Signalling, Reputation and Spinoffs*

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Abstract

I propose a new channel of spinoff (firm formed when an employee leaves to form 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 signalling), 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.

Keywords - Reputation, Signalling, Spinoffs, Entrepreneurship, Moral hazard, Adverse Selection

JEL Codes - L14, L26, D81, D02

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[1]. Such firms have been observed in industries ranging from semiconductors (National, AMD, Intel are all spinoffs) to auto-mobiles

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[1]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.

(Klepper (2007)) to law firms (Phillips (2002)). Recent literature on spinoffs has focused on the explanation that most of these spinoffs come about when an employee gets a private new idea and then forms the spinoff because of asymmetric information about the idea's profitability (the employee knows more than the employer) - Chatterjee and Rossi-Hansberg (2012), Anton and Yao (1995), Klepper and Thompson (2010). The intuition here is that asymmetric information about the quality of the idea implies that ideas with above average returns are implemented in spinoffs since the employer/market will not pay more than the expected return for an idea[2].

To the best of my knowledge, all papers in the spinoff literature assume that the benefits from forming a spinoff are exogenously given[3]. This assumes that customer *perception* about the new firm's quality does not matter. However, this may not be the case when the profitability of the idea is privately known by 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[4]. In this paper, I will present a model in which market perception about the quality of the new firm matters and therefore signalling 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 signalling 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 those who are scientists or engineers. Instead, I look at workers who are (incorrectly) *perceived* as low ability, like those high ability workers who, for one reason or another have not had a good education. 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 worker type and contracting limitations[5] may lead to the high ability worker getting much less than his marginal product as wages. Not only does this reduce the welfare of the good type worker, it could also hamper the regional economy by encouraging brain drain[6].

[2] Such models have been studied in environments where the parent firm has capacity constraints for the development of new ideas (Cassiman and Ueda (2006)), the new idea is far from the core business of the parent firm (Hellmann (2007)) etc.

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

[4] The entrepreneur may earn profits in the long run as the market will update beliefs 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 entrepreneur is not infinitely patient.

[5] Contract cannot ask the worker to pay to work/charge the worker for failing. Principal cannot 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

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 put in high effort. I introduce moral hazard in my baseline adverse selection model and show that the equilibrium in which the good type worker separates and forms a new firm can generate the highest incentives to work. This has implications for policy on covenants not to compete since they restrict signalling 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. 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 of my results with the Norwegian data in the discussion section (see section 6.5).

I consider a two period principal-worker model (the infinite horizon extension is discussed in the appendix). 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 is 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].

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

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 skewed.

[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 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 A.3.2.

[10]In general, a model of spinoffs should have a principal and a worker. 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) points 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 is 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 start his firm more easily.

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 than the good type worker[13] making him reluctant to form the spinoff if the cost of firm formation is high enough. The second question is - Why can't the principal always 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 low 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. In the internet appendix, I find sufficient 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 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 as 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

[13] As an example, think of the 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)).

success. However, I show that in any separating equilibrium, the 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 modelling choices in section 6, and section 7 concludes the paper. The appendix contains some proofs, and the infinite horizon extension of 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. I have already mentioned some of the papers which talk about spinoff formation in the introduction. In this section, I will discuss other work this paper is related to. My baseline model is one of adverse selection and signalling and, in the latter half of my paper I introduce moral hazard in my baseline model.

First and foremost, my paper is related to job market signalling as studied in the celebrated paper by Spence (Spence (1973)). However, the question here becomes all the 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. 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 signalling opportunities after the education stage. As Skogstrøm (2012) points put, education may not signal ability perfectly. Skogstrøm (2012) has a simple model of signalling to explain entrepreneurship. The author points out that if the cost to education and ability are not perfectly correlated then it is possible that high ability workers who have a high cost to education may take up entrepreneurship in equilibrium. However, the returns to entrepreneurship for high ability workers is

[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), Gilson (1999).

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 attempts to fill this gap.

Some of the ideas in this paper are borrowed from the literature on dynamic signalling. 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 at low reputations. The idea that a good type 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 signalling 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 cost. Thus, discount factors are important in my paper. Additionally, my paper also studies moral hazard simultaneously with adverse selection.

The idea of investing personal wealth to indicate quality of new firm has been explored in other 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 then 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 (Chatterjee and Rossi-Hansberg (2012), Anton and Yao (1995)). This is because these papers assume that the (average) profitability of a new idea is exogenous and known to the worker[16]. In my model, the payoff is strongly linked to the signalling 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 signalling channel of firm formation via a 'new idea' channel, this has not been

[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), Milgrom and Roberts (1986)).

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

addressed in the literature. Furthermore, at least the Norwegian data 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 only on new ideas then the spinoff should be very different from the parent. 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 looking at 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 latter is more valuable then the efficiency of non compete clauses is reduced[17]. 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 jobs executed by workers.

3 Principal Agent Problem

3.1 Model

There are two risk neutral players - a principal and a worker. It is a two period game (the infinite horizon extension is discussed in the appendix in section A.3). The worker can be one of two types - G or B (good and 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 the 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 the appendix in section A.3.2). These probabilities are common knowledge. The market values a successful 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 probability that the worker is good type) in some period, then the firm receives a price $(\theta V + (1-\theta)\lambda_b V)$

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

from the market in that period[18].

In period one, the principal moves first and offers either no contract or a one period contract(s)[19] 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. All contract offers are publicly observable[20]. 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 the 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 i.e. the principal knows the right people (to get licenses etc.) and therefore he can 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 one period payoff is not enough to make any worker form his own firm, and if types are known then 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 profits 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[21] 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 firm formation for only one period reward 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

[18]The strategies of the principal and 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).

[19]One period here may be long time. In particular, it could be the time required to complete the project. 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.

[20]I discuss what happens if the market cannot observe the contract in section 6.

[21]At zero wages.

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[22] 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 equilibrium concept is that of Perfect Bayesian Equilibrium. I assume that the principal offers at most two contracts in every period[23]. 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.

3.1.1 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 $A_p(t) = \{x \in 2^{\{(s,f);\ s,f \geq 0\}};\ |x| \leq 2\}$.[24] 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 to do nothing (i.e. do not accept a contract and do not form own firm), acc_i is the action to accept contract (s_i, f_i) and L refers to the action of 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 formed his firm in a 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 staying with 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

[22] 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.

[23] This is just for simplicity. The only reason principal may wish to offer more than two contracts is because he may want to rope in the worker in a bad contract if the worker goes off equilibrium to pick a contract. Alternatively, the results will also go through if I assume a small cost of offering every contract.

[24] $s, f \geq 0$ reflects limited liability for the worker. This is important for the results and is discussed further in section 6.

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 here 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 (where there will be more uncertainty about worker ability) as compared to workers with high education (less uncertainty about ability).

When there is uncertainty about the worker's type then the good type worker may form the spinoff in an equilibrium. The intuition is as follows. 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 the worker is good type but the type is private knowledge of 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[25] 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 the 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 beliefs 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 low ability, then the principal will be unwilling to offer high wage contracts 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 own firm in period 1 and the B worker accepts a contract in period 1. Alternatively, we could have a pooling equilibrium where workers of both types choose 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

[25] I will assume that in any equilibrium, the belief about a worker who fails at the job is that the worker is bad type. This is consistent with a model that allows for trembles in the worker's choice.

one and 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[26].

