Reorganizations

*** Job Market Paper ***

Enrique Ide*

1st November, 2019

Abstract

We study a dynamic relationship in which a principal chooses the timing of reorganizations but delegates implementation to an agent. The implementation process requires front-loaded effort and time to yield results. There is no asymmetric information, but the agent’s effort is not verifiable. The principal, moreover, cannot commit to a reorganization policy in advance. The equilibrium is unique and inefficient. Furthermore, compared to the first-best, the organization waits too little for new reorganizations to yield results, but retains the status quo longer when successful reorganizations lead to profitable new business. We discuss how these results might shed light on two seemingly contradictory perceptions commonly held about the frequency of reorganizations.

Keywords: Reorganizations, Strategic Change, Organizational Economics.

JEL classifications: D23, L23, M11

*Ide: Graduate School of Business, Stanford University, 655 Knight Way, Stanford, CA 94305 (email: eide@stanford.edu). I am deeply grateful to my advisor, Andy Skrzypacz, and committee members, Mike Ostrovsky and Ed Lazear for countless hours of discussion and continuous support. I also thank Nano Barahona, Jeremy Bulow, Nicolas Lambert, Ivan Marinovic, Juan-Pablo Montero, Cristóbal Otero, Sebastián Otero, Andrés Perlorth, Garth Saloner, and Akhil Vohra for their valuable comments and discussions.
1 Introduction

Organizations must be able to change, to reorganize themselves, to cope with an ever-changing environment. Reorganizations, however, are no free lunch: they require developing new processes and routines without any guarantee that the organization will succeed under a new, untried approach. An important but mostly unexplored question in organizational economics is whether organizations can efficiently navigate the tradeoffs that reorganizations involve (Roberts and Saloner, 2013; Garicano and Rayo, 2016).\footnote{This whole area of the meaning of strategic change, its frequency, and nature has not been the subject of much formal economic analysis.” Roberts and Saloner (2013, p. 812)} In other words, are organizations able to change efficiently and in a timely manner?\footnote{We use the term “change” instead of “adapt” to distinguish ourselves from the literature of “adaptive organizations,” e.g., Dessein and Santos (2006). That literature analyzes how organizations solve the tradeoff between coordination and local adaptation. This paper analyzes instead whether organizations can adapt to global or disruptive changes in the environment.}

This question has long been debated among management academics and practitioners alike. Some argue, for instance, that organizations do not change enough, and their inability to change explains many of the most prominent firm failures in history:

Each of these failures [referring to Kodak, Sears, and Firestone, among others] is unique in its details but the same in that each represents a failure in leadership. Every company described was at one point a great success and had the resources and capabilities needed to continue to be successful. The failure was that [...] the leaders of these companies were rigid in one way or another—unable or unwilling to sense new opportunities and to reconfigure the firm’s assets in ways that permitted the company to continue to survive and prosper.\footnote{O’Reilly and Tushman (2016, p. 12)}

Others, however, warn that organizations sometimes reorganize too much,\footnote{Indeed, reorganizations appear to be a relatively common phenomenon. For instance, a 2013 McKinsey survey found that 82% of executives had experienced a reorganization in their current company; 70% also reported that the most recent reorganization had taken place in the previous two years (Keller and Meaney, 2018).} leading to subpar performance\footnote{In the same 2013 McKinsey survey, only 23% of executives reported that their last reorganization had met its objectives and improved performance. Strikingly, an additional 10% stated that their last reorganization had impaired their organization’s performance. The idea that the firms reorganize too much is also consistent with Girod and Whittington (2017), who studied 50 large U.S. corporations between 1985 and 2004 and found that major reorganizations decreased profits by 2.6%, on average (a $57.1 million decline in profits, in U.S. dollars).} and also, in extreme cases, firm failure:

Given the turmoil and tension that major restructurings cause, they shouldn’t happen too often [...] When organizations try out too many structures too fast or continually bounce back and forth between old archetypes and new ones, confusion reigns and engagement, innovation, and performance falter [...] Some companies engaged in such elongated, persistent change cycles that they reconfigured themselves out of existence. Think Texaco, Digital Equipment Corporation, and McDonnell Douglas.\footnote{Girod and Karim (2017, pp. 130-131)}
In this paper, we propose a unified theory that reconciles these two seemingly contradictory perceptions. We develop a fully rational dynamic model of reorganizations that explains why the same firm will at some times reorganize too much and at other times reorganize too little. The model, moreover, provides a new, rational explanation as to why employees and middle managers often complain about organizational change.

