline{\theta}$ be the lowest among these types. By Claim 1, it holds then that all types in $[\underline{\theta}, \theta'']$ make the same offer ($\underline{\theta} = \theta''$ corresponds to the case in which type θ'' fully separates). Let $\theta^* \in [\underline{\theta}, \theta'']$ be the highest type that offers $\{w_{\theta''}, \Delta w_{\theta''}\}$ for which it holds that

$$x - w_{\theta''} + p_H(\theta^*)\,(\Delta x - \Delta w_{\theta''}) \geq x + p_N(\theta^*)\,\Delta x.$$

Such a type always exists, as the firm must at least break even in equilibrium.

Suppose to a contradiction that $\Delta w_{\theta'} > 0$, which (by Claim 1) also implies that all contracts offered in equilibrium have a strictly positive variable component. Construct a deviation contract $\{\widetilde{w}, \Delta\widetilde{w}\}$ with $\Delta\widetilde{w} = 0$ such that

$$\widetilde{w} = w_{\theta''} + p_H(\theta^*)\,\Delta w_{\theta''}.$$

By incentive compatibility for type θ^*, it further holds that

$$\widetilde{w} = w_{\theta''} + p_H(\theta^*)\,\Delta w_{\theta''} \geq w_\theta + p_H(\theta^*)\,\Delta w_\theta$$

for any contract $\{w_\theta, \Delta w_\theta\}$ offered by types $\theta \neq \theta^*$ in equilibrium (if all types offer the same contract, the inequality is weak). But since $p_H(\theta)$ is increasing in θ and $\Delta w_\theta > 0$ for all contracts offered in equilibrium, it holds that $\widetilde{w} > w_\theta + p_H(\theta)\,\Delta w_\theta$ for all types $\theta < \theta^*$, with the inequality being reversed for types $\theta > \theta^*$. Hence, any out-of-equilibrium beliefs satisfying the Intuitive Criterion should put a positive mass only on types $\theta \leq \theta^*$.

Consider, now, the firm's expected payoff. By construction, it holds that

$$x - \widetilde{w} + p_H(\theta)\,\Delta x \geq x + p_N(\theta)\,\Delta x \text{ for } \theta = \theta^* \tag{B.1}$$

Since the worker creates more value at less productive firms (i.e., $\frac{\partial}{\partial\theta}(p_H(\theta) - p_N(\theta)) < 0$), the inequality in (B.1) is strict for all types $\theta \leq \theta^*$. Hence, we obtain that for *any* out-of-equilibrium beliefs satisfying the Intuitive Criterion, the firm is better off hiring with the deviation contract than not hiring. Thus, it accepts the deviation. Hence, we obtain a contradiction, and it must be that $\Delta w_{\theta'} = 0$.

Suppose, next, that there is some type $\widehat{\theta} > \theta'$ that offers a contract $\left\{w_{\widehat{\theta}}, \Delta w_{\widehat{\theta}}\right\}$ with $\Delta w_{\widehat{\theta}} > 0$ and let $\widehat{\theta}$ be the lowest such type. By Claim 1, it must be that all types $[\theta', \widehat{\theta})$ offer the same contract with $\Delta w_\theta = 0$. We can construct now a profitable deviation for type $\widehat{\theta}$ following the same steps as above to show that there is a profitable deviation from $\Delta w_{\widehat{\theta}}$ to a contract with $\Delta\widetilde{w} = 0$ that will be accepted by the firm. We can proceed iteratively to show that all contracts offered in equilibrium by types $\theta < \theta''$ must have $\Delta w = 0$. ■

Claim 3: *If the worker creates more value at less productive firms, there is an equilibrium in which all worker types offer to be paid a fixed-wage offer.*

Proof. A fixed-wage offer for which the firm at least breaks from hiring

$$\int_0^1 \left(x + p_H(\theta)\,\Delta x - \left(x + p_N(\theta)\,\Delta x\right)\right) dF(\theta) = w \tag{B.2}$$

can be supported as an equilibrium. Clearly, the worker cannot deviate to an alternative fixed-wage offer for which she is better off, as then all types will benefit (note that the Intuitive Criterion has then no bite). Thus, for out-of-equilibrium beliefs placing probability one on the highest type, the firm would be making a loss from hiring and will not accept. This follows from the assumption that the worker creates more value at more productive firms, implying from (B.2) that $x + p_H(\theta)\,\Delta x - (x + p_N(\theta)\,\Delta x) < w$ for $\theta = 1$.