4.1 Separating Equilibrium

In this subsection, we will be interested in determining the conditions under which the 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 the 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 equilibrium outcome is unique. A short discussion of this is presented after proposition 1. The following proposition 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[27]. 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 action is to play L and get $2V - R_w$.

[26] 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 type 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 $\{x_b, y_b\}$.

[27] See claim 2 in the appendix.

Given the strategy of others, the G worker clearly has no incentive to deviate if $2V - R_w > 0$. For the 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 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 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 player expects by leaving. Note that the B type player 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 $\{2V - R_w, 0\}$, expected payoff for 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 $V < R_w/(1+\lambda_b(2-\lambda))$ is a sufficient condition to get a separating equilibrium. It is definitely not a necessary one. As an example, consider an environment where $R_w/(1+\lambda_b(2-\lambda)) < V < (R_w/(1+\lambda_b(2-\lambda))) + \nu$ where ν is small. In this case, there will be a separating equilibrium as well. However, since the outside option for the B worker may be positive now, the principal may offer a small amount to the B worker to compensate him for staying. I use the condition $V < R_w/(1+\lambda_b(2-\lambda))$ 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 the good type worker is going to separate unless offered a better contract - the principal will have to offer the good type 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 the bad type worker will accept while the good worker may leave. The payoffs in this equilibrium are given by table 1.

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

The expected payoff for the principal is given by $(1-p_g)(2\lambda_b V - R_p)$. Now, as is common in signalling 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 from the worker in equilibrium. In particular, what about a pooling equilibrium where the strategy for both type workers is to leave in period 1 to form their own firm? It is easy to show that when the prior reputation of the worker is low enough there cannot be a pooling equilibrium where both types can pool on L. This follows from the assumption that $2\lambda_b V - R_w < 0$ i.e. the assumption which says that 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 (the infinite horizon extension is in the appendix in section A.3.3). 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[28]. 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 project. Effort exerted is privately observed by the worker. Let $\beta \in [0,1]$. Let $P(S/t,e)$ be the probability of success of the project given worker type t and effort e. I assume the following parametric specification of $P(S/t,e)$

[28] I consider alternate definitions of welfare in section 6.

(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 project depends upon the inherent ability of the worker as opposed to the effort he puts in. In particular, notice that as $\beta \to 1$, we obtain our original model. Also, notice that if the good type worker puts in full effort, then 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 worker types.

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 types are common knowledge case also highlights a key property of having moral hazard in the baseline environment - namely, 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.

There are three primary results in this subsection. First, in any separating spinoff equilibrium, a G worker has to put in full effort after forming a spinoff in period 1. Two, there exists a separating equilibrium where the G worker's strategy (along the equilibrium path) is to leave and form his own firm in period 1 and the B 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 may be the best equilibrium in terms of probability of success of the project. 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 low payoff in period two) and none in period two (last period). I argue that the principal may have no incentive to extract effort via high wage offers[29]. So in any other equilibrium, the worker puts in no effort thereby making the separating equilibrium more desirable by making it the equilibrium where the project's success probability is the highest. The principal will not wish to extract effort when β is high and p_g is low. Suppose these conditions hold. Now, 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 project is a success and the resulting increased reputation of the worker in period two compensates for the high wages. This argument will 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 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 effort put in by the good worker in any separating equilibrium.

Claim 1. *In any separating equilibrium where a G 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. Therefore, when a worker plays L, the belief about the worker is that the worker is G type. 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 choosing L is: $2\beta V - R_w$.

[29] Of course, this is not always the case. In the internet appendix, I describe conditions such that the separating equilibrium leads to a lower probability of success of the project. This result is driven by the workers 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.

In any separating equilibrium, it should not be incentive compatible for the B worker to imitate a G worker's strategy. However, 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 project 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 from leaving. 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 less than $2\beta V - R_w$ (so he does not want to deviate and accept) and should pay the B type worker strictly more than $2\beta V - R_w$. Thus, it must be that $f > 2\beta V - R_w$ 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 efficient 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 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 than other equilibria which exists 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 exert 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 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. $\frac{1+\beta}{\beta(1-\beta)(1-\lambda_b)} - 1 < R_w < \frac{(1+\beta(1-\beta(1-\lambda_b)^2))(1-\beta+\beta\lambda_b)}{(1-\beta)^2} - 1$
2. $\frac{1+R_w}{1+\beta} < V < \frac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)}$

Then there exists a p_1 such that if $p_g \in [0, p_1)$, there exists a separating equilibrium where 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 worker accepts a zero wage contract offered in period 1 and 2, and puts in zero effort in both periods.

Proof. The details of the proof are in the appendix. I present the idea behind the proof here. The beliefs are based on Bayesian updation. On off equilibrium paths, I will assume beliefs consistent with type independent trembles in the worker's decision[30].

The intuitive idea is that under these conditions, G type worker will play $e = 1$ after playing L for fear of failing and receiving low payoffs in period 2 because the market will then believe he is B type. Since only the B 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 rather than on the effort he puts in. Thus, there are small immediate gains to extracting high effort through high wages. 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[31]. 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 try to imitate the G type worker and play L because of the following reason. Since the G type worker is supposed to exert $e = 1$ 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 tomorrow. This, along with the conditions on cost of firm formation and value of V, reduces the expected future wages of the B type worker enough for him to not copy the G type worker's strategy.

If the belief about the worker type is very low ($p_g < p_1$) then the principal cannot expect huge prices from the market (even if he offers lucrative contracts which makes both type workers accept the contract and put in maximum effort). This means that 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 the proposition above, the separating equilibrium is the equilibrium which generates maximum incentives to work. To do this, first, I will demonstrate that there

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

[31] If the principal high wages 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 try and attract the good type worker, both types will accept and therefore the reputation of the worker will be low if prior belief about the worker's ability are low. In this case, even a success will not lead to high reputation for the worker in period 2.

exists another equilibrium which generates a lower probability of success[32]. 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 equilibrium in which the G type worker's strategy is to play L in period 1, generates a lower probability of success for the project in period 1 and the same probability of success for the project 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. 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 proofs for proposition 1 and proposition 2. The intuitive idea here is that if the prior belief about the reputation of the worker is really low and both type workers are expected to accept a contract, then no type 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 restriction on the off equilibrium belief is consistent with a model which allows for mistakes 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 negative payoffs if he invests money to form his own firm. The value of V is low enough to ensure that the principal does not want to pay to induce high effort from the worker. The principal does not want to pay for high effort because effort is not a big factor in determining outcomes (high β implies that the impact of higher effort on probability of success is small). Also, since the prior 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 β'' such that if $\beta > \beta''$ and the conditions required for proposition 2 hold. Then, there exists a p_3 such that if $p_g \in [0, p_3)$, then:*

1. *There exists a separating equilibrium where G type worker's strategy is to play L in period 1 and then put in effort=1 in period 1 and e=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 (given the worker's type) is less than that in the above equilibrium.*

[32]When compared to separating equilibrium.

Proof. We only need to show part 2 as the first part follows from proposition 2. First, note that it is clear from the proof of proposition 2 that under the conditions required for the same, no type worker will exert effort in period 2. The idea is that the worker will never exert effort when the worker forms his own firm, and the low value of V combined with the low returns to effort (due to high β) ensures that the principal has little incentive to extract effort via high wage contracts in period 2. In the proposed equilibrium, the G type worker puts in full effort in period 1 and the bad type worker puts in no effort in period one. We need to show that there is no equilibrium in which the optimal strategy for both type of workers is to put in effort level 1 (as this is the only type of equilibria that can beat the current equilibria). Suppose there exists an equilibrium in which both type 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 - 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 good type. 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 equilibrium.

