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Workers Versus Firms: Bargaining Over a Firm's Value

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We introduce a distinction between a firm and its *network* of workers. In a competitive world, if networks are easily lured away, the workers must receive the entire value of their contribution to the firm. How then can service firms have equity value? A model is analysed in which workers are paid less as a group than their value, even in a competitive world. The workers are assumed to have a nonwage benefit for working at the current firm; this benefit is privately known. These privately known benefits make it impossible for the workers to agree on a division of their value should they leave the existing firm for a new enterprise. The result is that the workers may receive a total compensation that is less than their contribution to the firm.

1. INTRODUCTION

There are many firms (e.g. advertising agencies and brokerage houses) whose equity value seems to be substantially above the value of the physical and intangible assets (e.g. patents) owned by the firm. A plausible and popular explanation for this discrepancy is that all the assets of the firm have not been properly accounted for and that the work force (perhaps viewed as a network) is an important asset of the firm. For some advertising agencies and brokerage houses, the work force may well be the most important asset of the firm. If a firm's work force is an asset, however, it is an unusual one. In general nothing prevents a group of workers from leaving a firm and either joining a competitor or forming a new firm.¹ Furthermore, a firm cannot sell its work force without selling itself. Conversely, buying the firm doesn't guarantee that the work force will remain with the new owner. Nonetheless, we do observe large companies such as E. F. Hutton being purchased for their work forces. This suggests that while there may be risks in buying a firm to acquire its work force, it is still cheaper than hiring the work force directly.

We analyse a model in which a firm's work force has value and has some of the characteristics associated with more traditional assets. The work force of a firm, including management, is viewed as a *network* of people, each with an understanding about how information and goods move within the firm. They know whom to contact about particular

1. There may be legal restrictions such as key-employee clauses and court injunctions. Key-employee clauses, where they have been signed, are certainly important in preventing workers from leaving. The history of court injunctions to prevent workers who have left firms from pursuing their clients or co-workers from the original firm is uneven. In one recent case such an injunction was granted (the chairman and president of Lord, Einstein, O'Neill and Partners were at least temporarily barred on April 5, 1988, from pursuing clients or employees of Lord, Geller, Federico, Einstein, the ad agency they had left the previous month) while in another it was refused (Shearson, Lehman and Hutton sued to prevent Dean Witter from using any confidential information it obtained as a potential bidder for Hutton in luring workers and lost, January 14, 1988). We abstract from these legal restrictions.

problems that may arise and they know the strengths and weaknesses of their co-workers. A worker has substantial network specific human capital, which is of no value outside this network.

In a competitive environment a firm must pay each worker his marginal product outside the firm to prevent his leaving the firm. But, in a competitive world, will a worker's wage reflect his productivity *within* the company, which may be higher than his productivity outside the firm? In other words, will the workers as a group receive wages equal to their contribution,² or will the firm be able to extract part of the contribution that is due to the positive production externalities that the workers confer upon each other? If workers do not capture the portion of profits attributable to these effects, the owners of the firm receive a return not only on the traditional assets of the firm, but also on the *network of workers* that is in place.³

In the traditional neoclassical view of the firm, the firm sells a product and, from the revenues raised, pays each worker his marginal product. What remains after paying for this and other inputs is the return to the owner or the stockholders of the firm on the assets of the firm. These assets include both the physical assets of the firm such as building and equipment and the intangible assets such as patents, distribution channels, and goodwill (although we will argue that some of these intangibles, in particular goodwill, should not be treated as traditional assets of the firm; see Section 2). In a competitive world, the workers of a firm, as a group, must be paid their value, that is, they must receive an amount equal to the total revenues of the firm less the costs of generating these revenues (including a fair return on the market value of the assets of the firm other than the work force). If the workers were to receive less than this amount, they could simply purchase duplicates of the assets of the firm and guarantee themselves, as a group, their value.

The possibility that a firm's workers can leave (as a group) raises important questions about the structure and stability of the firm. The empirical importance of this possibility is borne out by the observation that partnerships are a prevalent form of ownership for service firms. Furthermore, small groups of workers do leave their current firm either to join another firm or to establish a new firm, while the observation that large groups of workers do not leave their current firm is implied by the model in Section 3.

In this paper, we describe a possible explanation for the existence of a gap between workers' total wage bill and their value in a competitive world. We do not view this model as a complete description of the firm;⁴ rather, its value is in the suggestive character of its implications. If the workers in a firm hope to expropriate the "excess" stockholder value,⁵ they must convince all (or at least a large part) of the work force to move to the new "clone" company. To do this, they must decide how to divide up the excess stockholder value. If each worker's *reservation wage* (that is, the wage at which he would move to the proposed clone company) is public information, then the workers' bargaining problem of dividing the gains is solvable. We say solvable in that most of the economic

2. Measurement of the contribution of a network to the value of the firm's output may be conceptually difficult. In a competitive economy, the contribution is the residual after all the other inputs have been accounted for.

