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Signaling, reputation and spinoffs☆

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ABSTRACT

I propose a new channel of spinoff (firm formed when an employee leaves to set up his own firm) formation in which the returns from spinning off are determined endogenously. If high ability workers are scarce, then despite the principal's ability to offer contracts (endogenous cost of signaling), there exists a separating equilibrium where the high type worker signals his ability by forming a spinoff. This result provides theoretical support to the empirical findings of Skogstrøm (2012). When moral hazard is introduced in the baseline model of adverse selection, I show that the spinoff equilibrium can generate the strongest incentives to work. This has policy implications for non-compete clauses.

1. Introduction

Employees often leave their firm to form a rival firm of their own. Firms formed in this manner are called intra-industry spinoffs and the firms from which they spawn are called parent firms[2]. Such firms have been observed in industries ranging from semiconductors (National, AMD, Intel are all spinoffs) to automobiles (Klepper, 2007) to law firms (Phillips, 2002). The recent literature on spinoffs has focused on the explanation that most spinoffs come about when an employee gets a new idea privately, and then forms the spinoff because of asymmetric information about the idea's profitability (the employee knows more than the employer) - (Anton and Yao, 1995; Chatterjee and Rossi-Hansberg, 2012; Klepper and Thompson, 2010). The intuition here is that asymmetric information about the quality of the idea implies that ideas with above av-

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[2] There is some disagreement in the literature about the definition of spinoffs. In this paper, I do not consider "sponsored spin-offs" (Cooper, 1971) in which a parent firm voluntarily establishes and holds stocks in a newly formed company intended to perform some of the business of the parent company. Also, for convenience, I will be dropping the words 'intra-industry' for the rest of this article.

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erage returns are implemented in spinoffs since the employer/market will not pay more than the expected return for an idea.

To the best of my knowledge, all papers in the spinoff literature assume that the benefit from forming a spinoff is exogenously given[3]. This assumes that customer *perception* about the new firm's quality does not matter. However, this may not be true when the profitability of the idea is privately known to the worker only. Even if a worker has a good idea, if the market believes that the idea is likely to be bad then the worker will not be able to get high profits when he forms the spinoff[4]. In this paper, I will present a model in which market perception about the quality of the new firm matters, and therefore, signaling plays a big role in determining the profits that can be earned from forming a new firm.

This paper makes three contributions to the literature. One, I suggest a different channel of spinoff formation based on signaling and reputation concerns. In particular, I demonstrate a new reason for firm formation amongst under-signalled workers (those who are high ability but are perceived to be low type). Thus, this paper does not endeavour to explain spinoffs by workers who are already known to be high ability (like scientists or engineers). Instead, I look at workers who are (incorrectly) *perceived* as low ability, like those high ability workers who are not highly educated. This leads to the primary question of this paper - if the worker type is known only to the worker, under what conditions can high ability workers signal their type to the market by forming their own firms? It is important to answer this question for the following reasons. One, asymmetric information about the worker's type and contracting limitations[5] may lead to the high ability worker receiving wages which are much lower than his marginal product. Not only does this reduce the welfare of the high type worker, it could also hamper the regional economy by encouraging brain drain[6].

The second contribution of this paper is to demonstrate a new effort inefficiency which may be inherent in non-compete clauses. If good workers get low wages because they are believed to be low ability, then they may not find it incentive compatible to exert high effort. I introduce moral hazard in my baseline model of adverse selection and show that the equilibrium with the spinoff outcome can generate the highest incentives to work. This has implications for policy on covenants not to compete since they restrict signaling behaviour by disallowing the worker from forming a competing firm.

Finally, my model of firm formation may be able to explain some empirical observations better than other models[7]. Skogstrøm (2012) uses Norwegian data to show that entrepreneurship rates are particularly high among workers with low education and high ability[8]. This is consistent with my results because high ability workers with low education may be perceived as low ability workers. In this case, as Proposition 1 points out, the high ability-low education worker can improve his payoff by becoming an entrepreneur. I further discuss the relation between my results and the Norwegian data in Section 6.7.

I consider a two period principal-worker model (how the results may extend to an infinite horizon model is discussed in Section 6.3). The worker may be good or bad. The type is known only to the worker. The worker needs to perform a job, and while the good type worker always succeeds[9] at the job, the bad type worker succeeds with a lower probability. The outcome of the job is publicly observed after each period. At the beginning of each period, the worker may accept a one period contract from the principal or form his own firm. Setting up a firm is costly and requires a one time investment[10]. If the worker forms his own firm he has to incur a one time fixed cost of R_w (interpret this as the cost of acquiring permissions) whereas if the worker accepts the contract offered by the principal, the principal incurs a fixed one time cost of R_p[11]. I assume that the principal is better suited to form the firm i.e. $R_w > R_p$[12].

[3] At least the mean payoff from spinning off is known to the worker in these papers. In the literature section, I will talk about dynamic signaling papers like Bar-Isaac (2003) where the value of the seller's output depends upon signaling and reputation.

[4] The worker who forms the spinoff may earn high profits in the long run as the market will update its belief about the quality of the idea/service after they see a series of good outcomes. However, short run payoffs will be strongly affected by customer perception about the quality of the new firm, and these could be crucial if the worker-entrepreneur is not infinitely patient.

[5] A contract cannot ask a worker to pay to work, or charge the worker for failing. Also, the principal may not be able to commit to long term outcome contingent contracts.

[6] It is not hard to imagine that if high ability workers are paid low wages because they are thought to be low type then they might leave to try their luck elsewhere. In India for example, numerous stories abound of low caste people moving away from their village (where they were known to be low caste and therefore believed to be worthy of only lowly jobs). Obviously, escape from oppression was their primary aim. However, it must be a factor that they could earn better in another place where the belief about their ability was not so biased.

[7] A caveat here. Identification of the cause of entrepreneurship is extremely difficult owing to the many possible explanations. In particular, unless explicitly asked in the survey, it is not easy to distinguish between entrepreneurship because the worker wanted to be his/her own boss, and any other reason. This will be especially true if 'wanting to be your own boss' is correlated with ability.

[8] Ability is measured by an armed forces test every male has to take in Norway.

[9] This particular formulation is not essential for the qualitative results - see Section 6.4.

[10] In general, a model of spinoffs has a principal and a worker where the worker works for the principal's firm. However, since the worker may have some fixed costs of firm formation and the principal may also have some fixed costs of operations (like getting/renewing licenses), I have simplified this environment and assumed that the principal is trying to recruit a worker and both have a fixed (but different) cost of firm formation.

[11] It may be asked - If the worker was working for the principal, why did he not form his firm before? The opportunity to form a firm comes very rarely. For example, Blanchflower and Oswald (1998) point out that people who get inheritances are more likely to be entrepreneurs. Obviously, these are somewhat random events. In terms of the model, the cost of firm formation may be prohibitive for the worker in most periods until that one period when it becomes feasible for the worker to incur this cost. I start my analysis at this period.

[12] This can be interpreted as a difference in networks, that is, the principal may know the right people which would guarantee that the principal can form his firm more easily.

If the prior belief about the worker's type is low (worker is likely to be bad), then a good worker would like to signal his type by making the costly investment and forming his own firm. However, the bad type worker may be tempted to copy the good worker's strategy in the hope of fooling the market into paying him more. Thus, to obtain conditions for a separating equilibrium, we must argue why a bad type worker will not find it optimal to copy the good type worker's strategy. Moreover, we must argue why the principal cannot offer a contract which would get accepted by the good worker.

First, let us think about why a bad type worker would not copy the strategy of the good worker. Since it is a two period model, the bad worker realizes that the market may learn his type after observing the outcome of the job at the end of period 1. This would give him a lower expected payoff tomorrow as compared to the good type worker[13], making him reluctant to form the spinoff if the cost of firm formation is high enough (while the good type worker may still find it profitable to spin off). The second question is - why can't the principal prevent the worker from leaving by offering a lucrative wage contract which the good type worker will always accept? Once we have conditions under which the bad worker does not copy the strategy of the good worker, the principal is left with two choices. The principal can offer a low wage contract knowing that only a bad worker will accept it. Alternatively, the principal can offer a high wage contract to attract the good type worker as well. The issue with the latter option is that both type workers will accept it, making it a pooling equilibrium. Then, if the prior belief about the worker's ability is low, the market will believe that the worker signing the lucrative contract is more likely to be bad type, which would give the principal a low price from the market. The principal will not find it incentive compatible to offer a high wage contract as he would be unwilling to pay wages substantially above the price he expects to get from the market. These ideas allow me to find conditions under which there exists a separating equilibrium in which a good type worker forms a spinoff and a bad type worker accepts a contract with the principal. In the internet appendix, I discuss refinements under which the spinoff outcome is the unique equilibrium outcome.

In the second half of the paper, I introduce moral hazard (the worker can put in unobservable effort which affects the probability of success of the job) into the model and analyze the principal-worker model again. A planner or a policy maker may be interested in knowing if the separating equilibrium actually generates higher incentives to put in effort (and therefore leads to a higher probability of success for the job) as compared to other equilibria which may exist under the same conditions. In particular, this may be of interest from the standpoint of policy on non-compete clauses, since they may induce an effort inefficiency if the worker puts in higher effort when he forms his own firm as compared to when he works for a principal. I find conditions under which this result holds. This result is interesting because, unlike the principal, the worker is unable to credibly offer himself outcome dependent contracts when he forms his own firm. Thus, he is unable to commit to effort after forming a spinoff whereas the principal can extract effort by offering higher wages for success. However, I show that in any separating equilibrium, a good type worker will put in full effort in the first period after separating. This is to avoid failure and being thought of as the bad type worker subsequently, as this will reduce payoffs in period two. If effort is valuable but not extremely important for success, then there exist conditions under which the principal does not find it worthwhile to offer high wage contracts to encourage effort. Under these conditions, the separating equilibrium generates the most effort which leads to the highest probability of success for the job[14].