Case 3 - Both types accept a contract in period one - It follows from proposition 3 that we can find a β and a p_g such that both types will put in zero effort in any pooling on contract equilibrium.

Case 4 - Good type worker mixes between L and accepting a contract and bad type worker accepts a contract in period 1 - From the above case, it follows that we can find a β and a p_g such that both type workers will put in zero effort in this equilibrium after accepting a contract under the conditions required by proposition 2. When the G type worker plays L, then he will put in full effort (follows from claim 1). Thus, the expected effort from the G type worker in this equilibrium is lower than that in the proposed separating 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. None the less, the intuition from these results are sound and would apply more generally. One empirical implication of this model is that we should hope to find higher effort in spinoff equilibria if reputation can be easily lost through a few bad outcomes. 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 low reputation and start his own practise. This could signal his ability to the market. However, a few bad results could really hurt the lawyers 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 look at some of my modelling choices and discuss 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 key assumptions. The important assumptions are that the good type is better than the bad type, the worker's outcomes are 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 and the bad type worker. On the principal's side, 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 (the principal can never pay the worker negative wages). Suppose the principal could offer the worker a contract like $(2V - R_w, -M)$ where $M > 0$ 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.

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 positive payoffs from firm formation, then for our separating equilibrium, all the principal has to do is to offer the bad type worker his expected payoff from firm formation (lower than good type worker) instead of the zero wage contract.

6.3 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 separating equilibrium. Consider an equilibrium in which the principal offers a zero wage contract which only the bad type accepts and the good type forms his own firm. Even if the customer can't observe contracts, there is no deviation which makes the principal better of - if he offers a high wage contract to attract the good worker, the market only observes that the worker signed with the principal. So they think it must be the bad type worker since they don't notice that the principal deviated and offered a high wage contract. However, then the principal would not want to deviate.

6.4 What if effort and ability were not substitutes?

In section 5, I assume that probability of success is a linear combination of effort and ability. Thus, here 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 $P(S/G,e) = e\beta \text{ and } P(S/B,e) = e\beta\lambda_b$. 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 profits from forming his own firm (because second period probability of success is zero, second period payoff is zero). However, we have assumed this is not good enough ($V - R_w < 0$). Note that this argument would break down in the infinite horizon case (see section A.3.3 in the appendix).

Consider an alternate model where the 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 one hand $G's$ cost of separating has gone down. This is because he must exert full effort in the first period after separation and the cost for this 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 separating equilibrium since principal would be unwilling to offer high wages to attract G type if the G type worker is scarce. However, it may be harder to get the separating equilibrium as the highest effort equilibrium since the principal needs to offer less to extract full effort (as cost of effort has gone down).

6.5 On Empirical support

In the paper, I argue that a high ability-low education worker may choose to become an entrepreneur to signal ability and increase 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 also. 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 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 latter argument is part of the whole explanation, could all of the gap (11 percentage points) be explained by the survival argument alone?

6.6 Competition for the Worker

What if there were two principals competing to hire the worker? We can still get separating equilibria in the same way as we got in section 4. However, we will require stronger conditions to get 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 much higher. A more detailed analysis of this model is available upon request. The result that workers with higher wages may be less likely to become entrepreneurs than workers with lower wages has also been shown by papers like Evans and Leighton (1989).

6.7 Welfare Alternatives

In section 5, we look for conditions under which the separating equilibrium is the highest effort equilibrium. We were interested in this result because in some environments[33] it may be desirable to maximize the job's success rate. However, it would be informative look at other welfare criteria as well. First, note that under the conditions mentioned in corollary 1, both type 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 are maximized[34].

Suppose we know that the worker is good type (the principal does not know this though) then which

[33]Like the worker being engaged on a public project.
[34]As is traditionally analyzed.

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

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

Essentially, 4 says that if the gains for the good type worker from separating are bigger than the gains for the principal in the pooling on contract equilibrium, then welfare is maximized by the separating equilibrium.

Next, consider the case of ex-ante welfare i.e. making welfare calculations when we do not know the worker type. On one hand, the separating equilibrium may increase welfare by increasing the probability of success (and therefore payments to the good worker from separation). The increase in probability of success comes due to the higher effort put 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[35] 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 maximizes 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 signalling and reputation concerns. I show that in the presence of asymmetric information about the worker's type, there can exist a separating equilibria 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 put in effort.

In view of its impact on the welfare of the high type workers and on effort efficiency, the signalling aspect of new firm formation is important to understand. As I point out, these issues 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

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

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.

References

Agarwal, R., Echambadi, R., Franco, A. M., and Sarkar, M. B. (2004). Knowledge transfer through inheritance: Spin-out generation, development, and survival. *Academy of Management journal*, 47(4):501–522.

Akerlof, G. A. (1970). The market for âĂIJlemonsâĂİ: Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 84(3):488–500.

Anton, J. and Yao, D. A. (1995). Start-ups, spin-offs, and internal projects. *Journal of Law, Economics and Organization*, 11(2):362–78.

Audretsch, D. B., Bönte, W., and Mahagaonkar, P. (2012). Financial signaling by innovative nascent ventures: The relevance of patents and prototypes. *Research Policy*, 41(8):1407–1421.

Bar-Isaac, H. (2003). Reputation and survival: learning in a dynamic signalling model. *The Review of Economic Studies*, 70(2):231–251.

Basu, S. and Ray, K. (2016). Limits to auditor reputation incentives. working paper.

Berglann, H., Moen, E. R., Røed, K., and Skogstrøm, J. F. (2011). Entrepreneurship: Origins and returns. *Labour economics*, 18(2):180–193.

Blanchflower, D. G. and Oswald, A. J. (1998). What makes an entrepreneur? *Journal of labor Economics*, 16(1):26–60.

Brealey, R., Leland, H. E., and Pyle, D. H. (1977). Informational asymmetries, financial structure, and financial intermediation. *The Journal of Finance*, 32(2):371–387.

Calvo, G. A., Wellisz, S., et al. (1978). Supervision, loss of control, and the optimum size of the firm. *Journal of Political Economy*, 86(5):943–952.

Cassiman, B. and Ueda, M. (2006). Optimal project rejection and new firm start-ups. *Management Science*, 52(2):262–275.

Chatterjee, S. and Rossi-Hansberg, E. (2012). Spinoffs and the market for ideas. *International Economic Review*, 53(1):53–93.

Conti, A., Thursby, M., and Rothaermel, F. T. (2013). Show me the right stuff: Signals for high-tech startups. *Journal of Economics & Management Strategy*, 22(2):341–364.

Cooper, A. C. (1971). The founding of technologically-based firms.

Evans, D. and Leighton, L. S. (1989). Some empirical aspects of entrepreneurship. *American Economic Review*, 79(3):519–35.

Fudenberg, D. and Tirole, J. (1991). Perfect bayesian equilibrium and sequential equilibrium. *journal of Economic Theory*, 53(2):236–260.

Garmaise, M. J. (2011). Ties that truly bind: Noncompetition agreements, executive compensation, and firm investment. *Journal of Law, Economics, and Organization*, 27(2):376–425.