3. We are not the first to observe that human capital can be an important input for the firm and that it is (potentially) transferrable; see, for example, Prescott and Visscher (1980) and Klein (1988). However, other authors have not asked whether the existence of network specific human capital allowed the firm to not pay the network its value.

4. Indeed this model does not address many important issues. Section 4 discusses some of these.

5. By excess we mean that part beyond the value of the physical and intangible assets *excluding* the ability to expropriate a portion of the workers' value, unless that ability is tied to an asset of the firm such as a legal monopoly.

models of bargaining will give us an (perhaps many) efficient solution.⁶ If information about the workers' reservation wages is asymmetric, however, the problem of dividing the excess stockholder value may be very difficult. We introduce asymmetric information into the workers' bargaining problem by assuming that a worker's reservation wage is not necessarily equal to his current wage and further, that each worker's reservation wage is private information. We refer to the difference between a worker's reservation wage and his current wage as his *benefit* from working for the current owner.⁷

It is not surprising that with asymmetric information about the workers' reservation wages the workers are not able to solve their bargaining problem with probability one. The problem is actually much worse: if the reservation wages are private, the probability that the workers can solve the bargaining problem *must* go to zero as the number of workers in the firm gets large.⁸

If the workers can agree on how to divide the surplus available to them when they leave the firm, then we would expect the workers to leave the firm and implement an agreed upon division. The firm can affect the reservation wages of the workers, and hence the likelihood of the work force leaving, through the wages it pays. If the workers as a group receive compensation equal to their contribution, then there is no surplus and so no incentive to leave. On the other hand, if wages are so low that it is possible to pay each worker an amount equal to the greatest possible reservation wage that he/she could have out of the value of the network, then the work force can easily devise an agreement to divide the surplus and will leave the firm.

In Section 2 we discuss briefly some of the issues that arise from viewing the network of workers as an entity distinct from the firm. In Section 3 we present our model of the firm with private reservation wages. We discuss interpretations, applications, limitations and extensions of our model in Section 4.

2. THE NETWORK AND THE FIRM.

The distinction between a firm and its network of workers is an important one. In order to illustrate this distinction we will discuss various issues involving a theory of the firm as an institution of ownership; it owns physical and intangible assets. The owner of a firm receives the return on these assets. A network is *mobile* if offering each worker in the network a marginally higher wage is sufficient inducement for the network to leave the current firm.

The distinction between networks and firms does not lose any force when some workers own shares in the company (as senior managers may). As long as the firm is not *completely* owned by the workers, there exist shareholders who potentially are receiving returns on the network of workers. The network will be mobile even if some of the workers own shares, if those workers only require an equivalent holding in the new firm and marginally higher wages to move.

6. For example, in two-person bargaining with complete information and alternating offers Rubinstein (1982) has shown that for most specifications of costs of delay (such as discounting) there is a unique subgame-perfect equilibrium outcome of the infinite-horizon game that is Pareto efficient. For three-person bargaining problems with alternating offers and complete information, there are many equilibrium outcomes (see Shaked's example in Sutton (1986)), some of which are efficient.

7. This benefit may be pecuniary or nonpecuniary. Examples and motivation of such benefits are discussed below. To the extent that a portion of a worker's wage is not publicly known, this may qualify as a benefit as well.

8. While the model assumes that all the workers' reservation wages are private, this is not necessary. Simply interpret all quantities as being net of those workers with publicly known reservation wages.

A critical implication of the distinction between the network of workers and the firm begins by considering an important issue in agency theory: how can a firm induce workers to invest sufficiently in firm-specific human capital.⁹ If workers invest in firm-specific human capital then, in the absence of long-term contracts, workers cannot prevent the firm from expropriating, *ex post*, some (or all) of the benefits. One solution, of course, is for the firm to subsidize the workers' investment. Familiarity with the operating procedures of the firm and its corporate culture is often given as an example of firm-specific human capital. But, we argue, this is *not* firm-specific human capital; if the entire set of workers of a firm created a clone of the firm, this human capital would remain. The human capital is specific to the network rather than to the firm. Most, if not all, examples of firm-specific human capital are, in fact, examples of network-specific human capital. If the network of workers has new owners and physical assets that are identical to those in the original firm, then the new firm should have no difficulty replicating the operating procedures of the original firm.

Thus, so long as the original firm's operating procedures can be replicated and the network is mobile, the original firm cannot expropriate *any* of the returns from this human capital. Since the worker need not fear that the firm will expropriate the benefits of investment in network-specific human capital, the firm need not subsidize worker investments. In fact, the argument we are making is even stronger: the firm *should not* subsidize; if it did, the workers could expropriate the benefits in the manner just described. The only worker investments that should be underwritten by the firm are those that yield firm-specific, rather than network-specific, human capital.