Consider a deviation to a contract with $\Delta\widetilde{w} > 0$. If there is at least one type θ^* that weakly benefits from this deviation, then it must be that all $\theta > \theta^*$ benefit as well, implying that the firm is worse off with the deviation contract for all these types. Hence, for out-of-equilibrium beliefs placing probability one on the highest type, $\theta = 1$, the firm will reject the deviation, as it will hold that

$$x + p_H(\theta)\Delta x - (x + p_N(\theta)\Delta x) < w < \widetilde{w} + p_H(\theta)\Delta\widetilde{w} \quad \text{for } \theta = 1.$$

■

We omit the case in which the worker creates more value at less productive firms and first-best is not attainable, as it follows from a straightforward modification of Claims 2 and 3 above. In Claim 2, this modification requires constructing a deviation to a contract with $w = 0$ for which higher (instead of lower) types benefit from deviating. For a very similar game with continuous cash flows, we refer the reader to Nachman and Noe (1994). **Q.E.D.**

B.2 Equilibria With External Financing

Claim: *In any equilibrium of the hiring and financing game in Proposition 6, it must hold that* $w + S = x$*.*

Proof. We argue to a contradiction. Suppose that there is an equilibrium in which type θ' hires the worker and raises financing with contracts $\{w_{\theta'}, \Delta w_{\theta'}\}$ and $\{S_{\theta'}, \Delta S_{\theta'}\}$ for which it holds that $R_{\theta'} = w_{\theta'} + S_{\theta'} < x$ and $\Delta R_{\theta} = \Delta S_{\theta'} + \Delta w_{\theta'} > 0$. For any two types $\theta'' > \theta'$ offering contracts $\{S_{\theta''}, \Delta S_{\theta''}\}$ and $\{w_{\theta''}, \Delta w_{\theta''}\}$, respectively, incentive compatibility requires that

$$\begin{aligned} x - R_{\theta''} + p_H(\theta'')(\Delta x - \Delta R_{\theta''}) &\geq x - R_{\theta'} + p_H(\theta'')(\Delta x - \Delta R_{\theta'}) \\ x - R_{\theta''} + p_H(\theta')(\Delta x - \Delta R_{\theta''}) &\leq x - R_{\theta'} + p_H(\theta')(\Delta x - \Delta R_{\theta'}), \end{aligned}$$

which implies that $\Delta R_{\theta''} < \Delta R_{\theta'}$ and $R_{\theta''} > R_{\theta'}$ (where the inequalities are weak if the two types offer the same contract).

Note that the only thing that matters for incentive compatibility is the joint claim offered to the worker and financiers. Thus, we consider contracts that have the same R and ΔR as equivalent for the firm. Furthermore, note that there can be no separating equilibrium in which two types offer contracts with the same ΔR but different R, as such contracts are not incentive compatible. Hence, if there is a type $\overline{\theta}$ that makes the same contract offer as θ', then all types in $\left[\theta', \overline{\theta}\right]$ make the same offer.

Consider the case in which there is a type $\overline{\theta} \geq \theta'$ that makes the same offer as θ' and let $\overline{\theta}$ be the highest among these types. From above, it holds then that all types in $\left[\theta', \overline{\theta}\right]$ make the same offer. Let $\theta^* \in \left[\theta', \overline{\theta}\right]$ be the lowest type in this set for which it holds that

$$\begin{aligned} w_{\theta'} + p_H(\theta)\Delta w_{\theta'} &\geq w &\quad \text{(B.3)} \\ S_{\theta'} + p_H(\theta)\Delta S_{\theta'} &\geq 0. &\quad \text{(B.4)} \end{aligned}$$

Such a type always exists, as the investor and the worker must at least break even in equilibrium. Crucially, note that the inequalities (B.3) and (B.4) hold for all types $\theta > \theta^*$, as $\frac{\partial}{\partial\theta} p_H(\theta) > 0$ and $\Delta w_{\theta'} \geq 0$ and $\Delta S_{\theta'} > 0$.