Gilson, R. J. (1999). The legal infrastructure of high technology industrial districts: Silicon valley, route 128, and covenants not to compete. *NYUL Rev.*, 74:575–1786.

Golan, L. (2009). Wage signaling: A dynamic model of intrafirm bargaining and asymmetric learning. *International Economic Review*, 50(3):831–854.

Han, L., Fraser, S., and Storey, D. J. (2008). *Signalling Process and Self-selection Mechanism in Entrepreneurial Finance*. Centre for Small and Medium Sized Enterprises, Warwick Business School.

Hellmann, T. (2007). When do employees become entrepreneurs? *Management science*, 53(6):919–933.

Holmstrom, B. (1999). Managerial incentive problems: A dynamic perspective. *The Review of Economic Studies*, 66(1):169–182.

Hsu, D. H. and Ziedonis, R. H. (2008). Patents as quality signals for entrepreneurial ventures. In *Academy of Management Proceedings*, volume 2008, pages 1–6. Academy of Management.

Hvide, H. K. (2009). The quality of entrepreneurs. *The Economic Journal*, 119(539):1010–1035.

Klepper, S. (2007). Disagreements, spinoffs, and the evolution of detroit as the capital of the us automobile industry. *Management Science*, 53(4):616–631.

Klepper, S. (2009). Spinoffs: A review and synthesis. *European Management Review*, 6(3):159–171.

Klepper, S. and Thompson, P. (2010). Disagreements and intra-industry spinoffs. *International Journal of Industrial Organization*, 28(5):526–538.

Liu, Q. (2011). Information acquisition and reputation dynamics. *The Review of Economic Studies*, 78(4):1400–1425.

Mailath, G. J. and Postlewaite, A. (1990). Workers versus firms: Bargaining over a firm's value. *The Review of Economic Studies*, 57(3):369–380.

Marx, M., Singh, J., and Fleming, L. (2015). Regional disadvantage? employee non-compete agreements and brain drain. *Research Policy*, 44:394–404.

Matheson, J. H. (1998). Employee beware: The irreparable damage of the inevitable disclosure doctrine. *Loyola Consumer Law Review*, 10:145–162.

Milgrom, P. and Roberts, J. (1986). Price and advertising signals of product quality. *The Journal of Political Economy*, pages 796–821.

Myerson, R. B. (1978). Refinements of the nash equilibrium concept. *International journal of game theory*, 7(2):73–80.

Nelson, P. (1970). Information and consumer behavior. *Journal of political economy*, 78(2):311–329.

Nelson, P. (1974). Advertising as information. *Journal of political economy*, 82(4):729–754.

Noldeke, G. and Van Damme, E. (1990). Signalling in a dynamic labour market. *The Review of Economic Studies*, 57(1):1–23.

Pakes, A. and Nitzan, S. (1983). Optimum contracts for research personnel, research employment, and the establishment of "rival" enterprises. *Journal of Labor Economics*, 1(4):345–365.

Phillips, D. J. (2002). A genealogical approach to organizational life chances: The parent-progeny transfer among silicon valley law firms, 1946–1996. *Administrative Science Quarterly*, 47(3):474–506.

Prasad, D., Bruton, G. D., and Vozikis, G. (2000). Signaling value to businessangels: the proportion of the entrepreneur's net worth invested in a new venture as a decision signal. *Venture Capital: An international journal of entrepreneurial finance*, 2(3):167–182.

Rajan, R. G. and Zingales, L. (2001). The firm as a dedicated hierarchy: A theory of the origins and growth of firms. *The Quarterly Journal of Economics*, 116(3):805–851.

Rubin, P. H. and Shedd, P. (1981). Human capital and covenants not to compete. *The Journal of Legal Studies*, 10(1):93–110.

Saxenian, A. (1994). *Regional networks: industrial adaptation in Silicon Valley and route 128*. Harvard University Press, Cambridge (Mass).

Selten, R. (1975). Reexamination of the perfectness concept for equilibrium points in extensive games. *International journal of game theory*, 4(1):25–55.

Skogstrøm, J. F. B. (2012). Entrepreneurial school dropouts: A model on signalling, education and entrepreneurship. Technical report, Memorandum, Department of Economics, University of Oslo.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics*, 87(3):355–374.

Tadelis, S. (1999). What's in a name? reputation as a tradeable asset. *American Economic Review*, 89(3):548–563.

Tirole, J. (1996). A theory of collective reputations (with applications to the persistence of corruption and to firm quality). *The Review of Economic Studies*, 63(1):1–22.

A Appendix

A.1 Types are Private knowledge and Principal Agent Problem

As we show in our internet appendix, when the worker type is known then the worker never forms his own firm. This result does not hold when there is asymmetric information about the worker 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 (since $V < R_p < R_w$), in any equilibrium, the principal will offer no contract if the worker formed his own firm in period one or played N. If the worker had accepted a contract in period one (and thus the principal has already formed a firm in period one), then the principal's optimal strategy is to offer a zero wage contract. 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 any formal proof.

Thus, in any equilibrium, in period 2, we have the following equilibrium outcome:

$$\text{If worker formed firm in period 1} \rightarrow \textit{Principal offers no contract and worker plays S} \; ; \tag{6}$$

$$\text{If worker accepted contract in period 1} \rightarrow \textit{Principal offers zero wage contract and worker accepts} \; ;$$

$$\text{If worker played N in period 1} \rightarrow \textit{Principal offers no contract and worker plays N} \; ;$$

A.1.2 Period 1

In period 1 of the game, we will be most 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:

$$\textbf{For Principal}:$$

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

$$\textbf{For Worker}:$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1 \; ; s_1^1 \geq s_2^1 \textit{ and } s_1^1 \geq 2V - R_w$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2 \; ; s_1^1 < s_2^1 \textit{ and } s_2^1 \geq 2V - R_w$$

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

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1 \; ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2 \; ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1$$

$$s_w(\phi, B) = N$$

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

The belief about the worker's type are formed using Bayesian updation based on equilibrium strategies. On off equilibrium paths, I will assume beliefs consistent with type independent trembles in the worker's decision[36] in particular, if the worker forms his own firm in period one and then fails then this is 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 in period 1 and the beliefs 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

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

the B worker accepts a contract in period 1. Thus, in this equilibrium, if the worker forms his firm in period 1 then his reputation is one and therefore the beliefs about the worker being G type at the end of period one are either one (if job is successful) or zero (if job fails).

Consider the strategies to be played in period one. Let's look at 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. To make sure accepting a contract is incentive compatible the following condition will suffice: $0 > V - R_w + (\lambda_b V + (1-\lambda_b)\lambda_b V)$. 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 optimal.