It may be argued that for many firms, name recognition and goodwill prevent the network of workers from being able to create a replica of the existing firm. But, because the firm's reputation and any goodwill it may have should rest with the workers of the firm, this cannot be an insurmountable obstacle to the replication of the firm. In a world of rational consumers, the only reason goodwill and reputation can matter is if there is some original uncertainty about the quality of the output. If the physical assets of the firm (buildings and equipment) are duplicated in a second firm and the entire work force of the first firm moves to the second, any reputation effects or goodwill should move with the workers.¹⁰ This argument depends upon the customers of the firms *knowing* that the move has been made, which may involve some expenditures in informing the customers, such as costs in certifying that the move has been made and that the process is not an attempt to "trick" the customers. In any case, the amount of profits that an existing firm can extract from the workers' value would be limited to the costs of this information process to another entrepreneur.¹¹ The value of the name of the firm is similarly limited.

A network not being mobile has implications for the valuation of firm-specific assets, such as name lists, goodwill, patents, and ownership of unique physical assets. A common technique for valuing these assets is to account for all the assets that the firm acquires on competitive markets and impute the residual to the firm-specific assets. This technique overvalues these assets to the extent that there are network externalities captured by the firm.

9. Relationship-specific investment and "lock-in" effects have been emphasized by Williamson (1985), among others, and are discussed in Hart and Holmstrom (1987).

10. This assumes that the workers (or the new owners) have the same incentives to provide high quality as the original owner of the firm. If not, some (or conceivably all) of the goodwill or reputation of the firm could be lost if the workers form a new firm with different owners. See Section 4.4 on the role of owners.

11. Moving a network from one firm to another may involve significant relocation costs, especially if a major geographical move is necessary. For example, the estimated cost for RJR Nabisco to move its corporate headquarters from Winston-Salem, N.C. to Atlanta is \$33 million (*Business Week*, September 7, 1987, page 68).

3. A MODEL WITH PRIVATE BENEFITS.

Suppose that workers have different reservation wages for working at the existing firm and that these reservation wages are not common knowledge. This difference can arise from loyalty to the existing firm, the management style of the original owners, a particularly nice view from an office window that will be lost if a worker leaves the firm, or myriad other sources. That is, the firm gives some workers benefits that would cease should the worker leave this firm.¹² We take this difference in reservation wages as exogenous.

The original firm has n workers. Denote the set of workers by $N = \{1, \dots, n\}$. The value (i.e., revenues less non-labour costs) of the network consisting of the set of $M \subset N$ workers is $S(M) = s|M|$ if $|M| \geq (1 - \alpha)n$, and 0 otherwise, where s and α are constants with $s > 0$, $\alpha \in [0, 1]$, and $|M|$ is the cardinality of M .¹³ Thus, output is a linear function of the number of workers once a critical number of them is involved.¹⁴ Each worker's reservation wage is either w or $H > w$, where w is the wage paid by the firm. Let H^* ($= H - w$) be the benefit of the high-reservation wage workers. Denote worker i 's reservation wage by ω_i . Workers do not receive their value if there exists M such that $\sum_{i \in M} \omega_i < S(M)$. The distribution of benefits is independent and identical across workers. Let p denote the probability that a worker has a benefit H^* . Workers are indistinguishable.

Rather than explicitly model the process by which a new firm is formed, we will study direct revelation mechanisms in which, for any subset of workers, the probability of formation of any new firm and the schedule of wages in the new firm are determined as a function of workers' reported benefits or, equivalently, their reservation wages (their private information), denoted $\hat{\omega} = (\hat{\omega}_1, \dots, \hat{\omega}_n)$. We can imagine many different forms that attempts to attract the workers to a new firm might take: individual conversations, group meetings, etc. By the revelation principle (see, e.g. Myerson (1985)), the restriction to direct revelation mechanisms is without loss of generality in the sense that any outcome associated with an equilibrium of some process will also be an equilibrium outcome of some revelation mechanism in which the agents report their private information (here, their benefits) truthfully. A direct revelation mechanism is *incentive compatible* if truthful reporting forms a Nash equilibrium. Let $k = \#\{j: \hat{\omega}_j = H\}$, the number of reported highs. When all workers truthfully report their benefit, k is a binomial random variable with n trials and probability p of success on any trial.

We assume that any workers who do not join the new firm stay with the original owner at their original wages and only one new firm can form. The first assumption is most plausible in the case that the current owner does not observe the reports. We also require that wages in the new firm be paid out of the value of the new firm (i.e. we require *budget balance*). Finally, a worker joins a new firm only if he receives a wage at least equal to his reservation wage (i.e. we require *ex post individual rationality*).

Since we are only interested in the probability that a subset of workers will leave the current firm, we can restrict attention to a particularly simple class of revelation mechanisms (see the Proposition in Appendix 1). Since the incentive problem is to induce low-reservation wage workers to reveal truthfully, we would like to reward them maximally

12. Possible evidence for the existence of reservation wages not equal to actual wages (with the difference due to the current owner) is given by the observation that when ad agencies and brokerage houses are taken over by new owners, many of their workers either leave and establish their own firms or are lured away by competitors. See Section 4.4.