Construct a deviation contract $\left\{\widetilde{R}, \Delta\widetilde{R}\right\}$ with $\widetilde{R} = x > R_{\theta'}$ and $\Delta\widetilde{R} < \Delta R_{\theta'}$ (where $\Delta\widetilde{w} \leq \Delta w_{\theta'}$ and $\Delta\widetilde{S} < \Delta S_{\theta'}$) such that

$$\begin{aligned} \widetilde{w} + p_H(\theta^*)\Delta\widetilde{w} &= w_{\theta'} + p_H(\theta^*)\Delta w_{\theta'} \\ \widetilde{S} + p_H(\theta^*)\Delta\widetilde{S} &= S_{\theta'} + p_H(\theta^*)\Delta S_{\theta'}. \end{aligned}$$

Note that by continuity of the worker's and investor's payoffs in $w, \Delta w$ and $S, \Delta S$, respectively, the deviation can be constructed such that it continues to hold that

$$\begin{aligned} \widetilde{w} + p_H(\theta)\,\Delta\widetilde{w} &\geq w \\ \widetilde{S} + p_H(\theta)\,\Delta\widetilde{S} &\geq 0. \end{aligned}$$

for all types $\theta > \theta^*$. Thus, for the deviation to be successful (i.e., accepted by the worker and the financier), it is sufficient to argue that the worker and investor will place probability zero on the deviation coming from types $\theta < \theta^*$. To see that this is the case, observe that by construction of $\left\{\widetilde{R}, \Delta\widetilde{R}\right\}$ and incentive compatibility, it holds that

$$x - \widetilde{R} + p_H(\theta^*)\left(\Delta x - \Delta\widetilde{R}\right) = x - R_{\theta'} + p_H(\theta^*)\left(\Delta x - \Delta R_{\theta'}\right) \geq x - R_\theta + p_H(\theta^*)\left(\Delta x - \Delta R_\theta\right)$$

for all contracts $\{R_\theta, \Delta R_\theta\}$ offered in equilibrium by types $\theta \geq \theta^*$ (where the last inequality is weak in case these types offer the same contracts). But then for any such contracts, for which $R_\theta < x$, it holds that $x - \widetilde{R} + p_H(\theta)\left(\Delta x - \Delta\widetilde{R}\right) > x - R_\theta + p_H(\theta)\left(\Delta x - \Delta R_\theta\right)$ for $\theta > \theta^*$, as $\Delta\widetilde{R} < \Delta R_{\theta'} \leq \Delta R_\theta$, and $x - \widetilde{R} + p_H(\theta^*)\left(\Delta x - \Delta\widetilde{R}\right) < x - R_{\theta'} + p_H(\theta^*)\left(\Delta x - \Delta R_{\theta'}\right)$ for $\theta < \theta^*$. Hence, for any beliefs satisfying the Intuitive Criterion, the worker and the financier should place positive probability only on types $\theta > \theta^*$. Hence, the deviation is accepted, leading to the desired contradiction. Since this deviation can be constructed for any equilibrium in which types $\theta < 1$ do not offer $R = x$, all types $\theta < 1$ must offer $R = x$. **Q.E.D.**

B.3 Derivation of Optimal Strategies in Example 2

In this Appendix, we derive the optimal strategies for the worker and the firms for the four different mechanisms discussed in Section 4. In the calculations of all examples, we assume that $c = 0.7$.