Consider the strategy for principal now. According to the strategies, B type worker will accept the contract and if the worker is G type, then he will leave to form his own firm. We will have to check if the principal can deviate and do better. The only profitable deviation 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 player expects by leaving.[37] Note that the B type player will also have to get an expected wage of atleast $\lambda_b(2V - R_w)$ 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 $\{2V - R_w, 0\}$, expected payoff for principal is bounded above by:

$$
\begin{aligned}
&p_g V + (1-p_g)\lambda_b V - (p_g(2V - R_w) + (1-p_g)\lambda_b(2V - R_w)) - R_p + \\
&p_g\left(\frac{p_g}{p_g + (1-p_g)\lambda_b}V + \frac{(1-p_g)\lambda_b}{p_g + (1-p_g)\lambda_b}\lambda_b V\right) + (1-p_g)\left(\lambda_b\left(\frac{p_g}{p_g + (1-p_g)\lambda_b}V + \frac{(1-p_g)\lambda_b}{p_g + (1-p_g)\lambda_b}\lambda_b V\right) + (1-\lambda_b)\lambda_b V\right)
\end{aligned} \tag{7}
$$

Under the equilibrium strategy, principal's payoffs are $(1-p_g)(2\lambda_b V - R_p)$. 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 the expression on the RHS is between zero and one. □

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

The worker's type is 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 type is known extends to the environment with

[37] Today's payoff is $V - R_w$. This is because he will have to invest R_w today and the market will pay V if firm is formed since they expect only the G type to form it. The G type player will be successful and his reputation will remain one. Therefore, as described before, in period 2 he will remain with his new firm and get a payoff of V.

moral hazard as well. First, we state a lemma which point out that the worker will not put 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.*

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 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 bid its expected value (βV) when the worker is known to be G type.

In period 1, once the worker has already played L, he realizes that 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 one 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 previous results which say 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.

Claim 3. *If the worker type is known to be G, 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 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 one (worker played L in period one), accepted a contract in period one (worker played *acc* in period one) or the worker did neither (worker played N in period one). The worker's strategy in period 2 depends upon his actions in period one, 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:

$$\textbf{For Principal}:$$
$$s_{p,2}(acc, p_g^2) = \{0,0\}$$
$$s_{p,2}(N, p_g^2) = \phi$$
$$s_{p,2}(L, p_g^2) = \phi$$
$$\textbf{For Worker}:$$
$$If\ worker\ had\ formed\ firm\ in\ period\ 1,\ principal\ does\ not\ offer\ contract\ and$$
$$s_{w,2}(L, p_g^2, \phi, G/B) = S,\ e = 0$$
$$If\ worker\ had\ not\ formed\ firm\ in\ period\ 1:$$
$$s_{w,2}(acc/N, p_g^2, \{\{s_1^2, f_1^2\}, \{s_2^2, f_2^2\}\}, G/B) = Choose\ (contract, effort)\ maximizing\ payoff$$
$$s_{w,2}(acc/N, p_g^2, \phi, G/B) = N$$

Consider the following strategies in period 1:

$$\textbf{For Principal}:$$
$$s_p(\phi) = \{\{0,0\}\}$$
$$\textbf{For Worker}:$$
$$WLOG\ let\ contract\ 1\ be\ better\ than\ contract\ 2\ for\ G\ worker$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1, e = 1\ ;\ -1 + s_1^1 = max\{-1 + s_1^1, \beta s_1^1\}\ and$$
$$-1 + s_1^1 \geq -1 + V - R_w + \beta V$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1, e = 0\ ;\ -1 + s_1^1 \neq max\{-1 + s_1^1, \beta s_1^1\}\ and$$
$$\beta s_1^1 \geq -1 + V - R_w + \beta V$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = L, e = 1\ ;\ else.$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = Choose\ (contract, effort)\ maximizing\ payoff$$
$$s_w(\phi, B) = N$$
$$s_w(\phi, G) = L, e = 1$$

The belief about the worker's type are formed using Bayesian updation based on equilibrium strategies.

On off equilibrium paths, I will assume beliefs consistent with type-independent trembles in the worker's decision[38].

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 maximal effort[39]. 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 IR and IC for the principal to offer the contract $\{\{(1/(1-\beta)),0\}$ and extract maximum effort:

$$Payoff\ from\ \{\frac{1}{1-\beta},0\} > Payoff\ from\ \{0,0\}$$
$$\Leftrightarrow [p_g^2+(1-p_g^2)(\beta\lambda_b+(1-\beta))](V-\frac{1}{1-\beta}) > [p_g^2\beta+(1-p_g^2)\beta\lambda_b]V$$

Clearly, if $V(1-\beta^2)-\beta\lambda_b-(1-\beta)<0$, then the principal prefers to offer a zero wage contract. We also know that the G worker plays $e=1$ 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 $\beta \geq \beta'$. We would also like that it is IR 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 holds:

$$\frac{1+R_w}{1+\beta} > \frac{1}{\beta(1-\beta)(1-\lambda_b)} \tag{10}$$
$$\frac{1+R_w}{1+\beta(1-\beta(1-\lambda_b)^2)} < \frac{1}{1-\beta}+\frac{\beta\lambda_b}{(1-\beta)^2} \tag{11}$$

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

[39]$\{(1/(1-\beta)),0\}$ is the minimum amount required for a worker of either type to put in effort 1. This is regardless of worker type i.e. even if the worker type was known, for any type of worker, this contract would be an optimal contract to induce maximum effort.

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:

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

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: 1. IR for G to play L in period 1, 2. Not IR for B to play L in period 1, 3. If G plays L in period 1, then puts in effort $e = 1$ in period 1, 4. 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 play $e = 1 = -1+s$
2. Payoff from accept and play $e = 0 = \beta s$
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 effectively three choices: 1. Offer zero wage contract. Only B type worker will accept and put in zero effort, 2. 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, 3. Offer the contract $\{(1/(1-\beta)), 0\}$. Both G and B type worker will accept and put in full effort.

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 zero wage contract. This is because it will be 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.

A.3 Infinite Horizon Extension

In this section we look at the infinite horizon extension of the main model. In particular, we will be interested in determining the conditions under which the main results of the paper (existence of the separating equilibrium and the effort efficiency of it) hold in an infinite horizon model. The model remains similar with the following additions. One, it is an infinite horizon game but the worker is allowed to form a spinoff in period one only. This is a simplification since we are only interested in the conditions under which the worker may choose to spinoff, and not how the worker arrived at those conditions. $\frac{\lambda_b V}{1-\delta} < R_w < \frac{V}{1-\delta}$ i.e. if the worker's type is known then the bad type worker finds setting up his own firm too costly, while the good worker does not. The principal is willing to contract with the even the bad type worker if he doesn't have to offer wages i.e. $\frac{\lambda_b V}{1-\delta} > R_p$. Let's begin by looking at the baseline model of adverse selection only.

A.3.1 Only Adverse Selection

Let p_t denote the reputation of the worker in period t. Suppose the worker had played L in period 1 and suppose the strategy of both type workers calls for playing S forever after playing L in period one. Let $PDV_G(p_t)$ denote the present discounted value of the payoff a good type worker can get at time t by always playing S from that period on. Similarly define $PDV_B(p_t)$. Consider the following strategy now:

Strategy for period t (> 1)

For Principal :

$s_p = \{\{0,0\}\}\ \forall\, t \textit{ and all histories}$

For Worker :

If worker played L in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1\ ; s_1^1 \geq s_2^1 \textit{ and } s_1^1 \geq PDV_G(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2\ ; s_1^1 < s_2^1 \textit{ and } s_2^1 \geq PDV_G(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = S\ ;\ else$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1\ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \textit{ and } \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2\ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1 \textit{ and } \lambda_b s_2^1 + (1-\lambda_b) f_2^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = S\ ;\ else$

If worker played N/acc in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G/B) =$ accept best contract if offered any, else play N

Strategies for period 1:

For Principal :

$s_p = \{\{0,0\}\}$

For Worker in period 1 :

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1 \; ; s_1^1 \geq s_2^1 \; and \; s_1^1 \geq \frac{V}{1-\delta} - R_w$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2 \; ; s_1^1 < s_2^1 \; and \; s_2^1 \geq \frac{V}{1-\delta} - R_w$$

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

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1 \; ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2 \; ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1$$

$$s_w(\{\phi\}, B) = N$$

The belief about the worker at any off equilibrium node is assumed to be determined by Bayes rule consistent with trembles in the worker's decision i.e. as if our model allowed for the worker to make mistakes with small probability in their action choices. These mistakes are independent of worker type.