In a nutshell, our theory relies on four key elements: (i) the organization’s leadership decides when a reorganization should take place; (ii) uncertainty exists as to whether the organization will succeed under a new approach; (iii) some reorganizations require middle managers and employees to front-load effort in an implementation process whose outcome takes time to bear fruit; and (iv) contracts are incomplete.

More precisely, we study an organization consisting of a principal (hereafter referred to as she or her) and an agent (he or him) who must pursue one of an infinite number of possible business opportunities to generate profits. Profits stemming from already tried opportunities decrease over time, forcing the organization to change periodically to stay profitable. The principal’s role is to decide when to switch from the current opportunity to a new one. When she decides to do so, which is irreversible, we say the firm has reorganized.

Changing business opportunities, however, is not without risk. First, not all opportunities have the potential to deliver profits, and whether a particular opportunity can become profitable is not known by the players. Second, new opportunities sometimes require the organization to undertake a costly, lengthy implementation process. This process is undertaken by the agent and requires effort to be exerted up-front in the form of a one-time, discrete implementation cost, \( F > 0 \). Its outcome, moreover, takes time to yield results: once the agent implements a new opportunity, and conditional on the opportunity’s having potential to become profitable, the firm starts generating profits at the arrival of a breakthrough that occurs at an exponentially distributed random time.

We assume the principal cannot commit to a reorganization policy in advance. Players hold common priors and all their actions are assumed to be perfectly observable, so there is no asymmetric information. The agent’s implementation efforts, however, are not verifiable. Hence, to incentivize the agent to implement a new opportunity, the principal offers the agent a bonus contingent on a breakthrough for successful implementation.

Our main results are the following: The equilibrium reorganization policy is unique and inefficient. Furthermore, compared to the first-best, the organization waits too little for new reorganizations to yield results, but retains the status quo longer when successful reorganizations lead to profitable new business. That is, reorganizational hyper-action describes the organization’s behavior during the transition between two different businesses, while reorganizational inaction describes its behavior once the transition is complete and the exploitation phase begins.
To understand these results, begin by noting that if the agent’s efforts were verifiable, the principal would incentivize the agent to implement a new opportunity by offering to pay him exactly $F$. The latter implies that (1) the principal ends up being the full residual claimant of the opportunity’s potential profits and (2) that the equilibrium in this case coincides with the first-best.

When the agent’s implementation decision is not verifiable, however, the principal cannot incentivize the agent to implement a new opportunity and simultaneously position herself as the full residual claimant of future profits. She now needs to pay the agent the promised bonus in case of a breakthrough. The principal has, then, incentives to reorganize sooner than in the first-best, thus explaining the firm’s hyperactive behavior. The latter also explains why the agent dislikes organizational change: when effort must be front-loaded and contracts are incomplete, the agent acts with an expectation of future benefits, which are curtailed when the organization changes direction.

The problem is then compounded by the fact that, anticipating the principal’s incentives, the agent will require a higher bonus in the first place, which, in turn, induces the principal to wait even less. As the implementation cost $F$ increases, this problem becomes increasingly severe and eventually unravels, in which case there is no bonus capable of inducing the agent to implement a new opportunity. When the latter happens, we say the firm has fallen victim to a reorganization trap, as the principal has no other choice but to continually reorganize the firm until an opportunity arises that does not require any implementation at all.

Reorganizational inaction during the exploitation phases, in turn, is a reaction to reorganizational hyper-action during the transition phases. Indeed, given how particularly tumultuous transitions are, the attractiveness of embarking on a reorganization when the firm is exploiting a profitable opportunity is lower in equilibrium, inducing the principal to exploit profitable opportunities longer compared to the first-best. Hence, even though reorganizational inaction and hyper-action appear to be, at first glance, contradictory, they are, in fact, opposite sides of the same coin.

Our results thus imply that both sides of the reorganization debate we presented above have some merit: the issue was that each position was describing different phases of the reorganization cycle of the firm (exploitation v. transitions). It also implies that if we analyzed the reorganization behavior of this organization without taking into account the incentive frictions, we would sometimes conclude that it is reorganizing too frequently and other times that it is not reorganizing frequently enough. This result is consistent with Hambrick and D’Aveni (1988), who analyzed 57 large bankruptcies and found that both reorganizational inaction and hyper-action describe firms’ behavior in their years before failure.