13. We would like to thank John Moore for suggestions that led to this formulation.

14. The important qualitative characteristics of the production function are that average product is increasing as the number of workers increases from 0 to some threshold level and that average productivity is constant thereafter.

for doing so. To do this, we want to include only as many high-reservation wage workers as are needed to achieve the critical number of workers $((1-\alpha)n)$, and to pay them as little as possible (consistent, of course, with individual rationality). The remainder of the output is divided equally among the announced low-reservation wage workers. Formally, this means that $\xi_i^*(\hat{w})$, i 's wage in the new firm if i is included, is:

$$\xi_i^*(\hat{w}) = \begin{cases} H, & \hat{w}_i = H, \\ s, & \hat{w}_i = w, k \leq \alpha n, \\ ((1-\alpha)ns - k^*H)/(n-k), & \hat{w}_i = w, k \geq \alpha n + 1, \end{cases} \quad (1)$$

where $k^* \equiv (1-\alpha)n - (n-k) = k - \alpha n$ is the number of included high-reservation wage workers. A mechanism is described by (ρ^*, ξ^*) , where $\rho^*(k)$ is the probability that a new firm forms when there are k reported highs and wages in the new firm, ξ^* , are given by (1). The size of the new firm, when it forms, is $\max\{(1-\alpha)n, n-k\}$. For any ρ^* , (ρ^*, ξ^*) satisfies budget balance and ex post individual rationality by construction.

The current owner can affect the likelihood of dissolution through the choice of current wage w . If, for a given wage, there is no incentive compatible, ex post individually rational, budget-balanced mechanism, then the current firm is safe from dissolution.

A lower bound on w is given by the restriction $s \leq w + H^* \equiv H$. If $w < s - H^*$, the trivial mechanism of paying every worker $w + H^* + \varepsilon$, for $\varepsilon > 0$ and small will result in all the workers leaving the current owner for sure.

Individual rationality, budget balance, and $w \geq s - H^*$ imply that the incentive compatibility constraint for the high-reservation wage workers is never binding. The incentive compatibility constraint for the lows is given by

$$\begin{aligned} & \sum_{k=0}^{\alpha n} \Pr(k) (\rho^*(k)s + (1-\rho^*(k))w) + \sum_{k=\alpha n+1}^{n-1} \Pr(k) \\ & \quad \times \left(\frac{\rho^*(k)((1-\alpha)ns - k^*H)}{(n-k)} + (1-\rho^*(k))w \right) \\ & \geq \sum_{k=0}^{\alpha n-1} \Pr(k)w + \sum_{k=\alpha n}^{n-1} \Pr(k) \\ & \quad \times \left(\frac{\rho^*(k+1)(k^*+1)H}{(k+1)} + \left(1 - \frac{\rho^*(k+1)(k^*+1)}{(k+1)} \right) w \right). \end{aligned} \quad (2)$$

This incentive compatibility constraint captures both sources of disincentive on a low-reservation wage worker from reporting a high reservation wage. First, observe that if the true number of lows excluding the given low reservation wage worker (which is equal to the number of reported lows, $n-k-1$, if the other workers truthfully report and he reports high) is greater than or equal to $(1-\alpha)n$, then the new firm will definitely not include him (since no highs are needed). Second, if the number of lows is less than $(1-\alpha)n$, then $(1-\alpha)n - (n-k-1) = k^* + 1$ highs are selected at random to join the new firm, giving a probability of selection of $(k^*+1)/(k+1)$.

We are interested in the ability of the firm to pay less than s as $n \rightarrow \infty$. Suppose first that $\alpha > p$. Then, the expected number of highs in the firm is less than the number of workers that can be excluded without production cost. Thus we would expect in a large firm (where the number of actual highs will be very close to the expected number) that any wage strictly less than s would permit a mechanism to lure all the low reservation wage workers with probability 1. This in fact turns out to be the case (Proposition 1). Furthermore, even when $\alpha < p$, if there is a mechanism that forms a new firm with positive probability, then a new firm can (almost) always be formed (Propositions 2 and 3). The proofs of the next three propositions are in Appendix 2. Recall that by the construction

of (1), any mechanism satisfies budget balance and ex post individual rationality. The content of the three propositions relates to incentive compatibility.

Proposition 1. *Suppose $\alpha > p$ and $w < s$. The mechanism that always forms a new firm (i.e. $\rho^*(k) = 1$ for all k) satisfies incentive compatibility, budget balance, and ex post individual rationality for large n .*

Suppose, now, that $\alpha < p$. There is a critical wage rate, given by

$$w(\alpha, p) \equiv s - \frac{(p - \alpha)H^*}{(1 - \alpha)p}.$$

If the firm pays less than $w(\alpha, p)$ then it will (asymptotically) certainly lose some of its workers. Any wage above $w(\alpha, p)$ is enough to (asymptotically) prevent any group of workers from leaving.