Proposition 4. *There exists a p_1 such that if $p_g \in (0, p_1)$ and $V < \frac{R_w}{(\frac{1}{1-\delta\lambda_b} + \frac{\delta(1-\lambda_b)\lambda_b}{(1-\delta\lambda_b)(1-\delta)})}$, then the strategies and beliefs given above constitute a perfect Bayesian equilibrium.*

Proof. Given the strategy of others, it is clear that the strategy of the good type worker is optimal. Can the bad type worker do any better by copying the good type worker in period 1? The condition $V < \frac{R_w}{(\frac{1}{1-\delta\lambda_b} + \frac{\delta(1-\lambda_b)\lambda_b}{(1-\delta\lambda_b)(1-\delta)})}$ ensures that it is not individually rational for the bad type worker to form the firm. The intuition remains that the bad type worker has a lower expected future payoff from firm formation as compared to the good type worker. This is because the bad worker's type can get revealed by a failure. Thus, if the cost of firm formation is high enough (in comparison to V), the bad type worker will never form the firm.

Now let us check for optimality of the principal's strategy. If the principal follows the proposed strategy, he gets the expected payoff of $(1-p_g)(\frac{\lambda_b V}{1-\delta} - R_p)$. If the worker leaves in the first period, then in any future period the worker's reputation is either one or zero (if worker fails). The principal will have to offer the worker either $\frac{V}{1-\delta}$ (if reputation is one) or $\frac{\lambda_b V}{1-\delta}$ (if reputation is zero) to lure him back but this is also the most the principal can earn from getting the worker back. Since R_p is positive, this is not individually rational. The best deviation possible for the principal is to offer a higher wage to stop the good type worker from leaving in period 1. The good type worker gets a payoff of $\frac{V}{1-\delta}$. The principal must offer this as he cannot commit to offering a positive wage after period 1 (since the worker can't leave after period 1, the principal never offers positive wages after employing the worker in period 1). If the principal offers the contract $\{\frac{V}{1-\delta}, 0\}$, both types will accept the contract and the payoff for the principal will be:

$$(p_g + (1-p_g)\lambda_b)V - R_p - (p_g + (1-p_g)\lambda_b)(\frac{V}{1-\delta}) + \delta(...) \xrightarrow[p_g \to 0]{} \frac{\lambda_b V}{1-\delta} - R_p - \frac{\lambda_b V}{1-\delta} < 0 < \lim_{p_g \to 0}(1-p_g)(\frac{\lambda_b V}{1-\delta} - R_p)$$

Thus, we can find a p_1 low enough such that the principal will be unwilling to offer high wages to the worker if the worker's reputation is below p_1. □

A.3.2 When G type can fail

Hitherto, we have used the condition that failure perfectly reveals the worker's type to be bad (on the equilibrium path by Bayesian updating and off the equilibrium path by assumption). Is this truly necessary for the separating equilibrium to exist? We explore this question in this subsection. 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 the reputation can never fall). We will show that in this case we can get a hybrid equilibrium where the good type worker leaves to form the spinoff in period one and the bad type worker mixes between spinning off and accepting a contract.

Suppose that the G type worker succeeds with probability λ_g where $0 < \lambda_b < \lambda_g < 1$. So the G type worker may fail but the bad type worker is more likely to fail. Similar to our assumption before, we assume that $\frac{\lambda_b V}{1-\delta} < R_w < \frac{\lambda_g V}{1-\delta}$.

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. Suppose there was such an equilibrium. Then, the bad type worker could deviate and play L in period one, and get the payoff $\frac{\lambda_g V}{1-\delta} - R_w$ (since the good type worker can fail, the bad type worker does not fear a loss in reputation upon failure and can therefore obtain the same payoff as the good type worker). For this to not be incentive compatible for the worker, the principal would have to offer the bad type worker these wages in period one. However, $\frac{\lambda_g V}{1-\delta} - R_w$ is the most the good type worker can get by playing L, and if the principal is willing to offer these wages to get only the bad type worker then the principal is willing to offer the same wages to the more productive good type worker. Then, the good type worker will deviate and accept a contract. Contradiction.

Consider the following strategies:

Strategy for period t (> 1)

For Principal :

$s_p = \{\{0,0\}\}\ \forall\, t$ *and all histories*

For Worker :

If worker played L in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1\ ; \lambda_g s_1^1 + (1-\lambda_g) f_1^1 \geq \lambda_g s_2^1 + (1-\lambda_g) f_2^1$ *and* $\lambda_g s_1^1 + (1-\lambda_g) f_1^1 > PDV_G(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2\ ; \lambda_g s_2^1 + (1-\lambda_g) f_2^1 > \lambda_g s_1^1 + (1-\lambda_g) f_1^1$ *and* $\lambda_g s_2^1 + (1-\lambda_g) f_2^1 > PDV_G(p_t)$

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

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1\ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1$ *and* $\lambda_b s_1^1 + (1-\lambda_b) f_1^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2\ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1$ *and* $\lambda_b s_2^1 + (1-\lambda_b) f_2^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = S\ ;$ *else*

If worker played N/acc in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G/B) =$ accept best contract if offered any, else play N

Strategies for period 1:

For Principal :

$s_p = \{\{0,0\}\}$

For Worker in period 1 :

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1\ ; s_1^1 \geq s_2^1 \text{ and } s_1^1 \geq PDV_G\left(\frac{p_g}{p_g + (1-p_g)q}\right) - R_w$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2\ ; s_1^1 < s_2^1 \text{ and } s_2^1 \geq PDV_G\left(\frac{p_g}{p_g + (1-p_g)q}\right) - R_w$$

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

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1\ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \text{ and } \lambda_b s_1^1 + (1-\lambda_b) f_1^1 \geq PDV_B\left(\frac{p_g}{p_g + (1-p_g)q}\right) - R_w$$

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2\ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1 \text{ and } \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq PDV_B\left(\frac{p_g}{p_g + (1-p_g)q}\right) - R_w$$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = q.L + (1-q)(\textit{Accept Best Contract})\ ;$ *else*

$s_w(\{\phi\}, B) = N$

The belief about the worker at any off equilibrium node is assumed to be determined by Bayes rule consistent with trembles in the worker's decision i.e. as if our model allowed for the worker to make mistakes with small probability in their action choices. These mistakes are independent of worker type.

Proposition 5. *There exists a p_1 such that if $p_g \in (0, p_1)$, then there exist a q^* such that the strategies and beliefs given above constitute a perfect Bayesian equilibrium for $q = q^*$.*

Proof. Checking optimality is similar to checking those for several of the strategies we have proposed before, so I will only check two things here - one, that there exists a q which makes the strategy of the bad type worker optimal and two, that the principal cannot do better than offering a zero wage contract.