The rest of the paper is organized as follows. Section 2 describes the relevant literature. Section 3 contains the baseline model and Section 4 presents the analysis for the principal-worker problem. Section 5 introduces the moral hazard dimension to the baseline model of adverse selection. I discuss some of my modeling choices in Section 6, and Section 7 concludes the paper. The appendix contains some proofs omitted from the paper. The internet appendix for this paper is available at http://www.surajshekhar.com/. This contains additional proofs and results of interest.

2. Literature

This paper is related to several branches of the economics and business literature. In Section 1, I have already mentioned some papers which talk about spinoff formation. In this section, I will discuss other work this paper is related to. My baseline model is one of adverse selection and signaling, and in the latter half of this paper I introduce moral hazard in the baseline model.

First and foremost, my paper is related to job market signaling as studied in the celebrated paper by Spence (1973). However, the question here becomes more interesting because the worker's employer is aware of the possibility of the worker forming his own firm, and can offer contracts to make the worker stay. Thus, the opportunity cost of leaving to form a spinoff is endogenously determined in my model (endogenous cost of signaling). Moreover, the model here is dynamic in nature where the unknown worker type may get revealed by the worker's performance at the end of each period. This brings reputation concerns into play. Also, unlike Spence's (and many others') paper which is concerned with the idea of using education as a signal to potential employers, in this paper I look at the signaling opportunities after the education

[13] As an example, think of people who leave their high paying jobs, invest their own money, and start firms. Their move may be interpreted as a signal indicating that they are really high ability people (because low ability people will not find it profitable to make an investment, get found out later, and then earn low returns). Another example of this is the belief held by movie goers when a film is released in 3-D ("*the producers must have real faith in the film*") or when a firm spends a lot of money on advertising a good whose efficacy is revealed soon after use (see Nelson (1974)).

[14] This can add to explanation for the rise of Silicon Valley over Massachusetts Route 128. Unlike Massachusetts, California does not enforce non-compete covenants (except under a few special circumstances). Also see Saxenian (1994) and Gilson (1999).

stage. As Skogstrøm (2012) points out, education may not signal ability perfectly. Skogstrøm (2012) has a simple model of signaling to explain entrepreneurship. The author points out that if the cost of education and ability are not perfectly correlated then it is possible that high ability workers who have a high cost to education take up entrepreneurship in equilibrium. However, the return to entrepreneurship for high ability workers is assumed to be an exogenous function of ability. In fact, Skogstrøm (2012) specifically rules out the possibility of entrepreneurship itself acting as a valuable signal of ability. This paper fill this gap.

Some of the ideas in this paper are borrowed from the literature on dynamic signaling. For example, in Bar-Isaac (2003), the author studies a dynamic model with unknown seller types where the quality of the product is revealed after use. When the seller knows her quality, a good seller never stops selling, whereas a bad seller may exit the market when her reputation is sufficiently low. The idea that a high ability player has a better future and is therefore willing to separate using a costly signal is used in my paper as well[15]. The difference from my paper is that Bar-Isaac (2003) has a daily cost of signaling which induces a lower bound below which reputation does not fall (since bad types get out of the game with positive probability below this reputation). This can make discount factors irrelevant. In my model, the bad type will never get out of the game once he has paid the fixed one time cost. Thus, discount factors can affect the results in my paper[16]. Additionally, my paper also studies moral hazard simultaneously with adverse selection.

The idea of investing personal wealth to indicate quality of a new firm has been explored in papers like Brealey et al. (1977), Prasad et al. (2000) and Han et al. (2008). For example, in Brealey et al. (1977), the amount of equity kept by the owner helps solve the adverse selection problem. Players who have higher expected returns keep more of the equity. Similarly, in Han et al. (2008), good type players signal their type by taking up high collateral-low interest loans from the bank. However, these papers don't allow for a principal who has the power to stop a worker from forming a new firm by offering him a better contract. Moreover, the reasoning in my paper depends crucially on the reputation aspect as the worker's type may get revealed through performance. This reputation angle is missing in these papers. For example, in Han et al. (2008), the bank is able to screen the workers perfectly so that they self select into different contracts. In contrast, in my paper, when the conditions required for a separating equilibrium are satisfied, the principal has no incentives to screen. Other papers have looked at quality signals *after* a new venture is formed. For example, in Hsu and Ziedonis (2008) and Audretsch et al. (2012), patents can be used as a signal for quality.

I should also differentiate this paper from those in the literature which attribute spinoff formation to a worker getting a private new idea (Anton and Yao, 1995; Chatterjee and Rossi-Hansberg, 2012). This is because these papers assume that the (average) profitability of a new idea is exogenous and known to the worker[17]. In my model, the payoff is strongly linked to the signaling aspect of the problem. Even a good type worker will earn much less than his ability if the market believes him to be a bad type worker. While it is possible to model the signaling channel of firm formation via a 'new idea' channel, this has not been addressed in the literature. Furthermore, at least the Norwegian data[18] seems to suggest a story beyond the new ideas theory. Many people who form spinoffs in the Norwegian data form the same kind of firm as their parent firm. If new firms were formed based only on new ideas then the spinoff should be very different from the parent firm. Also, as Berglann et al. (2011) point out - *"If new ideas was always key to new firms, the following would not have been true - The observed entrepreneur rate among hairdressers is in fact almost ten times as large as the entrepreneur rate among scientists with PhD"*. The intuition being that the latter are more likely to have new ideas.

In the latter half of the paper, I introduce moral hazard into an environment with adverse selection. This makes my model suitable for studying non-compete covenants. In the literature on such covenants, while Rubin and Shedd (1981) show that non-compete clauses may encourage worker training investments by firms, Garmaise (2011) points out that managers may have less incentives to invest in their own human capital after they have signed non-compete covenants. If the effort of the manager to increase her own human capital is very valuable, the efficiency of non compete clauses is reduced[19]. In this paper, I describe conditions under which the worker puts in the most effort when he forms his own firm. Since non-compete covenants rule out the possibility of rival entrepreneurship for the worker, they can generate an effort inefficiency leading to a lower probability of success for any job executed by the worker.

3. Principal agent problem

There are two risk neutral players - a principal and a worker. It is a two period game (how the results may extend to an infinite horizon model is discussed in Section 6.3). The worker can be one of two types - G or B (good or bad). Only the worker knows his type. The probability of being type G is p_g. The worker performs a job whose outcome could be a success or a failure. Worker type G is better than worker type B at performing the job. In particular, I assume that a G worker always succeeds at the job but a B worker succeeds with a strictly lower probability denoted by λ_b (the case of both type workers being allowed to fail is discussed in Section 6.4). These probabilities are common knowledge. The market values a successful

[15] The idea of a 'brighter future' for good types has also been used by Tadelis (1999) and in earlier papers on advertising (see Nelson (1974) and Milgrom and Roberts (1986)).

[16] In a simple infinite horizon extension of my model, it is easy to highlight the role of discounting. This result is available upon request.

[17] In Anton and Yao (1995), the payoff to the worker from the new idea is exogenously given as the payoff from a duopoly.

[18] See Skogstrøm (2012).

[19] Also see Marx et al. (2015), Gilson (1999), and Saxenian (1994) for criticisms of non compete covenants.

job at V and does not get any utility from a failed job. To keep the market side simple, I assume that the firm gets paid its expected value for the job i.e. if the market believes that the worker's reputation is θ (the belief about the worker being good type) in some period, then the firm receives a price $(\theta V + (1-\theta)\lambda_b V)$ from the market in that period[20].

In period 1, the principal moves first and offers either no contract or a one period contract(s)[21] to the worker. Each contract is a tuple (s, f). If the worker accepts the contract (s, f) then the worker's wage for that period is s if the job is successful, and f if it is not. I assume that $s, f \geq 0$ (limited liability for the worker). This is important for obtaining spinoffs and I discuss this assumption further in Section 6.1. Furthermore, for most results in the paper, I will focus on equilibrium strategies which have $f = 0$. Thus, when I refer to high/low wage in the text, it will refer to high/low wage for success. The focus on equilibrium strategies with $f = 0$ is without loss of generality, as the principal will not want to reward failure. It should be noted though that I am not limiting the strategy space of the principal - the principal is allowed to offer positive wages for failure. All contract offers are publicly observable[22]. Having observed the menu of contracts that the principal offers, the worker chooses between three actions - accepting one of the contracts, forming his own firm, or doing nothing. I will assume that the worker will not choose 'doing nothing' unless he strictly prefers this action. The formation of a firm requires a one time fixed investment. The principal is better suited to forming a firm. This is reflected in my assumption that the fixed investment needed to start a firm is higher for the worker as compared to the principal. This can be attributed to networking differences - the principal knows the right people (to get licenses, for example), and can therefore start a new firm at a lower cost. Let R_w and R_p denote the fixed cost of firm formation for the worker and principal respectively. By assumption $R_w > R_p$. Additionally, I assume that $R_w > V$ and $2V > R_w > 2\lambda_b V$. These assumptions imply that a one period payoff is not enough to make any worker form his own firm, and if the worker's type is known, only a G type worker finds it individually rational to form his own firm. This is a natural assumption. The cost of forming a firm will generally be high enough to dissuade workers from incurring this cost if the reward is profit from a single period only. Moreover, a worker who is known to be inefficient may never find it worthwhile to incur costs and form his own firm. From the principal's point of view, he may[23] be willing to form the firm even with a bad type worker in period 1 (due to his cost advantage, this can be individually rational) but does not want to form a firm with any type of worker if the reward is one period payoff only i.e. $\lambda_b V < V < R_p < 2\lambda_b V$. Thus, since forming a firm for only one period is too costly for both the principal and the worker, in any equilibrium, all firm formation decisions will take place in period one only.