Proposition 2. *Suppose $\alpha < p$ and $w < w(\alpha, p)$. Then the mechanism that always forms a new firm (i.e. $\rho^*(k) = 1$ for all k) satisfies incentive compatibility, budget balance, and ex post individual rationality for large n .*

Proposition 3. *Suppose $\alpha < p$ and $w > w(\alpha, p)$. Then for all mechanisms (ρ^*, ξ^*) satisfying incentive compatibility, budget balance, and ex post individual rationality, the unconditional probability that a new firm is formed converges to zero as n gets large, i.e.*

$$\sum_{k=0}^n \Pr(k) \rho^*(k) \rightarrow 0, \quad \text{as } n \rightarrow \infty.$$

The critical wage captures the relationship between the probability of any worker having a high reservation wage and the proportion of workers that can be excluded. Note that $w(\alpha, p)$ is continuously increasing in α , decreasing in p , equals s when $\alpha = p$, and equals $s - H^*$ when $\alpha = 0$. Thus when $\alpha = 0$, large firms can pay workers as if they all had a high reservation wage, regardless of the value of p .

When $\alpha = 0$, the workers are faced with the public good problem described in Mailath and Postlewaite (1990). All workers must agree to the change and each worker's willingness to move is private information. The results of Mailath and Postlewaite (1990) can be applied to the case of general distributions for ω_i to conclude that for large firms, the wage rate is $s - H^*$.

4. DISCUSSION

4.1. Origination of the firm

Some might interpret our results as a capitalist receiving a part of the output without having to provide any inputs. This is misleading in that it ignores the origin of the firm. In our model and discussion, we have taken the firm and the network of workers as given. If it was foreseen that an owner would be able to extract some of the output of the workers, this would provide incentives to start such a firm. If there are several entrepreneurs who could start such firms, we should expect the future value of the underpayment of workers to be competed away at this initial stage. Thus, the underpayment of the workers today may have been compensated for in earlier periods. We say "may have" since if there are factors other than labour, some of the benefits of the competition among entrepreneurs at the origination of the firm may have gone to these

non-labour factors. To the extent that this competition among entrepreneurs takes place at the origination of the firm, the transfer identified in this paper is a transfer from workers today to some factor of production at the origination of the firm (possibly labour) rather than a transfer to capitalists today.

4.2. *Source of private benefits*

Our model rests on the existence of benefits to workers that are not publicly known. These benefits must be firm-specific; if they were due to factors that could be replicated in the marketplace, they would present no obstacle to the workers leaving. These firm-specific benefits would generally be transferable from the current owners to new owners, but may not be. For example, if the benefits are due to loyalty to the current owner, they would presumably disappear if the firm is sold. If the benefits are due to physical characteristics such as location, then the network can continue to be underpaid by any entrepreneur who purchases the firm and the market value of the firm will reflect the increased profitability due to this underpayment.

A critical feature of our model is the difference between a worker's reservation value for moving to a new firm and his current wage. One of the most plausible sources of such a difference would seem to be risk aversion on the workers' part regarding the likelihood of a successful move to a new firm. The workers in the model in Section 3 are risk-neutral, so risk-aversion cannot be the source of any benefits in *that* model.¹⁵ However, the intuition for the asymptotic result does not seem to rely on the assumption of risk-neutrality. If the workers were risk-averse and there were some uncertainty about the success of a new venture (for example, uncertainty about replicating all the capital of the old firm or uncertainty that the old customers will be convinced that the new firm is identical to the old firm), then a worker's reservation wage for moving would include a risk premium. As long as this risk premium is private information there will be asymmetric information about the reservation wages of the sort that drives our results. A firm is then underpaying its workers when the value of the network of workers is greater than the compensation of the workers including any insurance value the workers may attribute to their jobs.

4.3. *Endogenous benefits*

The difference between a worker's wage and his reservation wage for leaving in our model is exogenous. The presence of these differences, so long as they are privately known, causes the owner's profits to be larger than would otherwise be the case. This suggests that the firm has a clear incentive to encourage the formation of private reservation wages. For example, the firm might pay each worker privately and not allow the worker to have any proof of his wage (in this case, reservation wages equal actual wages which are privately known). There are obvious difficulties with such a procedure; it is not clear how a firm can credibly influence workers' beliefs about the distribution of wages it pays, for example. However, there is a variant of this idea that does seem to have merit. Suppose the work force is divided into two classes, with the members of the first class (e.g. partners of the firm) receiving substantially higher wages than the second. The owner decides on who is promoted from the second class to the first. If the firm uses a private characteristic to make its decision (so that the publicly available information

15. The analysis of mechanism design models with risk averse agents is substantially more complicated than with risk neutral agents—see, for example, Matthews (1983) and Maskin and Riley (1984).

about a worker's characteristics is not enough to predict the firm's promotion decisions), then a worker may be better informed about the chances of promotion than either his or her co-workers or an outside entrepreneur. This private information about the chances of promotion, and the ensuing monetary prize, can constitute the private values assumed in our model.¹⁶

4.4. *The role of owners*

We have treated any equity holder with a role in the running of the firm as a worker and member of the network. Only those equity holders who are "passive" would be adversely affected by the departure of the network of workers. We have not yet been explicit about who the passive equity holders are. In our view, passive investors are those investors who have no role in making decisions within the firm and no special expertise in choosing employees (including board members) for the firm.