Let us start with the former. On the equilibrium path, the bad type worker gets offered a zero wage contract. For it to be optimal for the bad type worker to mix, he must be indifferent between the zero wage contract and playing L. Given everyone's strategy

$$Payoff\ from\ playing\ L\ =\ PDV_B(\frac{p_g}{p_g+(1-p_g)q})-R_w$$

Note that

$$\lim_{q\to 0} PDV_B(\frac{p_g}{p_g+(1-p_g)q})-R_w = \frac{\lambda_g V}{1-\delta}-R_w>0$$

and

$$\lim_{q\to 1} PDV_B(\frac{p_g}{p_g+(1-p_g)q})-R_w = PDV_B(p_g)-R_w \xrightarrow[p_g\to 0]{} \frac{\lambda_b V}{1-\delta}-R_w<0$$

.

Thus, by the intermediate value theorem, we can find a p' such that if $p_g \leq p'$ then there exists a $q(p_g)$ such that when the principal offers a zero wage contract, the bad type worker is indifferent between accepting the contract and playing L. It is also easy to see that $q(p_g)$ must be an increasing function of p_g[40]. Also note that when the bad type worker mixes with $q(p_g)$, the payoff for the good type worker from playing L is $PDV_G(\frac{p_g}{p_g+(1-p_g)q})-R_w > PDV_B(\frac{p_g}{p_g+(1-p_g)q})-R_w=0$. So the good type worker still finds it optimal to play L.

Now consider the principal's strategy. Can the principal offer a better contract at period one[41]? According to the proposed strategies, the principal's payoff is $(1-p_g)(1-q(p_g))(\frac{\lambda_b V}{1-\delta}-R_p)$. The principal could offer higher than zero wages to attract the good type worker or at least the bad type worker. However, as $p_g \to 0$, the principal's payoff will converge to $\frac{\lambda_b V}{1-\delta}-R_p-X$ where X is a positive real number which depends upon the higher wages offered and which type of worker accepts it. On the other hand, if the principal follows the equilibrium strategy then the principal's payoff converges to $\frac{\lambda_b V}{1-\delta}-R_p$[42]. Thus, there exists a p'' such that if $p \leq p''$ then the principal will always offer zero wage contracts in equilibrium. Choose $p_1 = min\{p', p''\}$ and $q^* = q(p_g)$ □

[40] As p_g goes up the reward from copying the good type worker and playing L increases. To keep the bad type worker indifferent between L and the zero wage contract it must be the case that $q(p_g)$ rises so that reward from playing L reduces.

[41] The argument for why the principal cannot offer a better contract in a later period is similar to those given before. Uncertainty about the worker's type implies that the principal will have to offer more as wages than he would get as prices from the market.

[42] It is easy to show that $q(p_g) \xrightarrow[p_g\to 0]{} 0$.

A.3.3 Adverse Selection and Moral Hazard

In this subsection, we allow for moral hazard in the infinite horizon baseline model (in the same way as section 5). In the two period case, there were two main results in the corresponding section. One, in any separating equilibrium where the good type worker forms a spinoff and the bad type worker accepts a contract in period one, the good type worker must put in full effort in the first period, and will not put in any effort in the last period. Two, the separating equilibrium (as described above) can be the equilibrium which draws the most effort.

Full effort in the former result was driven by the good type worker's fear of losing his reputation and getting paid less subsequently. No effort in period two was a consequence of being unable to commit to effort after being paid in the last period. In the infinite horizon case, in any separating equilibrium the good type worker must exert full effort in sufficiently many periods after playing L. Since the good worker can never fail as long as he is putting in full effort, this strategy will dissuade the bad type worker from copying the strategy of the good type worker because the bad worker is aware that he can fail even if he puts in full effort. In particular, we will focus on the equilibrium in which the good type worker *always* puts in full effort after forming a spinoff (since there is no *last period*, this can be optimal). Under some conditions, this equilibrium will be the highest effort equilibrium. We had previously defined $PDV_G(p_t)$. We modify it's definition to suit the environment with moral hazard on top of adverse selection. Suppose the worker played L in period one. In any period $t(>1)$, let the worker's reputation be p_t and suppose that the strategy profile (along the equilibrium path) calls for the G,B worker to play S and put in effort $e_G(t), e_B(t)$. Then, $PDV_G(p_t)$ denotes the present discounted value that the G type worker can get at time t by following the strategy. Similarly define $PDV_B(p_t)$. Consider the following strategy:
Strategy for period t ($t > 1$)

For Principal :

$s_p = \{\{0,0\}\}\ \forall\, t \text{ and all histories}$

For Worker :

If worker played L in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1 \text{ and } e = 0\ ; s_1^1 \geq s_2^1 \text{ and } s_1^1 \geq PDV_G(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2 \text{ and } e = 0\ ; s_1^1 < s_2^1 \text{ and } s_2^1 \geq PDV_G(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = S \text{ and } e = 0\ ; max\{s_1^1, s_2^1\} < PDV_G(p_t) \text{ and } p(t) = 0$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = S \text{ and } e = 1\ ;\ else$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1 \text{ and } e = 0\ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \text{ and } \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2 \text{ and } e = 0\ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1 \text{ and } \lambda_b s_2^1 + (1-\lambda_b) f_2^1 > PDV_B(p_t)$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = S \text{ and } e = 0\ ; max\{\lambda_b s_1^1 + (1-\lambda_b) f_1^1, \lambda_b s_2^1 + (1-\lambda_b) f_2^1\} < PDV_B(p_t) \text{ and } p(t) = 0$

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = S \text{ and } e = 1\ ;\ else$

If worker played N/acc in period 1

$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G/B) =$ accept best contract if offered any and $e = 0$, else play N

Strategies for period 1:

For Principal:

$s_p = \{\{0,0\}\}$

For Worker in period 1:

$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_1 \textit{ and } e = 0\ ; s_1^1 \geq s_2^1 \textit{ and } s_1^1 \geq \frac{V-1}{1-\delta} - R_w$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = acc_2 \textit{ and } e = 0\ ; s_1^1 < s_2^1 \textit{ and } s_2^1 \geq \frac{V-1}{1-\delta} - R_w$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, G) = L \textit{ and } e = 1\ ;\ else$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_1 \textit{ and } e = 0\ ; \lambda_b s_1^1 + (1-\lambda_b) f_1^1 > \lambda_b s_2^1 + (1-\lambda_b) f_2^1$$
$$s_w(\{\{s_1^1, f_1^1\}, \{s_2^1, f_2^1\}\}, B) = acc_2 \textit{ and } e = 0\ ; \lambda_b s_2^1 + (1-\lambda_b) f_2^1 \geq \lambda_b s_1^1 + (1-\lambda_b) f_1^1$$
$$s_w(\{\phi\}, B) = N$$

The belief about the worker at any off equilibrium node is assumed to be determined by Bayes rule consistent with trembles in the worker's decision i.e. as if our model allowed for the worker to make mistakes with small probability in their action choices. These mistakes are independent of worker type.

Proposition 6. *There exists a p', β' such that if $p_g \in (0, p')$, $\beta \in (\beta', 1)$ and*

1. $\dfrac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1-\beta\lambda_b)} < V < \dfrac{\beta\lambda_b + 1 - \beta}{(1-\beta)^2}$
2. $V - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)] < R_w < V - 1 + \delta(\dfrac{V-1}{1-\delta})$

then the strategy and beliefs given above constitute a perfect Bayesian equilibrium.