If the worker accepts a contract then the principal incurs the cost R_p and forms the firm with the worker. If the worker forms his own firm then the worker has to bear an initial one time cost of R_w. Note that the principal cannot form the firm without the worker. So, in any period there is at most one firm in the market (principal-worker firm or worker owned firm). We can think of a 'firm' in this model to consist of the worker and a fixed investment, where the latter could come from either the principal or the worker.

The expected value of the job is paid to the firm and then the worker performs the job. The success or failure of the job is chosen by nature according to the worker's type. The outcome of the job is publicly observed. Wages are paid to the worker[24] and the principal is the residual claimant for whatever is left of the price obtained from the market by the firm (if it is a principal-worker firm). In period two, the same process is repeated i.e. the principal moves first with the contract offer, then the worker, then the outcome is realized. Note that if the worker had already formed his firm in period one, then his action set in period two consists of choosing one of the contracts, staying with his own firm, or doing nothing. Since this is a two period model, it is innocuous to assume that there is no discounting, and all players maximize the sum of payoffs.

The relevant equilibrium concept is Perfect Bayesian Equilibrium. I assume that the principal offers at most two contracts in every period[25]. Also, I assume that if a worker chooses to accept a contract and is indifferent between the contracts (s_1, f_1) and (s_2, f_2), a G worker accepts (s_1, f_1) whereas a B worker would accept (s_2, f_2) in the same situation.

3.1. Strategies

The strategy for the principal is a function from the history of play to the principal's action set. The action set for the principal in any period t is given by $A_p(t) = \{x \in 2^{\{(s,f);\ s,f \geq 0\}};\ |x| \leq 2\}$. This means that the principal can offer at most two contracts (could offer no contract as well). Let $\{(s_1, f_1), (s_2, f_2)\}$ be the set of contracts offered by the principal to the worker in any period t. At $t = 1$, the action set for the worker is given by $\{N, acc_1, acc_2, L\}$ where N is the action denoting that the worker does nothing (i.e. does not accept a contract and does not form his own firm), action acc_i denotes that the worker accepts contract (s_i, f_i), and L refers to the action of the worker leaving and forming his own firm. At $t = 2$, the action set for the worker is given by either $\{N, acc_1, acc_2, L\}$ (if the worker had accepted a contract or chosen N, and therefore not

[20] The strategy of the principal and the worker depends on the price they expect to get, and this assumption makes the model more tractable. A similar assumption of the market always paying the expected utility has been made in many papers in the past, for example Holmstrom (1999).

[21] One period here may be long time. In particular, it could be the time required to complete the job. While this assumption restricts the principal's ability to write long run contracts, this restriction is not necessary for the results to go through. Also, note that the principal can offer more than one contract to screen the two types of workers.

[22] I discuss what happens if the market cannot observe the contract in Section 6.

[23] At zero wages.

[24] If it's a principal-worker firm. In the case in which the worker forms his own firm, he gets the price the market has paid immediately.

[25] This is just for simplicity. The only reason the principal may wish to offer more than two contracts is because he may get a high payoff if the worker goes off equilibrium and picks a very low wage contract. Alternatively, the results will also go through if I assume a small cost of offering every contract.

formed his own firm in period one) or {N, acc_1, acc_2, S} (if the worker had formed his own firm in the previous period, where S refers to the action of staying with his own firm). A strategy for the worker is a function from the history of play and his own type to his action set.

4. Results

We start with the simple case where the worker's type is common knowledge. In this case, the worker never forms his own firm in equilibrium. The intuition for this is simple. Since the principal has a lower cost of firm formation, he can always offer a contract which the worker will accept. This result is trivial to show so I skip the proof here and leave it for the internet appendix. As we shall see, this result will cease to hold when there is uncertainty about the worker's ability. The empirical implication is that ceteris paribus, the rate of spinoff formation will be lower when there is little doubt about the ability of the workers (as compared to environments in which the ability of the worker is more uncertain). This result is borne out by the Norwegian data discussed by Berglann et al. (2011) and Skogstrøm (2012), where they find higher rates of entrepreneurship amongst workers with low education (high uncertainty about the worker's ability) as compared to workers with high education (less uncertainty about ability).

When there is uncertainty about the worker's type, the good type worker may form a spinoff in equilibrium. To get conditions under which a separating equilibrium exists, we must argue: a) Why won't the bad type worker copy the strategy of the good type worker and form a spinoff? b) Why can't the principal offer a contract which will always be accepted by the good type worker? Suppose that the worker is good type but the worker's type is known only to the worker. It is easy to see that the good type worker has a higher expected utility from firm formation. This is because the good type worker will succeed and will therefore get a high payoff in period two as well. In contrast, a bad worker may fail, which reveals his type[26] and results in a low payoff in period two. Thus, if the cost of firm formation is high enough for the worker, then only the good type worker will be willing to incur this cost and form his own firm. Additionally, the principal realizes that he must offer higher wages to make a good type worker stay (higher than that needed for a bad type worker). However, if the principal offers a high wage contract then both type workers will accept the lucrative contract. This will make it a pooling equilibrium where the price obtained from the market will be according to the prior belief about the ability of the worker. When the prior belief about the worker's ability is low i.e. the principal and the market are almost convinced that the worker is bad type, then the principal will be unwilling to offer a high wage contract because he expects only a low price from the market. Next, I describe some notation and then formally state the result which will describe sufficient conditions under which there is a separating equilibrium where the G type worker's strategy is to leave in period one to form his own firm and the B type worker's strategy is to accept a contract in period one.

Let the contracts offered in period t be $\{(s_1^t, f_1^t), (s_2^t, f_2^t)\}$. Let $s_{p,\,t}$ and $s_{w,\,t}$ denote the strategy function for the principal and the worker at time t respectively. I will look for conditions under which the worker forms his own firm in period one. This can happen via a separating equilibrium where the G worker leaves to form his own firm in period 1 and the B worker accepts a contract in period 1. Alternatively, we could have a pooling equilibrium where a worker of any type chooses to form a firm in period 1. Note that we can never have a separating Perfect Bayesian Equilibrium where the B type worker leaves to form his own firm in period one and a G type worker accepts a contract. This is because of the assumption $2\lambda_b V < R_w$ which implies that the worker will get negative payoffs from firm formation if the market believes that the worker who forms the new firm is almost surely bad type (this assumption is further discussed in Section 6.2). Also, note that since the principal is risk neutral, he has no incentives to offer two contracts to separate the G and B type workers as he can get the same expected payoff by offering one contract[27].

4.1. Separating equilibrium

In this subsection, we will be interested in determining the conditions under which a good type worker can signal his type by making the costly decision of forming his own firm in period 1. This equilibrium is particularly interesting as it offers an insight into the conditions needed for spinoff formation, and how we can infer ability from the act of spinoff formation. Also, unlike the complete information model where the worker never forms his own firm, here a G worker always leaves and forms a spinoff.

We will also be interested to know if there are conditions under which the separating outcome can be the unique equilibrium outcome of the game. In the internet appendix, I describe conditions under which the separating spinoff equilibrium

[26] On the equilibrium path, this follows from Bayesian updating. Off the equilibrium path, I assume that the belief about a worker who fails at the job is that the worker is bad type. This assumption is consistent with a model that allows for trembles in the worker's choice.

[27] This can be easily seen through this example - Suppose the optimal menu of contracts for the principal in period 1 is $\{x_g, y_g\}$ and $\{x_b, y_b\}$ where G type worker accepts the first contract and B type the second. Incentive compatibility for separation of types demands that $\lambda_b x_b + (1-\lambda_b)y_b \geq \lambda_b x_g + (1-\lambda_b)y_g$ and $x_g \geq x_b$. In fact, since the constraint for the B type will bind in equilibrium, $\lambda_b x_b + (1-\lambda_b)y_b = \lambda_b x_g + (1-\lambda_b)y_g$. Thus, the B type worker is indifferent between the two contracts. Also, note that since the outside option for both types of workers is negative in period 2, if they accept a contract in period 1, the principal will never offer the worker a positive wage contract in period 2. Then, we can easily see that since the principal is risk neutral, the expected payoff (for the principal) when he offers a single contract $\{x_g, y_g\}$ is the same as the expected payoff when he offers the two contracts - $\{x_g, y_g\}$ and $\{x_b, y_b\}$.

Table 1
Payoffs if private types and separating equilibrium.

Worker type	Principal	Worker
G	0	$2V - R_w$
B	$2\lambda_b V - R_p$	0

outcome is unique. A short discussion of this is presented after Proposition 1. Proposition 1 highlights sufficient conditions needed to get the desired separating equilibrium.

Proposition 1. *Let* $V < \frac{R_w}{1+\lambda_b(2-\lambda_b)}$. *Then, if* $p_g \in (0, \frac{R_p-\lambda_b R_w+(2\lambda_b V-R_p)}{R_w-\lambda_b R_w+(2\lambda_b V-R_p)})$, *there exists a separating equilibrium where the G worker forms his own firm in period 1 and the B worker accepts a zero wage contract offered by the principal.*

Proof. The detailed proof is in the appendix[28]. The intuitive idea is as follows. Since $V < R_p$, in period 2, the principal offers no contract if the worker did not accept a contract in period 1. If the worker accepted a contract in period one, then it is optimal for the principal to offer a zero wage contract only ($V < R_w$ implies that the worker will not find it incentive compatible to leave).

In period one, the principal offers a zero wage contract. The bad type worker's strategy calls for accepting the best contract and the good type worker never accepts any contract which pays less than what he can get by playing L in a separating equilibrium. So the good type worker's equilibrium action is to play L and get $(2V - R_w)$.