We then extend our model in two directions. First, we consider whether complementing the agent’s bonus with additional contractual instruments might help the principal to achieve more
efficient outcomes. We analyze, for instance, whether compensating the agent in the event of a reorganization (with the use of a severance package, for example), could help to achieve the first-best. The answer is negative, and the reason is simple. Even though severance payments allow the principal to pre-commit to not reorganizing too soon, these payments also create moral hazard on the side of the agent. We also discuss what types of contracts can actually achieve the first-best and why they are unlikely to emerge in practice.

In the second extension, we address the following valid criticism of our baseline model: in practice, we do not always observe big lump-sum bonuses being offered by an organization to employees to embrace change. We show, however, that the lump-sum nature of the agent’s compensation is not essential for our main results to hold. What is vital is the combination of front-loaded effort and incomplete contracting.

The rest of this paper is organized as follows: After reviewing the existing literature, we present our model and analyze the first-best/complete-contract benchmark in Section 2. Section 3 characterizes the equilibrium of the game. Sections 4 and 5 consider the two extensions just described, and Section 6 concludes.

1.1 Literature Review

To the best of our knowledge, this is the first dynamic and fully rational model studying reorganizations and strategic change. This paper, however, borrows from several strands of the literature.

A. Technological Adoption with Switchover Disruptions

First, our model is closely related to the literature of technological adoption in the presence of switchover disruptions. Parente (1994), Jovanovic and Nyarko (1996), and Klenow (1998) study technological adoption when a single agent accumulates expertise the longer it uses a particular technology. Any given technology, however, has bounded productivity, so to continue growing, the agent must continually adopt more advanced technologies. The cost of adopting new technologies, in turn, is the fact that expertise is only partially transferable among the different technologies.

While closely related to our paper, none of these other papers studies how incentive-related conflicts within the organization affect firms’ behavior when such tradeoffs are involved.

B. Motivation and Commitment

In our model, the incentive problem that arises is one of motivation and commitment: the fact that the principal cannot commit to a reorganization policy in advance makes motivating

---

7See also Schivardi and Schneider (2008) and Holmes, Levine and Schmitz (2012).
the agent more difficult and costly. Similar tradeoffs are considered by Rotemberg and Saloner (1994, 2000), and Almazan and Suarez (2003).

Rotemberg and Saloner (1994, 2000) study a model in which employees can exert effort to come up with ideas that will enhance the profitability of the firm. The upper management, however, cannot commit ex-ante to implement those ideas, making it hard to motivate employees in the first place. They show that the organization can ameliorate this commitment problem and become more innovative by focusing on a narrow set of activities. Almazan and Suarez (2003), in turn, argue that some degree of CEO entrenchment is optimal when the CEO can undertake actions that enhance the profitability of the firm but is concerned about being replaced if a superior CEO becomes available.

Even though the underlying incentive problem proves to be similar, three critical factors differentiate those papers from ours. First, the other two papers consider a static setting involving a single innovation/replacement. This paper, in contrast, allows for multiple reorganizations. Second, those other papers do not consider the possibility of switchover disruptions as this paper does. Multiple reorganizations and switchover disruptions are both crucial in explaining the presence of reorganizational inaction and hyper-action in our model. Third, the other papers differ from ours in terms of the phenomenon they try to explain. While they aim to explain why firms (i) engage in only a narrow set of activities or (ii) benefit from some degree of CEO entrenchment, this paper tries to explain the different patterns of reorganizational behavior observed in practice.

C. Vested Interests and Reorganizational Inaction

Our paper is also relates to Schaefer (1998) and Dow and Perotti (2010), who study organizational change in the presence of vested interests. In both their models, organizational change creates winners and losers in the organization. Winners, unfortunately, cannot compensate losers. Hence, employees have incentive to engage in harmful activities (e.g., politics or sabotage), to affect the new organizational form. Upper management might decide to not reorganize in the first place to avoid creating any incentive for employees to engage in such activities, resulting in reorganizational inaction.8

These two papers differ from ours in two critical ways. First, the inefficiency created by the presence of incomplete contracting is different. Most importantly, however, is the fact that those papers consider only a single reorganization. Thus, they can explain only reorganizational inaction but not reorganizational hyper-action.