Proof. Consider the optimality of worker type G's strategy. Can the worker deviate profitably in period one? There are two deviations possible at period 1. One, the worker accepts a contract. Two, the worker plays L but exerts no effort. The first deviation is not optimal as long as $\frac{V-1}{1-\delta} - R_w > 0$ i.e. as long as $V > 1 + R_w(1-\delta)$. The second deviation is not optimal if:

$$V - 1 - R_w + \delta\frac{V-1}{1-\delta} > V - R_w + \delta(\beta\frac{V-1}{1-\delta} + (1-\beta)\frac{\lambda_b\beta V}{1-\delta})$$
$$\Leftrightarrow \frac{\delta(1-\beta)}{1-\delta}[V(1-\beta\lambda_b) - 1] > 1$$
$$\Leftrightarrow V > \frac{1-\delta\beta}{\delta(1-\beta)(1-\beta\lambda_b)}$$

Now it follows that if $V > \frac{1-\delta\beta}{\delta(1-\beta)(1-\beta\lambda_b)}$ then the second deviation is not optimal as well. Under the above conditions, it is clear that the good type worker will exert full effort at any time after $t = 1$ as well. What if the reputation of the worker fell to zero (like after a failure)? The prescribed strategy requires the worker to put in zero effort. Since the worker cannot build reputation after a failure, it is pointless to put in effort. So this is optimal as well.

Next, consider the optimality of worker type B's strategy. Can the worker deviate profitably in period one? There are two deviations possible at period 1. One, the worker plays L. Two, the worker accepts a contract but exerts full effort. The latter deviation is not optimal since the principal offers no reward for success. For the former deviation, the bad type worker may put in full effort or no effort in period one after playing L:

$$\text{Payoff from e=1} = V - R_w - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)]$$
$$\text{Payoff from e=0} = V - R_w + \delta[\beta\lambda_b PDV_B(1) + (1-\beta\lambda_b)PDV_B(0)]$$

where

$$PDV_B(1) = V - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)]$$
$$PDV_B(0) = \frac{\lambda_b\beta V}{1-\delta}$$

Thus, $PDV_B(1) = \frac{V-1+\delta\beta(1-\lambda_b)PDV_B(0)}{1-\delta(\beta\lambda_b+(1-\beta))} = \frac{V-1+\delta\beta(1-\lambda_b)(\frac{\lambda_b\beta V}{1-\delta})}{1-\delta(\beta\lambda_b+(1-\beta))}$

Payoff from full effort is more than payoff from zero effort if:

$$\delta(1-\beta)[PDV_B(1) - PDV_B(0)] > 1$$
$$\Leftrightarrow \frac{\delta(1-\beta)}{1-\delta}[\frac{(V-1)(1-\delta) + \delta\beta(1-\lambda_b)\lambda_b\beta V}{1-\delta(\beta\lambda_b + (1-\beta))} - \lambda_b\beta V] > 1$$
$$\Leftrightarrow [\frac{\delta(1-\beta)}{1-\delta(\beta\lambda_b+(1-\beta))}][V(1-\lambda_b\beta) - 1] > 1$$
$$\Leftrightarrow V > \frac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1-\beta\lambda_b)}$$

Note that this is higher than the cut off needed to make the good type worker exert full effort. This is because the returns to effort are lower for the bad type worker. It is easy to show that if $V > \frac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1\beta\lambda_b)}$ then the it is optimal for the bad type worker to stick to the equilibrium strategy and exert full effort after playing L (till he fails). Next, we show that the B type worker will not deviate and play L in period one. It is sufficient to show that playing L is not individually rational for the bad type worker. Thus, we want:

$$V - R_w - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)] < 0$$

Note that the good type worker's payoff from playing L is: $V - R_w - 1 + \delta(\frac{V-1}{1-\delta})$. Pick $V > \frac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1-\beta\lambda_b)}$. It is easy to check that $max\{PDV_B(1), PDV_B(0)\} < \frac{V-1}{1-\delta}$ (because the good worker always succeeds after full effort whereas the bad worker may fail, the good worker has a higher future expected payoff). Thus, given V, we can find an R_w such that the following holds:

$$V - R_w - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)] < 0 < V - R_w - 1 + \delta(\frac{V-1}{1-\delta})$$

So, if $V > \frac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1-\beta\lambda_b)}$ and $R_w \in (V - 1 + \delta[(\beta\lambda_b + (1-\beta))PDV_B(1) + (1 - (\beta\lambda_b + (1-\beta)))PDV_B(0)], V - 1 + \delta(\frac{V-1}{1-\delta}))$, then we have that the strategy of the good and bad type worker is optimal.

Finally, can the principal do better than offer a zero wage contract? In any period after the first one, the only reason a principal may wish to offer a higher wage contract is to extract full effort[43]. We will show that if β is high enough then regardless of the worker's type, this is not optimal for the principal.

It is simple to show that the principal will always prefer (weakly at least) a contract which does not reward failure. For a worker of any type to put in full effort, the lowest wage contract required is $\{\frac{1}{1-\beta}, 0\}$. If the worker's reputation is p_t and $p_t \approx 0$ then:

$$\text{Period payoff for principal with contract } \{\tfrac{1}{1-\beta}, 0\} > \text{Period payoff for principal with contract } \{0,0\}$$
$$\Leftrightarrow (\beta\lambda_b + 1 - \beta)(V - \frac{1}{1-\beta}) > \beta\lambda_b V \Leftrightarrow V > \frac{\beta\lambda_b + 1 - \beta}{(1-\beta)^2}$$

Similarly, if the worker's reputation is p_t and $p_t \approx 1$ then:

$$\text{Period payoff for principal with contract } \{\tfrac{1}{1-\beta}, 0\} > \text{Period payoff for principal with contract } \{0,0\}$$
$$\Leftrightarrow (V - \frac{1}{1-\beta}) > \beta V \Leftrightarrow V > \frac{1}{(1-\beta)^2}$$

Thus, if $V < \frac{\beta\lambda_b + 1 - \beta}{(1-\beta)^2}$, then for all p_t, the principal will never find it optimal to extract effort and will therefore always offer a zero wage contract. Now, there exists a β' such that if $\beta > \beta'$ then there exists a V such that $\frac{1-\delta\beta\lambda_b}{\delta(1-\beta)(1-\beta\lambda_b)} < V < \frac{\beta\lambda_b + 1 - \beta}{(1-\beta)^2}$.

Finally, can the principal offer a higher wage contract in period one? In this case the principal may offer higher wage to attract the good type worker. However, just as we have proved before, there exists a p' such that if $p_g < p'$ then the principal will not find it optimal to offer a higher wage to attract that good type worker when the expected price from the market is low (due to low p_g). □

[43] Once the worker has formed a spinoff, in any subsequent period the worker's reputation is either 1 or zero. The principal can never offer the worker a contract which is incentive compatible for the worker to accept and profitable for the principle to offer. See proof of proposition 4.

Corollary 3. *If the conditions in the above proposition hold then the separating equilibrium defined above is the highest effort equilibrium.*

Proof. In the equilibrium above, if the worker is good type then the worker will always exert full effort, and if the worker is bad type then the worker will never put in any effort. Also, under the conditions required in the above proposition, the bad type worker does not find it individually rational to play L. Therefore, to find a higher effort equilibrium we will need to find an equilibrium in which the bad type worker exerts effort after having accepted a contract. However, irrespective of the worker's reputation, since $V < \frac{\beta\lambda_b+1-\beta}{(1-\beta)^2}$, the principal never finds it optimal to extract effort with higher pay. □