B.3.1 Sequential Offers

Fixed wage: If firms sequentially improve on each other's offers until only one firm remains, it is a weakly dominating strategy for each firm to continue increasing its offers until the final compensation it offers extracts all surplus from hiring, $(p_H(\theta) - p_N(\theta))\,\Delta x = \frac{\theta}{c+1}\Delta x$. Hence, the worker's expected compensation will be equal to the expected surplus it creates at the firm with the second-highest willingness to pay for labor. If the firms compete by offering fixed compensation, the worker's expected payoff is

$$\begin{aligned}
\mathrm{E}\left[\min\left(\theta_1, \theta_2\right)\right] \frac{\Delta x}{c+1} &= \int_0^1 \left(y \frac{\Delta x}{c+1}\right)\left(2\left(1-y\right)\right) dy \\
&= \frac{\Delta x}{3\left(c+1\right)} = 0.196\Delta x.
\end{aligned}$$

Call options: If the firms compete by offering call options, their maximum offer will be $\Delta w^s = \frac{\theta}{c+\theta}\Delta x$. Hence, the worker's expected compensation

$$\begin{aligned}
&\mathrm{E}\left[p_H\left(\theta\right)\min\left(\frac{\theta_1}{c+\theta_1}, \frac{\theta_2}{c+\theta_2}\right) |\theta > \min\left(\theta_1, \theta_2\right)\right] \Delta x \\
= &\int_0^1 \int_y^1 \left(\frac{c+\theta}{c+1}\right) \frac{1}{1-y} d\theta \left(\frac{y}{c+y}\right) \left(2\left(1-y\right)\right) dy \Delta x = 0.242\,\Delta x
\end{aligned}$$

B.3.2 Sequential Offers, Followed by TIOLI Offer

We consider now a final take-it-or-leave-it offer made by the worker to the last remaining firm. If the firm rejects, the workers take their initial outside option of $\underline{w}$. We compute the examples with $\underline{w} = 0$.

Fixed wage: Note that if the worker offers a fixed-wage contract, which corresponds to type θ's maximum willingness to pay, $\frac{\theta}{c+1}\Delta x$, this offer's probability of acceptance is $\frac{1-\theta}{1-y}$, where y is the type of the firm with the lower willingness to pay. Hence, the worker maximizes

$$\max_{\theta} \frac{\theta}{c+1} \Delta x \min\left(\frac{1-\theta}{1-y}, 1\right) + \theta \underline{w},$$

where the min-operator indicates that the minimum θ that the worker will choose is y, in which case the firm's probability of acceptance is one. Hence, the worker's optimal choice will be $\theta^* = \max\left(y, \frac{1}{2} + \frac{\underline{w}}{2}\frac{(c+1)(1-y)}{\Delta x}\right)$. Let $\widehat{y}$ be the value of y for which the two terms in the max operator are equal. The worker's ex ante expected payoff (before y is revealed) becomes

$$\int_0^{\widehat{y}} \frac{\left(\underline{w}\left(c+1\right)\left(1-y\right)+\Delta x\right)^2}{4\left(c+1\right)\left(1-y\right)\Delta x}\left(2\left(1-y\right)\right)dy + \int_{\widehat{y}}^1 y\left(\frac{\Delta x}{c+1}+\underline{w}\right)\left(2\left(1-y\right)\right)dy$$

and for $\underline{w} = 0$, we have

$$\left(\int_0^{0.5} \frac{1}{4\left(c+1\right)\left(1-y\right)}\left(2\left(1-y\right)\right)dy + \int_{0.5}^1 \frac{y}{c+1}\left(2\left(1-y\right)\right)dy\right)\Delta x = \frac{5}{12}\frac{\Delta x}{c+1} = 0.245\Delta x.$$