It may be, however, that even investors who are passive can play a role. Current owners may have a "reputation" that affects the firm. This reputation may be for not expanding or moving the firm into new ventures. Such ventures may be risky for the firm (and *a fortiori* the workers); if the workers are risk averse (as discussed in Section 4.2 above), they may prefer working within a network if it is ultimately controlled by the current owners than by someone else (including the workers themselves). Similarly, current owners may have different preferences over choices of quality of product or of future hires than would the network of workers.

These considerations suggest that there may be limits to the extent to which the network of workers can credibly replicate the firm without the current stockholders. This, of course, constitutes a barrier to the workers leaving, and hence, allows the aggregate wage bill to be lower than otherwise. We plan to do further research in this area.

4.5. *The firm's response to a network's departure*

In our model, we assumed that if an attempt to form a new firm failed, the existing wage structure remained. This assumption might be justified if the existing firm were unaware of any attempt to form a new firm. However, if the firm learned of a plan of the workers to leave, it could respond by selectively offering some workers bonuses to refuse to go. Publicizing the selective bonus offer while withholding the names of the recipients would render the bonuses formally equivalent to the benefits we have included in the model. This, of course, would increase the barriers workers face in leaving the firm and would thus increase the degree to which the firm could underpay the workers. Alternatively, suppose that *before* the workers enter into their negotiations, the firm can commit to punishing those workers who participated in the negotiations but were excluded from the new firm. Then the IR constraints would alter (in particular, high reservation wage workers now require a higher wage if included, to compensate for the punishment that results if the new firm does not include them).

We should point out that there are other aspects of the modelling that have biased the outcome in the other direction. Our individual rationality constraints implicitly assume that a worker would continue to receive both his wage and his firm-specific benefits even if a part of the network leaves. But if part of the network leaves, the remaining workers

16. This example is motivated by a discussion with a partner of Goldman-Sachs. He said that he could never understand why he got paid as much as he did and half-jokingly mentioned that he always thought that his wage served as something of a "carrot" for the younger workers.

may not generate sufficient revenue to maintain the original firm, and either the wage and/or the firm specific benefit might vanish. This suggests that some workers may decide to move with a subset of other workers when they will be worse off than at the outset, because they would be even worse off were they to stay. The specific assumption implicit in our individual rationality constraint is thus somewhat arbitrary. An investigation of alternative individual rationality constraints would be an interesting topic for future research.¹⁷

A second modelling choice also biases the results in favour of the workers being underpaid, namely the bargaining structure we assumed. In our model, we have given the owner(s) of the firm a "first-mover" advantage: they set the wages of the workers subject to prevailing market conditions. This does not seem unreasonable as an approximation to existing practice, but the workers and the firm are modelled asymmetrically in this respect. Note that if reservation wages are public, then the first-mover advantage doesn't provide any advantage to the firm. The firm must pay the network of workers their full value.

4.6. *Distribution of wages among workers*

Our model suggests that for the firm to retain its workforce, the binding constraint depends on the total wage bill rather than on the wage of any single worker. In this case, the firm will have discretion as to how it divides the total wage bill among the workers. This discretion prompts two observations.

The first is that competition among firms may not prevent discrimination against particular groups of workers. It is sometimes argued that such discrimination cannot persist in competitive markets because entrepreneurs would find it profitable to hire away those workers who were being paid less than their marginal product. If the binding constraint depends upon some group of workers being paid a particular amount, reallocations of that amount among the group will not leave open the firm to raiding of the group being discriminated against.

A second observation concerns unions. One view of unions is that their role is to raise the wages of workers above market wages. Their power to do so rests on the threat to halt production, and thus the flow of profits. In this view, it is imperative that the unions prevent the firm from hiring replacements; since union members are paid above market wages, the firm could increase profits by firing everyone and hiring anew. If a network of workers does not capture all its value (whether this is because of transactions costs or privately known benefits), unions need to worry about the possibility of their workers being replaced. While the workers are attempting to raise their wages above market wages, the entire group may not be attempting to receive more than its value.