Given the strategy of others, a G worker clearly has no incentive to deviate if $2V - R_w > 0$. For a B worker, accepting any contract is incentive compatible if $0 > V - R_w + (\lambda_b V + (1-\lambda_b)\lambda_b V)$. Thus, if $V < R_w/(1+\lambda_b(2-\lambda_b))$, a worker of type B will always accept a contract as spinning off is not individually rational. For the principal, if he follows the prescribed strategy, a B type worker will accept the contract, but if the worker is G type, he will leave to form his own firm. The only profitable deviation for the principal may be if he can attract the G type worker with a contract. To do so he will have to offer a contract in which the reward for success is $2V - R_w$. This is the payoff that the G type worker expects by playing L. Note that a B type worker will also have to get an expected wage of at least $\lambda_b(2V - R_w)$ in period one if the principal offers the high wage contract (since a bad type worker can always accept the contract as well). Therefore, if the principal offers the wage contract $\{2V - R_w, 0\}$, the expected payoff for the principal is bounded above by:

$$p_g V + (1-p_g)\lambda_b V - (p_g(2V-R_w) + (1-p_g)\lambda_b(2V-R_w)) - R_p + p_g\left(\frac{p_g}{p_g+(1-p_g)\lambda_b}V + \frac{(1-p_g)\lambda_b}{p_g+(1-p_g)\lambda_b}\lambda_b V\right) + (1-p_g)\left(\lambda_b\left(\frac{p_g}{p_g+(1-p_g)\lambda_b}V + \frac{(1-p_g)\lambda_b}{p_g+(1-p_g)\lambda_b}\lambda_b V\right) + (1-\lambda_b)\lambda_b V\right) \quad (1)$$

If the principal offers zero wages, his payoffs are $(1-p_g)(2\lambda_b V - R_p)$. The principal prefers the zero wage contract if $p_g < (R_p - \lambda_b R_w + (2\lambda_b V - R_p))/(R_w - \lambda_b R_w + (2\lambda_b V - R_p))$. Note that $2V > R_w$, $2\lambda_b V > R_p$ and $R_w > R_p$ imply that the expression on the RHS is between zero and one. □

Along with low p_g, the condition $V < R_w/(1+\lambda_b(2-\lambda_b))$ is a sufficient condition to get a separating equilibrium. It is definitely not a necessary one. As an example, consider an environment where $R_w/(1+\lambda_b(2-\lambda_b)) < V < (R_w/(1+\lambda_b(2-\lambda_b))) + \nu$ where ν is small. In this case, there will be a separating equilibrium as well. However, since the payoff from playing L for the B type worker is positive now, the principal will offer a low wage contract (as opposed to a zero wage one) to the B type worker to compensate him for staying. I use the condition $V < R_w/(1+\lambda_b(2-\lambda_b))$ for simplicity and to bring out the intuition cleanly.

The principal has the ability to offer contracts which will screen the workers (different types choose different contracts). However, he may not want to do this. The reason is that if the worker strategies are such that a good type worker is going to separate unless offered a better contract, the principal will have to offer the good type worker at least as much as he would get by forming his own firm. Moreover, he will have to offer the bad type worker at least as much as the bad type worker can get by accepting the contract meant for the good type worker. If the prior belief about the worker is that the worker is bad type with very high probability, then the principal will prefer to offer a single low paying contract, which only a bad type worker will accept while a good worker will leave. The payoffs in this equilibrium are described in Table 1.

The expected payoff for the principal is given by $(1-p_g)(2\lambda_b V - R_p)$. Now, as is common in signaling games, there are several equilibria possible here. Is it possible to get the equilibrium outcome in Proposition 1 as the unique equilibrium outcome of the game? In the internet appendix, I show that if the worker can make mistakes and an assumption about the probability of mistakes (more costly mistakes are much less likely than less costly mistakes) holds along with the conditions required in Proposition 1, then the separating equilibrium outcome is the unique outcome of the game.

One might wonder if a separating equilibrium is the only way to get spinoff formation in equilibrium. In particular, what about a pooling equilibrium where the strategy for both type workers is to leave in period 1 to form a spinoff? It is easy to show that when the prior reputation of the worker is low enough, there cannot be a pooling equilibrium where both type

[28] See Claim 2 in the appendix.

workers pool on L. This follows from the assumption that $2\lambda_b V - R_w < 0$ (the inefficient worker never finds it worthwhile to form the spinoff if his type is known).

5. Moral hazard

In this section, I introduce moral hazard in the baseline principal-agent model (how the results may extend to an infinite horizon model is discussed in Section 6.3). There are two reasons for introducing moral hazard in this model. One, moral hazard is a ubiquitous feature of many real life relationships and it is important to understand how it affects outcomes. I will show that we can still get a separating spinoff equilibrium. This serves as a robustness check for my earlier results. Two, a planner or a policy maker may not be interested in the exact division of surplus between the principal and the worker, but may be interested in knowing if the separating equilibrium actually generates higher incentives to put in effort (and therefore leads to higher probability of success for the job) as compared to other equilibria which may exist under the same conditions[29]. This may be particularly important if the worker is engaged on a public project. Additionally, this may be of interest from the standpoint of the efficiency of covenants not to compete. Non-compete clauses prevent workers from leaving to form rival firms. To analyze such laws, it would be valuable to know if the worker will put in more effort in the new firm or less. The changes in the baseline model are as follows.

The worker can put in costly effort e ($\in\{0, 1\}$) to improve the probability of success of the job. Effort exerted is privately observed by the worker. Let $\beta \in [0, 1]$. Let $P(S/t, e)$ denote the probability of success of the job, given worker type t and effort level e. I assume the following parametric specification of $P(S/t, e)$ (alternate formulations are discussed in Section 6):

$$P(S/G, e) = \beta + (1 - \beta)e \tag{2}$$

$$P(S/B, e) = \beta\lambda_b + (1 - \beta)e \tag{3}$$

Thus, the probability of success is a convex combination of ability and effort, and β is inversely related to how much effort matters. The higher β is, the more the success of the job depends upon the inherent ability of the worker as opposed to the effort he puts in. In particular, notice that as β goes to 1, we obtain our original model. Also, notice that if the good type worker puts in full effort, he will always succeed. This is not true for the bad type worker. Both type workers can fail if they put in zero effort. It is costless for the worker to put in zero effort. The cost of putting in effort level 1 is 1. The cost of effort is the same for both types of workers.

5.1. Principal agent problem

First, we consider the case where the worker's type is known. In this case, it is easy to show that two results hold. One, as before, the worker will not form his own firm in equilibrium. The intuition remains the same - since the principal has a lower cost of firm formation, he can always offer a contract which the worker will accept. Two, the worker will never put in any effort if he forms his own firm. The idea here is pretty simple as well. Since the worker has to put in effort after he gets paid by the market, it will not be incentive compatible to put any effort in period 2 (last period). This fixes the worker's period 2 payoff and results in no effort in period 1 as well (since effort is put in after receiving the price from the market). The formal statement and proofs are in the appendix in Section A.2.1. I will show that both these results can be overturned when the worker's type is not known.

5.1.1. Types are private knowledge

Introducing moral hazard in the environment does not change the result that the worker never forms his own firm if the worker's type is known. The 'type is common knowledge' case also highlights a key property of having moral hazard in the baseline environment - when the worker has his own firm, he finds it difficult to convince the market that he will put in effort. On the other hand, if the worker signs a contract with the principal then the principal can get him to exert effort by offering him a contract where he gets paid much more if he succeeds. This problem arises because the worker is unable to credibly offer himself outcome dependent contracts when he forms his spinoff.

The primary results in this subsection are as follows. First, in any separating spinoff equilibrium, a G type worker will put in full effort after forming a spinoff in period 1. Second, there exists a separating equilibrium where the G type worker's strategy (along the equilibrium path) is to leave and form his own firm in period 1 and the B type worker's strategy (along the equilibrium path) is to accept a contract in period 1. Both these results are in contrast to the full information case.

The third result says that under some conditions, the separating equilibrium can be the best equilibrium in terms of the probability of success of the job. The intuition for this result is as follows. Under some conditions, only two types of equilibria are possible - a) separating equilibrium where the good type worker forms a spinoff and the bad type worker accepts a contract, or b) pooling equilibrium where a worker of any type accepts a contract in period one. In the former, the good type worker puts in full effort in period one (for fear of losing his reputation and getting a low payoff in period two) and none in period two (since it is the last period), while the bad type worker puts in no effort in any period. Furthermore, under the same conditions, the principal has no incentive to extract effort via high wage contracts. So, in the only other

[29] I consider alternate definitions of welfare in Section 6.

equilibrium, the worker puts in no effort (irrespective of type), thereby making the separating equilibrium more desirable by making it the equilibrium where the job's success probability is the highest[30]. To understand why the principal may be unwilling to extract effort with high wages, consider his incentives when β is high and p_g is low. The principal will only offer high wages to extract effort if he expects a high price from the market in period 1 or period 2. If β is high then the principal cannot expect a high price for full effort in period one because the market realizes that effort is not that important for success. However, one may argue that the principal may still want to extract full effort to make sure the job is a success and the resulting increase in reputation of the worker in period two compensates for the high wages in period one. This argument does not work when the prior reputation of the worker is too low (p_g low) as it results in the period two reputation of the worker not being high enough (even with a success in period one) to incentivize the principal to offer high wages to extract full effort from the worker.

All major proofs for this section are in the appendix in Section A.2.2. The first claim in this section describes a necessary condition about the effort put in by the good type worker in a separating spinoff equilibrium.