Call options: Note that if the worker offers a call options contract $\{0, \Delta w^s\} = \left\{0, \frac{\theta}{c+\theta}\Delta x\right\}$, which corresponds to type θ's maximum willingness to pay, this offer has a probability of acceptance $\frac{1-\theta}{1-y}$, where y is the type of the firm with the lower willingness to pay. Hence, the worker maximizes

$$\begin{aligned} & \max_{\theta} \int_{\theta}^1 \frac{c+z}{c+1}\left(\frac{\theta}{c+\theta}\Delta x\right)\frac{1}{1-y}dz + \theta\underline{w} \\ = & \ \frac{1}{2}\frac{\left(\theta-\theta^2\right)\left(2c+\theta+1\right)}{\left(c+\theta\right)\left(c+1\right)\left(1-y\right)}\Delta x + \theta\underline{w} \end{aligned}$$

and for the case where $\underline{w} = 0$, we have $\theta^* = \max\left(y, \frac{1}{3}\sqrt{4c^2+6c+3} - \frac{2}{3}c\right)$. And the ex ante expected payoff is

$$\begin{aligned} & \int_0^{\widehat{y}} \left(\frac{1}{2}\frac{\left(\theta^*-\theta^2\right)\left(2c+\theta^*+1\right)}{\left(c+\theta^*\right)\left(1-y\right)}\right)\left(2\left(1-y\right)\right)dy\frac{\Delta x}{c+1} \\ + & \int_{\widehat{y}}^1 \left(\frac{1}{2}\frac{\left(\widehat{y}-\theta^2\right)\left(2c+\widehat{y}+1\right)}{\left(c+\widehat{y}\right)\left(1-y\right)}\right)\left(2\left(1-y\right)\right)dy\frac{\Delta x}{c+1} = 0.282\Delta x \end{aligned}$$

B.3.3 First Price Auction

Fixed wage: If the firms offer fixed wages, the workers' expected compensation is the same as with sequential offers.

Call options: If the offers call options, let $\beta\left(\theta\right)$ denote the equilibrium payment in the high cash flow state offered by type θ. We restrict attention to symmetric equilibria in which the highest type wins. That is, type θ's probability of hiring is θ. Each firm maximizes

$$\max_b \left(\frac{c+\theta}{c+1}\left(\Delta x - b\right) - \frac{c}{c+1}\Delta x\right)\beta^{-1}\left(b\right)$$

By optimality, it needs to hold that

$$-p_H(\theta)\,\beta^{-1}(b) + (p_H(\theta)(\Delta x - b) - p_N \Delta x)\,\frac{1}{\beta'\left(\beta^{-1}(b)\right)} = 0$$

Furthermore, in a symmetric equilibrium, it must hold that $b = \beta(\theta)$. Using that $\frac{\partial}{\partial\theta}(\theta\beta(\theta)) = \beta(\theta) + \theta\beta'(\theta)$, we obtain

$$\frac{\partial}{\partial\theta}(\theta\beta(\theta)) = \frac{p_H(\theta) - p_N}{p_H(\theta)}\Delta x$$

and so

$$\begin{aligned}\beta(\theta) &= \beta(0) + \frac{1}{\theta}\int_0^\theta \left(1 - \frac{p_N}{p_H(y)}\right)\Delta x dy \\ &= \left(1 - \frac{c}{\theta}\ln\left(\frac{\theta + c}{c}\right)\right)\Delta x.\end{aligned}$$

where we use that it is weakly optimal for the lowest type to bid $\beta(0) = \frac{p_H(0) - p_N}{p_H(0)}\Delta x = 0$.[33] Since there are two firms, the worker's expected compensation is twice the ex ante expected payment made by any given firm

$$\begin{aligned}2\int_0^1 p(\theta)\,\beta(\theta)\,\theta d\theta &= 2\int_0^1 \left(\frac{c+\theta}{c+1}\left(1 - \frac{c}{\theta}\ln\left(\frac{\theta + c}{c}\right)\right)\Delta x\theta\right) d\theta \\ &= \left(\frac{2}{3} + \frac{3}{2}c + c^2 - c(c+1)^2\ln\frac{c+1}{c}\right)\frac{\Delta x}{c+1} = 0.242\,\Delta x.\end{aligned}$$

[33] Note that we present only a heuristic sketch of the argument. For a more-complete derivation of the optimal strategies in first-price auctions, see for example DeMarzo et al. (2005).