APPENDIX 1

In this Appendix we show that the restriction in Section 3 to the simple class of mechanisms is without loss of generality. Let $P(N)$ denote the power set of N and $\Delta(P(N))$ the set of probability distributions over $P(N)$. A (*direct revelation mechanism*) is a pair (ρ, ξ) , where $\rho: \Pi, W_i \rightarrow \Delta(P(N))$ gives a probability distribution over the set of possible new firms as a function of the vector of reports and $\xi: \Pi, W_i \times P(N) \rightarrow \mathbb{R}_+^n$ gives the vector of new wages as function of this vector of reports and the set of workers in the new firm. As a normalization, $\xi_i(\omega, M) = 0$ if $i \notin M$. For the reports $\hat{\omega}$ the probability that a new firm consisting of the workers in $M \subset N$ is formed is given by $\rho(\hat{\omega})(M)$ (setting $M = \emptyset$ gives the probability that all the workers stay with the firm).

17. This point was suggested by a referee.

A mechanism is incentive compatible (IC) if truthful reporting forms a Nash equilibrium. It is *budget balancing* (BB) if $S(M) \geq \sum_{i \in M} \xi_i(\omega, M)$ whenever M arises as a new firm with positive probability. Finally, it is *ex post individually rational* (IR) if, when M arises as a new firm with positive probability, $\xi_i(\omega, M) \geq \omega_i$ for any worker i in M .

Proposition: *Suppose (ρ, ξ) satisfies IC, BB, and IR. There exists a mechanism in the simple class analysed in Section 3 satisfying IC, BB, and IR, with the same probability that no new firm is formed.*

Proof. We first claim that we can restrict attention to mechanisms in which workers who make the same report are treated identically ex ante and if they are included receive the same payment; we will call such mechanisms *anonymous*. Given a report of $\hat{\omega}$, the probability of formation of a new firm under (ρ, ξ) is given by $1 - \rho(\hat{\omega})(\emptyset)$. We can construct an anonymous mechanism from any mechanism with the same expected probability of formation of a new firm as follows. There are $n!$ permutations of workers' names. The anonymous mechanism randomly chooses a permutation of the names of the workers (each permutation has probability $1/n!$) and applies the original mechanism to the relabelled workers. Since the relabelling is not determined by the reports, the anonymous mechanism satisfies IC, BB, and IR if the original mechanism does.¹⁸ Since $H \geq s \geq w$, we can assume that any high reservation wage workers included in a new network receive H .

Suppose the firm has chosen a wage w and there is a positive probability that a new firm will be formed under some anonymous mechanism (ρ, ξ) that satisfies (IR) and (BB). There is an alternative mechanism with, for all reports, the same probability of formation of a new firm that only assigns positive probability to networks in $M(\hat{\omega}) = \{N' \subset N : \{i : \hat{\omega}_i = w\} \subset N', \text{ if } \hat{\omega}_j = H \text{ and } j \in N', \text{ then } |N'| = (1 - \alpha)n\} \cup \{\emptyset\}$. The collection $M(\hat{\omega})$ is the set of networks that include all the announced lows and only include sufficiently many announced highs to achieve the critical number of workers and the empty set (i.e. no new firm is formed). Suppose $\rho(\hat{\omega})(N^*) \neq 0$ for some $\hat{\omega}$ and $N^* \notin M(\hat{\omega})$. Observe that including any lows not included in N^* does not adversely affect BB, IC, and IR. Similarly, omitting excess highs increases the wage that can be paid to the lows as well; this also decreases the chance that any particular reported high will be included in the new network. Thus we can restrict attention to the mechanisms analysed in the text.

APPENDIX 2

Proof of Proposition 1. Rearranging the incentive compatibility constraint for $\rho^*(k) = 1$ for all k gives:

$$\sum_{k=0}^{\alpha n} \Pr(k)(s - w) + \Pr(\alpha n)w \geq \sum_{k=\alpha n+1}^{n-1} \Pr(k) \left(\frac{(k - \alpha n + 1)H}{(k + 1)} - \frac{\{(1 - \alpha)ns - (k - \alpha n)H\}}{(n - k)} + \frac{\alpha nw}{(k + 1)} \right) + \Pr(\alpha n)(H + \alpha nw)/(\alpha n + 1).$$

Further rearranging yields:

$$(IC^*) \quad \sum_{k=0}^{\alpha n} \Pr(k)(s - w) - \Pr(\alpha n)H^*/(\alpha n + 1) \geq \sum_{k=\alpha n+1}^{n-1} \Pr(k) \left(\frac{(1 - \alpha)n(H - s)}{(n - k)} - \frac{\alpha nH^*}{(k + 1)} \right).$$