Claim 1. *In any separating equilibrium where a G type worker leaves to form his own firm in period 1 and the B type worker accepts a contract, the G type worker puts in full effort in period 1.*

Proof. Suppose there exists a separating equilibrium where a G worker leaves to form his own firm in period 1, and then puts in zero effort. In this equilibrium, when a worker plays L, the belief about the worker is that the worker is G type with probability one. Since the G worker puts in zero effort in equilibrium in period 1, and has to put in zero effort in period 2 in any equilibrium, the payoff from playing L is $(2\beta V - R_w)$.

In any separating equilibrium, it should not be incentive compatible for the B worker to imitate a G worker's strategy. However, the payoff to a B worker from deviating and playing L is also $2\beta V - R_w$. This is because if the G worker puts $e = 0$, he can fail. Since the posterior (after firm formation) belief about the worker is 1 in the separating equilibrium, even if the worker fails, the reputation of the worker remains 1. Therefore, the success or failure of the job in period one leads to no change in the reputation of the worker, and so the B worker can get exactly the same payoff as a G type worker by playing L. Since we assumed that a separating equilibrium exists, it must be the case that that B worker can get a higher payoff by accepting the contract. Suppose this contract is $\{s, f\}$. This contract should pay the G type worker less than $2\beta V - R_w$ (so he does not want to deviate and accept) and should pay the B type worker more than $2\beta V - R_w$. Thus, it must be that $f \geq 2\beta V - R_w$ and $s \leq 2\beta V - R_w$. It is easy to show that the principal would like to deviate since the contract $\{\frac{\lambda_b s + (1-\lambda_b) f)}{\lambda_b}, 0\}$ gives him a higher payoff. The idea is that the principal never finds it optimal to reward failure, and if the principal finds it incentive compatible to offer some wages to a B type worker, then he would definitely find it incentive compatible to offer those wages to the more able G type worker. □

Thus, in a separating equilibrium, the G type worker's strategy must require him to put in maximum effort after separating. For the G worker to actually follow this strategy, we must have off equilibrium beliefs which put a sufficiently high probability on the worker being B type if the worker forms a firm and then fails. In this case, the good type worker will put in full effort because if he puts in low effort and fails, his reputation will fall a lot in period 2 which will severely reduce his payoff.

The next two propositions highlight conditions under which a) there exists a separating equilibrium where along the equilibrium path, the G worker's strategy is to leave and form his own firm in period 1 and the B worker's strategy is to accept a contract in period 1, and b) the separating equilibrium generates a higher probability of success for the job as compared to other equilibria which exist under the same conditions. Proposition 2 describes conditions under which there exists a separating equilibrium where the bad type worker accepts a contract with the principal in both periods and exerts zero effort. The good type worker on the other hand, forms his own firm and exerts full effort in period 1 and zero effort in period 2. Proposition 3 and Corollary 1 establish that the separating equilibrium described in Proposition 2 generates the most effort when compared to other equilibria which exist under the same conditions.

Proposition 2. *There exists β' such that if $\beta > \beta'$ and the following hold:*

1. $\dfrac{1+\beta}{\beta(1-\beta)(1-\lambda_b)} - 1 < R_w < \dfrac{(1+\beta(1-\beta(1-\lambda_b)^2))(1-\beta+\beta\lambda_b)}{(1-\beta)^2} - 1$
2. $\dfrac{1+R_w}{1+\beta} < V < \dfrac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)}$

Then there exists a p_1 such that if $p_g \in [0, p_1)$, there exists a separating equilibrium where a G type worker's strategy is to play L in period 1, and then exert full effort in period 1 and no effort in period 2. The B worker accepts a zero wage contract offered in period 1 and 2, and puts in zero effort in both periods.

[30] Of course, this is not always the case. In the internet appendix, I describe conditions under which the separating equilibrium leads to a lower probability of success for the job as compared to another equilibrium. This result is driven by the worker's inability to commit to effort in period 2 and the principal's ability to induce high effort with contracts which pay well for success only.

Proof. The details of the proof are in the appendix. I present the idea behind the proof here. The beliefs are based on Bayesian updating. On off-equilibrium paths, I will assume beliefs consistent with type independent trembles in the worker's decision[31].

A *G* type worker will exert full effort after playing *L* for fear of failing and receiving low payoffs in period 2 because the market will then believe that the worker is *B* type. Since only a *B* type worker accepts the contract, the principal does not want to pay high wages to induce high effort. This is because when β is high, the job's success is largely dependent on the worker's inherent ability and not on the effort he puts in. Thus, the immediate gain from extracting high effort with a high wage is low. Furthermore, the future gains of having a worker succeed are also low. This is because even if the worker succeeds after accepting a contract, his reputation (and therefore the price offered by the market) rises by only a small amount[32]. In contrast, if the worker forms his own firm and then fails, his reputation goes from 1 to zero. This substantial threat induces the good type worker who separates to form the spinoff to put in full effort.

The *B* type worker does not play *L* (to imitate the *G* type worker) because of the following reason. Since the *G* type worker is supposed to exert full effort after leaving, this means that the *G* type worker will succeed in period 1. If a worker fails (and the *B* type worker can fail even if he puts in maximum effort), he will be recognized as a *B* type worker and get paid less in period 2. This, along with the conditions on the cost of firm formation and the value of *V*, makes spinoff formation suboptimal for the *B* type worker.

If the prior belief about the worker's type is very low ($p_g < p_1$) then the principal cannot expect high prices from the market (even if he offers lucrative contracts which makes both type workers accept the contract and put in maximum effort). Thus, the principal is unwilling to offer the high wage contract needed to stop the *G* type worker from leaving. □

Next, I will argue that under the conditions required in Proposition 2, the separating equilibrium generates the maximum incentive to work (exert effort). First, I will demonstrate that there exists another equilibrium which generates lower equilibrium effort, and therefore leads to a lower probability of success for the job[33]. Subsequently, it can be argued from the proof of that result that under some conditions, any equilibrium outcome different from the outcome of the separating spinoff equilibrium generates a lower probability of success for the job in period 1 and the same probability of success for the job in period 2.

Proposition 3. *Suppose the conditions needed to guarantee the separating equilibrium in Proposition 2 hold. There exists a* β'' *such that if* $\beta > \beta''$ *then there exists a* p_2 *such that if* $p_g < p_2$, *there exists a pooling equilibrium where the strategy of both types of workers is to accept the best contract in period 1 and 2, and put in zero effort in both periods. The principal offers a zero wage contract in both periods. The G/B type worker's strategy is to accept the contract in each period and put in zero effort in both periods.*

Proof. I will skip a detailed proof as the construction is very similar to the proof of Propositions 1 and 2. The intuitive idea is that if the prior belief about the ability of the worker is really low and both type of workers are expected to accept a contract, then no type of worker wants to deviate and play *L* instead. This is because the belief about the worker who plays this off-equilibrium action is assumed to be the same as the prior (this off-equilibrium belief is consistent with a model which allows for mistakes in the worker's action choice, and both types are equally likely to make the mistake). Thus, a worker who chooses to play *L* will have a low reputation which would lead to a negative payoff. The value of *V* is low enough and β is high enough to ensure that the principal does not want to pay high wages to induce high effort from the worker. This is because effort is not a big factor in determining outcomes (high β implies that the impact of higher effort on the probability of success is small). Also, since the reputation of the worker who accepts the contract is really low, the increase in reputation (and therefore future gains) from a success is low. Thus, the principal does not have strong incentives to offer a high wage contract to extract high effort. □

Corollary 1. *There exists a* β''' *such that if* $\beta > \beta'''$ *and the conditions required for Proposition 2 hold, there exists a* p_3 *such that if* $p_g \in [0, p_3)$, *then:*

1. *There exists a separating equilibrium where the G type worker's strategy is to play L in period 1 and then put in effort=1 in period 1 and effort=0 in period 2. The B type worker's strategy dictates accepting the zero wage contract offered in period 1 and 2 and putting in zero effort in both periods.*
2. *In any other equilibrium, the effort put in by the worker (conditional on the worker's type) is less than that in the above equilibrium.*

Proof. We only need to show part 2 as the first part follows from Proposition 2. First, note that our claim is that under the conditions highlighted above, there is no equilibrium (regardless of whether off-equilibrium beliefs are assigned via trembles or in any other manner) in which the worker will put in higher effort than the spinoff equilibrium. Second, it is clear from

[31] If the worker wants to choose an action *a*, then the worker chooses action *a* with probability $(1 - \epsilon)$ and any other action with positive probability.

[32] If the principal offers a high wage to induce the bad type worker to put in effort but not enough for the good type worker to accept the contract, then there is no increase in reputation. If the principal offers very high wages to attract the good type worker, both types will accept and therefore the reputation of the worker will be low if the prior belief about the worker's ability is low. In this case, even a success will not lead to a very high reputation for the worker in period 2.

[33] When compared to the separating spinoff equilibrium.

the proof of Proposition 2 that under the conditions required for the same, no type worker will exert effort in period 2 in any equilibrium. The idea is that the worker will never exert effort when the worker forms his own firm, and the low value of V ($V < \frac{1}{1-\beta} + \frac{\beta\lambda_b}{(1-\beta)^2}$) combined with the low returns to effort (due to high β) ensures that the principal has no incentive to extract effort via a high wage contract in period 2.

In the proposed equilibrium, the G type worker puts in full effort in period 1 and the B type worker puts in no effort in period 1. We need to show that there is no equilibrium in which the equilibrium strategy for both types of workers is to exert full effort in period 1 (as this is the only type of equilibrium which can beat the spinoff equilibria in effort). We prove this by contradiction. Suppose there exists an equilibrium in which both types of workers put in full effort in period 1. This equilibrium can be one of four types:

Case 1 - An equilibrium where both types play L with positive probability in period one - The best payoff possible for the bad type worker from playing L is $V - R_w - 1 + (\beta\lambda_b + 1 - \beta)\beta V + (1 - (\beta\lambda_b + 1 - \beta))\beta\lambda_b V$ i.e. when the market believes that the worker playing L is very likely to be good type[34]. From condition $V < \frac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)}$ in Proposition 2, we have that $V - R_w - 1 + (\beta\lambda_b + 1 - \beta)\beta V + (1 - (\beta\lambda_b + 1 - \beta))\beta\lambda_b V < 0$. Therefore, since the bad type worker can always play N and get a payoff of zero, there is no equilibrium in which the bad type worker plays L with positive probability in period 1 if the good type worker also plays L with some probability.

Case 2 - An equilibrium where only the B type plays L with positive probability - It follows from the previous case that this is not optimal for the bad type worker in any equilibrium.

Case 3 - Both types accept a contract in period one - It follows from the proof of Proposition 2 that if β is high enough and p_g is low enough then the principal will never want to extract effort via a high wage contract, and therefore a worker of any type will put in zero effort in any pooling on contract equilibrium.

Case 4 - The good type worker mixes between playing L and accepting a contract, and the bad type worker accepts a contract in period 1 - From the above case, it follows that if the conditions required by Proposition 2 hold and β is high enough and p_g is low enough, then both type workers will put in zero effort in any equilibrium after accepting a contract. When the G type worker plays L, he will put in full effort (follows from Claim 1). However, the good type worker plays L with a probability less than 1. Therefore, the expected effort from the G type worker in this equilibrium is lower than that in the proposed separating spinoff equilibrium. □

Thus, under these conditions, the separating equilibrium generates higher incentives to work compared to other equilibria which exist under the same conditions. I must point out that these are sufficient conditions and do not characterize the minimum conditions needed to make sure that the spinoff equilibrium is also the highest effort equilibrium. Nonetheless, the intuition from these results is sound and would apply more generally. One empirical implication of this model is that we should find higher effort in spinoff equilibria if reputation can be easily lost through a few bad outcomes (modeled in this paper by assuming that the G type worker does not fail). This would be true for several environments. Think of a smart lawyer who decides to split from his firm (as the firm and therefore the lawyer has a low reputation), and start his own practice. This could signal his ability to the market. However, a few bad results could really hurt the lawyer's expected future income. Thus, it would be intuitive to expect the lawyer to work harder in his own firm as compared to the parent firm.

6. Discussion

In this section I discuss some of my modeling choices and comment on how the results may change if the model was slightly different.

6.1. Crucial assumptions

This paper makes a few assumptions, some to simplify the math and some which are key to the results. In this subsection, I will highlight the important assumptions. It is important that the good type worker is better than the bad type worker at the job, the job's outcome is publicly visible, and that there is repeated interaction with the market. These assumptions imply that the good type worker has a higher expected payoff from firm formation. This, combined with the fact that firm formation is costly (costly signal) allows us to separate the good type worker from the bad type worker. As for the principal, since the principal has a lower cost of firm formation, he is able to extract some surplus from the game, but uncertainty about the worker's type prevents the principal from extracting all of the surplus. Another important assumption is that of limited liability for the worker (the principal can never pay the worker negative wages). Suppose the principal could offer the worker a contract like $(2V - R_w, -M)$ where M is positive and large. This contract pays the good type worker his expected payoff from spinning off in a separating equilibrium, and punishes failure with a very high negative wage. In this case, the principal can always offer a contract which only the good type worker will accept. The assumption of limited liability can be justified by labour laws which disallow the owner from charging the worker for failing.

[34] Therefore, first period payoff is approximately $V - R_w - 1$. Since both types play L with positive probability, failure reveals the worker's type to be bad. This explains the expression for period 2 payoff.

6.2. Bad type won't form firm if type is known

This assumption is not key for the results in this paper to go through. If the bad type worker can get a positive payoff from firm formation, then for our separating equilibrium, all the principal has to do is offer the bad type worker his expected payoff from firm formation (lower than the good type worker's expected payoff from spinning off) instead of the zero wage contract.

6.3. Infinite horizon extension

A natural question is whether the results in this paper are a function of the fact that we study a two period game i.e. will the results go through in an infinite horizon model? In this subsection, I discuss two ways in which the analysis can be extended to an infinite horizon model.

Consider first a simple infinite horizon extension of our two period model. Future payoffs are discounted by δ and the opportunity to form a firm arrives in period one only (thus, the principal needs to offer positive wages in period one only). This model will be relevant in environments in which the opportunity to form a firm comes rarely. In this case, all our results will go through. The key ideas that the future expected payoff from spinning off is higher for the good worker as compared to the bad worker, and that the principal will be unwilling to pay high wages if the worker's reputation is low still hold. The moral hazard results will go through as well. We can show that there exists an equilibrium in which the good type worker will work in all periods after forming a spinoff for fear of losing his reputation with a failure, and getting paid low wages in all periods after the failure. For a fixed δ, if β is high and p_g is low, the principal will be unwilling to offer high wages to extract effort since effort affects outcomes only marginally and reputation building is slow.

Next, we consider a more complicated infinite horizon extension of our model. Future payoffs are discounted by δ and the worker can leave to form a spinoff in *any* period. In this model, the interesting question is - when does the good type worker want to form the spinoff[35]? Since the good type worker can leave in any period, the principal must start paying positive wages as the worker's reputation grows (as the worker's reputation improves, the principal realizes that the worker may be good type, and could leave to form a spinoff if not offered higher wages). This could dissuade the worker from investing R_w and forming a spinoff. On the other hand, if the initial reputation of the worker is really low, the worker may have to wait for some periods before he can start earning high wages, whereas with a spinoff equilibrium, he can start earning payoffs today, albeit at a personal cost of R_w. This trade-off would be interesting to explore in future work. A full treatment of this model is beyond the scope of this paper. However, my guess would be that if reputation building is slow (λ_b high enough) and the prior belief about the worker's type is pessimistic enough (p_g low enough), the good type worker will form the spinoff in period one.

6.4. G type can fail

In the paper, we have used the condition that failure perfectly reveals the worker's type to be bad. Is this truly necessary for the separating equilibrium to exist? The issue is that if the good type worker can fail with positive probability, then the bad type worker may have no cost to copying the strategy of a good type worker and playing L (as reputation can never erode in a separating equilibrium). Clearly, we cannot have a fully separating equilibrium where the good type worker forms a spinoff and the bad type worker always accepts the contract in period one. In this case, if we consider a longer horizon game, we should be able to get a hybrid spinoff equilibrium where the good type worker leaves to form a spinoff in period one and the bad type worker mixes between spinning off and accepting a contract. The bad type worker knows that his reputation can erode after spinoff formation and this allows us to find mixing weights which keeps the bad type worker indifferent between a zero[36] wage contract with the principal and his expected returns from spinning off.

6.5. Market/Customers can't observe contracts

I have assumed that the market/customers observe all contracts being offered. In various environments, this may not be a realistic assumption. However, even if we drop this assumption, we can still get a separating spinoff equilibrium. Consider an equilibrium in which the principal offers a zero wage contract which only the bad type worker accepts, and the good type worker forms his own firm. Even if the customer can't observe contracts, there is no deviation which makes the principal better off. If the principal offers a high wage contract to attract the good worker, the market only observes that the worker signed with the principal. So the market believes that the worker signing the contract must be the bad type worker since the market does not observe that the principal deviated and offered a high wage contract. However, then the principal would not want to deviate.

[35] Assuming the bad type worker does not find it worthwhile (can be obtained by an upper bound on V as in Proposition 1).

[36] Optimal if the bad type worker does not find it individually rational to form a spinoff when his type is known.

6.6. What if effort and ability were not substitutes?

In Section 5, I assume that the probability of success is a linear combination of effort and ability. Thus, effort and ability are thought of as substitutes. In this section, I discuss what would happen if I model this in a different way. First, consider the simple case where effort and ability are complements in a multiplicative way. Suppose $P(S/G, e) = e\beta$ and $P(S/B, e) = e\beta\lambda_b$. Then the worker owned firm can never form. This is because the second period effort has to be zero after firm formation but then the worker can only get one period's profit from forming his own firm (second period payoff is zero because second period probability of success is zero). However, we have assumed that this is not good enough ($V - R_w < 0$).

Consider an alternate model where ability and effort are correlated. Suppose success probabilities are as described in Section 5 but now the good type worker has a lower cost of effort as well. Now, on the one hand, the G type worker's cost of separating has gone down. This is because he must exert full effort in the first period after separation and the cost of effort has gone down. On the other hand, the principal does not have to offer much to induce full effort from the good type worker. In this case, we will still have a separating equilibrium as the principal would be unwilling to offer a high wage to attract the G type worker if G type workers are scarce. However, it may be harder to get the result that the separating equilibrium is the highest effort equilibrium since the principal needs to offer less to extract full effort from the good type worker.

6.7. On empirical support

In the paper, I argue that a high ability-low education worker may choose to become an entrepreneur to signal his ability and increase his payoffs. This is consistent with the findings of Skogstrøm (2012). Alternatively, one could argue that high ability-low education workers become entrepreneurs because their low education results in few alternative job offers. However, if this was the case, we should have high levels of entrepreneurship among low ability-low education people as well. However, the percentage of entrepreneurs in that category is only 9% compared to 20% in the high ability-low education category (Skogstrøm, 2012). It could be further argued that this is because high ability entrepreneurs are more likely to *survive* and therefore show up more in the data from any given year. This argument relies on the assumption that people don't really know their ability and their cost of doing business. So, both types experiment with entrepreneurship but only the good types pull it off while the bad types learn that they may not be able to do so and exit the market. This is possible and therefore it is important to understand if the assumption that people know their own abilities is a strong or weak assumption in the labour market context. However, even if the survival argument is part of the whole explanation, could all of the gap (11 percentage points) be explained by the survival argument alone?