As $n \rightarrow \infty$, $\Pr(\alpha n)H^*/(\alpha n + 1)$ tends to zero. Thus the question of whether (IC*) is satisfied for large n revolves around the behaviour of the two summations. Denoting the frequency of highs by $\nu = k/n$, $\nu \rightarrow p$ almost surely. Now, since $\alpha > p$, $\sum_{k=0}^{\alpha n} \Pr(k) = \sum_{\nu=0}^{\alpha} \Pr(\nu) = \Pr\{\nu \leq \alpha\} \rightarrow 1$. If the last term is asymptotically ≤ 0 , then (IC*) is satisfied for large n . The last term equals

$$\sum_{\nu=\alpha+1/n}^{1-1/n} \Pr(\nu) \left(\frac{(1 - \alpha)(H - s)}{(1 - \nu)} - \frac{\alpha H^*}{(\nu + 1/n)} \right),$$

which converges to zero as $n \rightarrow \infty$. ||

Proof of Proposition 2. Since $\alpha < p$, and setting $\nu = k/n$, $\sum_{k=0}^{\alpha n} \Pr(k) = \sum_{\nu=0}^{\alpha} \Pr(\nu) = \Pr\{\nu \leq \alpha\} \rightarrow 0$, and the left-hand side of (IC*) converges to zero and it is enough to show that the right-hand side is asymptotically strictly negative. Fix $\delta > 0$ and suppose $|p - \nu| \leq \delta$. Then

$$\begin{aligned} \frac{(1 - \alpha)(H - s)}{(1 - \nu)} - \frac{\alpha H^*}{(\nu + 1/n)} &\leq \frac{(1 - \alpha)(H - s)}{(1 - p - \delta)} - \frac{\alpha H^*}{(p + \delta + 1/n)} \\ &= \frac{1}{(1 - p - \delta)} \left((1 - \alpha)(w - s) + \frac{(p - \alpha)H^*}{(p + \delta + 1/n)} \right) + \frac{(\delta + 1/n - \alpha/n)H^*}{(1 - p - \delta)(p + \delta + 1/n)}. \end{aligned}$$

18. More formally, let $\phi : \{1, \dots, n\} \rightarrow \{1, \dots, n\}$ be a permutation mapping (one-to-one and onto). Denote the vector of reports after permutation under ϕ by $\omega \circ \phi^{-1}$, i.e. $\omega \circ \phi^{-1} = (\omega_{\phi^{-1}(1)}, \dots, \omega_{\phi^{-1}(n)})$. The anonymous mechanism $(\rho^\alpha, \xi^\alpha)$ derived from (ρ, ξ) is given by $\rho^\alpha(\omega)(M) = \sum_{\phi} \rho(\omega \circ \phi^{-1})(\phi(M))/n!$ and $\xi^\alpha(\omega, M) = \{\sum_{\phi} \xi_{\phi(i)}(\omega \circ \phi^{-1}, \phi(M))\rho(\omega \circ \phi^{-1})(\phi(M))/n!\}/\rho^\alpha(\omega)(M)$.

By making δ sufficiently small and n sufficiently large, the second term in the last line can be made arbitrarily close to zero. The first term in the last line is bounded away from zero from below for δ small and n large, because $(1-\alpha)(w-s) + (p-\alpha)H^*p^{-1} = (1-\alpha)(w-w(\alpha, p)) < 0$. Since v is bounded away from zero and, for fixed δ , $\Pr(|p-v| > \delta) \rightarrow 0$ as $n \rightarrow \infty$, (IC*) is asymptotically satisfied. \parallel

Proof of Proposition 3. Rewrite the incentive compatibility constraint (2) as

$$\begin{aligned} & \sum_{k=0}^{\alpha n} \Pr(k)\rho^*(k)(s-w) + \sum_{k=\alpha n+1}^{n-1} \Pr(k)\rho^*(k) \frac{(1-\alpha)n(s-H)}{(n-k)} + \sum_{k=\alpha n+1}^{n-1} \Pr(k)\rho^*(k)H^* \\ & \geq \sum_{k=\alpha n}^{n-1} \Pr(k)\rho^*(k+1) \frac{(k-\alpha n+1)H^*}{(k+1)}. \end{aligned}$$

and rearrange to yield

$$\begin{aligned} & \sum_{k=0}^{\alpha n} \Pr(k)\rho^*(k)(s-w) + \sum_{k=\alpha n+1}^{n-1} \Pr(k)(\rho^*(k) - \rho^*(k+1)) \frac{(k-\alpha n+1)H^*}{(k+1)} - \Pr(\alpha n)\rho^*(\alpha n+1) \frac{H^*}{(\alpha n+1)} \\ & \geq \sum_{k=\alpha n+1}^{n-1} \Pr(k)\rho^*(k) \left(\frac{(1-\alpha)n(H-s)}{(n-k)} - \frac{\alpha n H^*}{(k+1)} \right). \end{aligned}$$

The second term on the left-hand side of the inequality converges to zero (see Mailath and Postlewaite (1990, Appendix 2)). Thus the left-hand side converges to zero.

If $\sum \Pr(k)\rho^*(k)$ does not converge to zero, then $\sum_{k \geq \alpha n+1} \Pr(k)\rho^*(k)$ also does not converge to zero. Thus we are done once we show that the expression on the left-hand side is positive for large n , with the term in brackets bounded away from zero. This argument is very similar to that used in Proposition 2 and so can be omitted. \parallel

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