6.8. Competition for the worker

What if there were two principals competing to hire the worker? We can still get a separating spinoff equilibrium in the same way as in Section 4. However, we will require stronger conditions to obtain the separating equilibrium when there is competition for the worker. The intuition for this result is that competition between the principals bids up the wages of the worker which makes the opportunity cost of firm formation higher. A more detailed analysis of this model is available upon request. The result that workers with higher wages are less likely to become entrepreneurs than workers with lower wages has also been shown by papers like Evans and Leighton (1989).

6.9. Welfare alternatives

In Section 5, we look for conditions under which the separating spinoff equilibrium is the highest effort equilibrium. We are interested in this result because in some environments[37] it may be desirable to maximize the job's success probability. However, it would be informative to look at other welfare criteria as well. First, note that under the conditions mentioned in Corollary 1, both types of workers weakly prefer the separating equilibrium to the pooling one (with the good type worker strictly preferring the separating equilibrium). For the rest of this subsection, I will assume that the conditions needed for Corollary 1 hold. Next, I discuss two situations where we will consider welfare to be maximized when the sum of payoffs of all players is maximized[38].

Which equilibrium maximizes welfare for the good type worker? If the following condition holds, then we can show that there exist conditions (consistent with those in Corollary 1) under which welfare is maximized by the separating equilibrium.

$$2V - R_w - 1 > 2\lambda_b V - R_p \tag{4}$$

Essentially, inequation (4) says that if the gain from separating for the good type worker is bigger than the gain from a 'pooling on contract' equilibrium for the principal, then welfare is maximized by the separating equilibrium.

[37] Like the worker being engaged on a public project.

[38] As is traditionally analyzed.

Next, consider the case of ex-ante welfare i.e. making welfare calculations when we do not know the worker's type. On the one hand, the separating equilibrium may increase welfare by increasing the probability of success (and therefore payoffs to the good worker from separation). The increase in probability of success comes due to the higher effort exerted in this equilibrium. However, there are two costs to this - higher effort by the worker, and higher firm formation costs when the worker forms the firm. On the other hand, in the pooling equilibrium where both type workers accept a contract, price obtained by the principal is lower[39] but so is the firm formation cost and the effort cost of the worker. We can show that in this case, we would require the following condition to hold for the separating equilibrium to maximize welfare:

$$V(1-\beta)(1+\beta-\beta\lambda_b) > R_w - R_p + 1 \tag{5}$$

However, it is not clear if (5) can hold along with the rest of the conditions required for Corollary 1.

7. Conclusion

This paper presents a theory of new firm formation based on signaling and reputation concerns. I show that in the presence of asymmetric information about the worker's type, there can exist a separating equilibrium where the good type worker can signal his ability by forming his own firm. This is true even if the principal can offer contracts to try and stop the worker from leaving. If the outcome of the worker's job depends upon unobserved effort as well as inherent ability, then, under some conditions, the spinoff equilibrium provides the highest incentive to exert effort.

In view of its impact on the welfare of high ability workers and on effort efficiency, the signaling aspect of new firm formation is important to understand. As I have pointed out, these results may have policy implications in the areas of brain drain and non-compete clauses. Moreover, entrepreneurship is crucial for the economic progress of a country and we must try and understand all possible causes behind new firm formation. This paper highlights these issues with a simple principal agent model. In the future, I hope to use the intuitions developed in this paper to deal with more specific problems like firm formation in teams and optimal contracts in such environments.

Appendix A

A.1. Principal agent problem when types are private knowledge

As we show in the internet appendix, when the worker's type is known, the worker never forms his own firm. This result does not hold when there is asymmetric information about the worker's type. In this subsection, I will illustrate this case. We will begin by analysing subgame perfect outcomes in period 2.

A.1.1. Period 2

In period 1, the worker could have either formed his own firm (action L), or accepted a contract (action acc), or done nothing (action N). Since it is not individually rational for the principal or the worker to form a new firm in the second period (because $V < R_p < R_w$), in any equilibrium, the principal will offer no contract in period two if the worker formed his own firm in period one or played N. If the worker accepted a contract in period one (which means that the principal has already formed a firm in period one), the principal's optimal strategy in period two is to offer a zero wage contract (too costly for the worker to leave in period 2 because $V < R_w$). The worker's strategy in period two would involve the worker accepting the best contract if he accepted a contract in period one or played N. If the worker formed his own firm in period one then the worker will stay with his own firm in period 2 (action S) since the principal will make no contract offers in any equilibrium. The above claims are trivial to show, so I skip the formal proof. Thus, in any equilibrium, in period 2, we have the following equilibrium outcome:

$$\begin{aligned}&\text{If worker formed a firm in period 1} \rightarrow \textit{Principal offers no contract and worker plays } S;\\ &\text{If worker accepted a contract in period 1} \rightarrow \textit{Principal offers zero wage contract and worker accepts};\\ &\text{If worker played N in period 1} \rightarrow \textit{Principal offers no contract and worker plays } N.\end{aligned} \tag{6}$$

A.1.2. Period 1

In period 1 of the game, we are interested in the equilibrium described next.

Separating Equilibrium where *G* worker plays *L*

The equilibrium outcome in period 2 is described above. Consider the following strategy profile for play in period 1:

For Principal:

$s_p(\phi) = \{\{0, 0\}\}$

For Worker:

[39] Due to low beliefs about the ability of the worker in a pooling equilibrium when priors are low.

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1 \ ; s_1^1 \geq s_2^1 \ and \ s_1^1 \geq 2V - R_w$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2 \ ; s_1^1 < s_2^1 \ and \ s_2^1 \geq 2V - R_w$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = L \ ; \ else$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1 \ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2 \ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1$$
$$s_w(\phi, B) = N$$
$$s_w(\phi, G) = L$$

The belief about the worker's type is formed using Bayesian updating based on equilibrium strategies. On off-equilibrium paths, I will assume beliefs consistent with type independent trembles in the worker's decision[40]. In particular, if the worker forms his own firm in period one and then fails, this would be off equilibrium because the good type worker never fails and the bad type worker never forms his own firm. In this case, the market updates the worker's reputation to zero i.e. the market believes that the worker must be bad type.

Claim 2. *If* $V < \frac{R_w}{1+\lambda_b(2-\lambda_b)}$ *and* $p_g \in (0, \frac{R_p - \lambda_b R_w + (2\lambda_b V - R_p)}{R_w - \lambda_b R_w + (2\lambda_b V - R_p)})$, *there is a separating equilibrium where the strategy and beliefs in period 1 are as given above, and the equilibrium outcome in period 2 is described by (6).*

Proof. We study conditions under which we have a separating equilibrium where the G worker plays L and the B worker accepts a contract in period 1. Thus, in this equilibrium, if the worker forms his own firm in period 1, then his reputation is one, and therefore the belief about the worker being G type at the end of period one are either one (if the job is successful) or zero (if the job fails).

Consider the strategies to be played in period one. Let's look at the G type worker's strategy, given the strategy of others. Clearly, he has no incentive to deviate if $2V - R_w > 0$. Consider the strategy of the B type worker now. Accepting a contract is optimal if: $0 > V - R_w + (\lambda_b V + (1-\lambda_b)\lambda_b V)$. Thus, if $V < R_w/(1+\lambda_b(2-\lambda_b))$, a worker of type B will always accept any individually rational contract.

Consider the strategy of the principal now. According to the proposed strategies, a B type worker will accept the contract whereas if the worker is G type, he will leave to form his own firm. The only profitable deviation for the principal may be if he can attract the G type worker with a contract. To do so, he will have to offer a contract in which the reward for success is at least $2V - R_w$. This is the payoff that the G type worker expects to get by spinning off[41]. Note that the B type worker will also have to get an expected wage of at least $\lambda_b(2V - R_w)$ in period one if the principal offers the high wage contract (since a bad type worker can always accept the contract as well). Therefore, if the principal offers the wage contract $\{2V - R_w, 0\}$, the expected payoff for the principal is bounded above by:

$$p_g V + (1-p_g)\lambda_b V - (p_g(2V - R_w) + (1-p_g)\lambda_b(2V - R_w)) - R_p + p_g\left(\frac{p_g}{p_g + (1-p_g)\lambda_b} V + \frac{(1-p_g)\lambda_b}{p_g + (1-p_g)\lambda_b}\lambda_b V\right) + (1-p_g)\left(\lambda_b\left(\frac{p_g}{p_g + (1-p_g)\lambda_b} V + \frac{(1-p_g)\lambda_b}{p_g + (1-p_g)\lambda_b}\lambda_b V\right) + (1-\lambda_b)\lambda_b V\right) \quad (7)$$

Under the equilibrium strategy, the principal's payoffs are $(1-p_g)(2\lambda_b V - R_p)$. The payoff indicated by 7 is less than this if $p_g < (R_p - \lambda_b R_w + (2\lambda_b V - R_p))/(R_w - \lambda_b R_w + (2\lambda_b V - R_p))$. Note that $2V > R_w$, $2\lambda_b V > R_p$ and $R_w > R_p$ imply that this upper bound for p_g is between zero and one. □

The expected payoffs in this equilibrium are as follows: Principal $= (1-p_g)(2\lambda_b V - R_p)$, Worker type $G = 2V - R_w$, Worker type $B = 0$.

A.2. Moral hazard

First, let's consider the simple case where the worker's type is common knowledge.

A.2.1. Types are common knowledge

Suppose the worker's type is G. The other case will follow. The result that the worker will not form his own firm when the worker's type is known extends to the environment with moral hazard as well. First, we state a lemma which points out that the worker will not exert any effort if he leaves to form a spinoff in period 1.

Lemma 1. *Suppose the worker is type G. If the worker forms his own firm in period 1, then he will exert zero effort in both periods.*

[40] If the worker wants to choose an action a, then the worker chooses action a with probability $(1-\epsilon)$ and any other action with positive probability.

[41] Today's payoff from spinning off is $V - R_w$. This is because the worker will have to invest R_w today and the market will pay V if the spinoff firm is formed since they expect only the G type worker to form it. The G type worker will be successful in period one and his reputation will remain one. Therefore, in period 2, he will get a payoff of V.

Proof. Suppose the worker has formed his own firm in period one. In period 2, it is not individually rational for the principal to form the firm, therefore, the worker stays with his own firm. Since the worker gets paid before he exerts effort, his effort choice in any equilibrium will be $e = 0$. Thus, in period 2, the market will pay its expected value (βV) when the worker is known to be G type.

In period 1, once the worker has played L, he realizes that the payoff for tomorrow is fixed at βV. The worker puts in effort only after the market has paid the worker in period 1. Therefore, in any equilibrium, the worker has no incentive to put in any effort in period 1 as well. □

Corollary 2. *If a G worker plays L in period 1, his payoff is $2\beta V - R_w$. If a B worker plays L in period 1, his payoff is $2\beta\lambda_b V - R_w$.*

Next, we describe the main result of this subsection. This upholds our previous result which said that the worker never forms his own firm when the worker's type is known. The reason, as before, is that the principal has a cost advantage in forming the firm, and can therefore offer a contract which will not be refused.

Claim 3. *If the worker type is known to be G type, the worker will never choose to form his own firm in any equilibrium.*

Proof. If the worker forms his firm in period 1, the payoff for the principal is zero. I will show that the principal can always offer a contract to the worker which satisfies the following two properties. The worker will accept and the principal will get positive payoffs. This rules out the spinoff equilibrium.

Consider the contract $\{2\beta V - R_w, 2\beta V - R_w\}$ followed by the contract {0, 0} in period 2 if the worker accepts in period 1 (and no contract offer in period 2 if the worker does not accept a contract in period 1). The worker cannot get more by leaving, so he will accept the contract. In both periods, the worker's payoff is independent of success, so the worker always chooses zero effort. Therefore, the payoff for the principal from this contract is: $\beta V - R_p + \beta V - (2\beta V - R_w) = R_w - R_p$ (> 0). □

Similarly, we can show that a B type worker will also not choose to form his own firm in any equilibrium.

A.2.2. Types are private knowledge

Proof for Proposition 2. In period 2, the principal's actions depend upon the worker's reputation at the beginning of period 2 (p_g^2), and on whether the worker formed his own firm in period 1 (worker played L in period 1), accepted a contract in period 1 (worker played *acc* in period 1), or the worker did nothing (worker played N in period 1). The worker's strategy in period 2 depends upon his actions in period 1, his reputation at the beginning of period 2 and on the contract(s) offered by the principal in period 2. Consider the following strategies in period 2:

For Principal:

$s_{p,2}(acc, p_g^2) = \{0, 0\}$

$s_{p,2}(N, p_g^2) = \phi$

$s_{p,2}(L, p_g^2) = \phi$

For Worker:

If worker had formed firm in period 1, *principal does not offer contract and*

$s_{w,2}(L, p_g^2, \phi, G/B) =$ *S*, $e = 0$

If worker had not formed firm in period 1:

$s_{w,2}(acc/N, p_g^2, \{\{s_1^2, f_1^2\}, \{s_2^2, f_2^2\}\}, G/B) =$ *Choose* $(contract, effort)$ *maximizing payoff*

$s_{w,2}(acc/N, p_g^2, \phi, G/B) = N$

Consider the following strategies in period 1:

For Principal:

$s_p(\phi) = \{\{0, 0\}\}$

For Worker:

WLOG let contract 1 *be better than contract* 2 *for G worker*

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1, e = 1$; $-1 + s_1^1 = max\{-1 + s_1^1, \beta s_1^1\}$ *and*

$-1 + s_1^1 \geq -1 + V - R_w + \beta V$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1, e = 0$; $-1 + s_1^1 \neq max\{-1 + s_1^1, \beta s_1^1\}$ *and*

$\beta s_1^1 \geq -1 + V - R_w + \beta V$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = L, e = 1$; *else*.

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) =$ *Choose* $(contract, effort)$ *maximizing payoff*

$s_w(\phi, B) = N$

$s_w(\phi, G) = L, e = 1$

The belief about the worker's type is formed using Bayesian updating based on equilibrium strategies. On off-equilibrium paths, I will assume beliefs consistent with type-independent trembles in the worker's decision[42].

Consider incentives in period 2. The principal will only offer a contract if the worker had accepted a contract in period 1. Suppose the worker accepted a contract in period 1. It is easy to check that the principal must be willing to offer $\{(1/(1-\beta)), 0\}$ to get full effort[43]. Now, the principal can either offer the contract $\{(1/(1-\beta)), 0\}$ to get maximal effort from the worker, or he can offer a contract which pays nothing and get zero effort from the worker. Note that any contract which offers something in the middle is not optimal as anything less than $(1/1-\beta)$ for success will result in zero effort. We need the following conditions to make it individually rational and incentive compatible for the principal to offer the contract $\{(1/(1-\beta)), 0\}$ and extract maximum effort:

$$Payoff\ from\ \left\{\frac{1}{1-\beta}, 0\right\}\ >\ Payoff\ from\ \{0,0\}$$

$$\Leftrightarrow \left[p_g^2 + (1-p_g^2)(\beta\lambda_b + (1-\beta))\right]\left(V - \frac{1}{1-\beta}\right) > \left[p_g^2\beta + (1-p_g^2)\beta\lambda_b\right]V$$

Clearly, if $V(1-\beta^2) - \beta\lambda_b - (1-\beta) < 0$, then the principal prefers to offer a zero wage contract.

In period one, the strategies call for the G worker to play $e = 1$ after L. For this to be incentive compatible, we need the condition $V > 1/(\beta(1-\beta)(1-\lambda_b))$. Therefore, for both conditions on V to hold together, we need:

$$\frac{1}{\beta(1-\beta)(1-\lambda_b)} < \frac{1}{1-\beta} + \frac{\beta\lambda_b}{(1-\beta)^2} \tag{8}$$

Clearly, this holds if β is high enough. Suppose β' is such that the above holds for all $\beta \geq \beta'$. To make the proposed strategies optimal, we want to show that it is individually rational for the G type worker to play L but not for the B type worker. We can easily show that the following condition is sufficient:

$$\frac{1+R_w}{1+\beta} < V < \frac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)} \tag{9}$$

Note that if the following hold:

$$\frac{1+R_w}{1+\beta} > \frac{1}{\beta(1-\beta)(1-\lambda_b)} \tag{10}$$

$$\frac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)} < \frac{1}{1-\beta} + \frac{\beta\lambda_b}{(1-\beta)^2} \tag{11}$$

then 8 holds if we can pick a V such that (9) holds. For the above to hold, we need R_w, β such that:

$$\frac{1+\beta}{\beta(1-\beta)(1-\lambda_b)} - 1 < R_w < (1+\beta(1-\beta(1-\lambda_b)^2)\left(\frac{1-\beta+\beta\lambda_b}{(1-\beta)^2}\right) - 1 \tag{12}$$

It is clear that there exists a β'' such that if $\beta > \beta''$ then we can choose an R_w for which (12) holds. Pick $\beta > max\{\beta', \beta''\}$. So now we have the following to be true: i) It is IC for G worker to play L in period 1, ii) It is not IR for B type worker to play L in period 1, iii) If the G type worker plays L in period 1, then he puts in full effort in period 1, iv) In period 2, if the worker had accepted a contract with the principal in period 1, then the principal offers a zero wage contract which the worker accepts and puts in zero effort.

We now consider why it is not possible for the principal to get the G worker. Consider the first period incentives for worker type G if a contract $\{s, 0\}$ is offered:

1. Payoff from accept and full effort $= -1 + s$
2. Payoff from accept and no effort $= \beta s$
3. Payoff from play $L = -1 + V - R_w + \beta V$

Choose β''' such that if $\beta > \beta'''$ then the following to holds:

$$\frac{1}{\beta}[-1 + V - R_w + \beta V] < V - R_w + \beta V < \frac{1}{1-\beta}$$

If $\beta > max\{\beta', \beta'', \beta'''\}$, the principal has three relevant choices: a) Offer zero wage contract. Only B type worker will accept and put in zero effort, b) Offer the contract $\{(1/\beta) * [-1 + V - R_w + \beta V], 0\}$. Both G and B type worker will accept and put in zero effort, c) Offer the contract $\{(1/(1-\beta)), 0\}$. Both G and B type worker will accept and put in full effort.

[42] If the worker wants to choose an action a, then the worker chooses action a with probability $(1-\epsilon)$ and any other action with positive probability.

[43] This is independent of type. To induce effort from a good worker, the principal needs to offer $\{x, 0\}$ such that $x - 1 \geq \beta x - 0 \Rightarrow x \geq \frac{1}{1-\beta}$. To induce effort from the bad type worker, the principal needs to offer $\{y, 0\}$ such that $[\beta\lambda_b + (1-\beta)]y - 1 \geq \beta\lambda_b y - 0 \Rightarrow y \geq \frac{1}{1-\beta}$.

It is easy to see now that there exists a p_1 such that if $p_g < p_1$, then the principal will not find it optimal to offer any more than a zero wage contract. This is because if the principal offers a higher wage contract, it will result in a pooling equilibrium where the market will not be willing to pay a high price since it believes that the worker is most likely bad type (because prior p_g is low). □

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