D. Organizational Change in the Management Literature

8Reorganizational inaction can also emerge in models with relational contracts, e.g., Chassang (2010) and Li, Matouschek and Powell (2017).
Finally, this paper is related also to numerous papers studying disruption and organizational change in the management literature. Henderson (1993) studies the photolithographic alignment equipment industry, concluding that organizational factors are important for explaining the failure of many established firms to invest and adapt to radical innovations.

Tushman and Romanelli (1985) propose a “punctuated equilibrium” model of organizational change in which organizations evolve through long periods of stability disrupted by spurts of revolutionary change. Romanelli and Tushman (1994) further track the history of 25 minicomputer producers founded in the United States between 1967 and 1969, finding empirical support for that theory. The micro-founded rational model that we propose here is consistent with this “punctuated equilibrium” theory of change.

Hannan and Freeman (1989) argue that structural inertia enhances the performance of organizations by making them more reliable and accountable. Therefore, organizations designed to be immutable to small changes in the environment are more likely to survive the Darwinian process of market competition. A harmful by-product, however, is that such immutability makes organizations unable to adapt to disruptive change. Their model, however, explains only reorganizational inaction, not hyper-action. Nickerson and Zenger (2002), in turn, argue that firms engage in periodic reorganizations to “shake-up” the organization to avoid routines and processes becoming ossified.

2 A Model of Reorganizations

2.1 The Environment

Basics. — Time $t \in [0, \infty)$ is continuous and infinite. At every point in time, a firm must pursue one of an infinite number of possible business opportunities $z \in \mathbb{N}$. An opportunity in this context is defined as a particular configuration of assets and capabilities needed by an organization to generate profits. We denote by $Z_t$ the opportunity pursued by the firm at time $t$, where $Z_0 = 1$ is exogenous.

Business Opportunities. — Each opportunity $z \in \mathbb{N}$ can be of four different types, $\omega^z \in \{G, B, P_D, P_N\}$. Good opportunities ($\omega^z = G$) are implemented effortlessly by the organization and are profitable at the outset. Bad opportunities, or bombs ($\omega^z = B$), immediately lead to the firm’s demise when pursued, ending the game. Finally, there are two types of promising opportunities, $\omega^z = P_D$ and $\omega^z = P_N$, which do not generate profits initially but do not end the game. While $P_D$ opportunities can become profitable under appropriate circumstances explained below, $P_N$ opportunities cannot.
The type of opportunity \(z \in \mathbb{N}\) is never observed directly. The common prior is:

\[
\begin{align*}
P(\omega^z = G) &= p \\
P(\omega^z = B) &= 1 - p - q \\
P(\omega^z = P_D) &= q\bar{\mu} \\
P(\omega^z = P_N) &= q(1 - \bar{\mu})
\end{align*}
\]

where \(p, q, \text{ and } \bar{\mu}\) are strictly between 0 and 1, and \(1 - p - q > 0\). Furthermore, the types of two different opportunities \(z, z' \in \mathbb{N}\) with \(z \neq z'\), are independent of each other.

Once \(z\) is first pursued at time \(t\), it is observed whether: (i) \(z\) led to the firm’s demise and (ii) the firm is ready to generate profits with \(z\). Hence, once \(z\) is pursued, the following partition of its type-space is observed: \(\{G, B, \{P_D, P_N\}\}\). Observing \(P = \{P_D, P_N\}\) implies that there is uncertainty as to whether a promising opportunity can become profitable. Notice that, by Bayes’ Rule:

\[
P(\omega^z = P_D \mid \omega^z = \{P_D, P_N\}) = \bar{\mu}
\]

**Developing Capabilities.**— For a newly selected \(P_D\) opportunity to become profitable, the firm needs to incur a one-time, discrete implementation cost \(F > 0\) (and have some luck). \(F\) symbolizes the front-loaded effort incurred by part of the organization in redeploying assets and developing new capabilities. For example, it could represent the time and effort spent in (i) hiring new/different people (e.g., Oyer and Schaefer, 2011), (ii) changing processes and routines (e.g., Chassang, 2010), or (iii) acquiring new knowledge (e.g., Garicano, 2000).

The success of the implementation process is stochastic. It requires a single arrival of a Poisson process \(N_t^z\) with intensity \(\lambda > 0\) that runs as long as the firm continues to pursue \(z\). Hence, once \(F\) is incurred, and conditional on the firm not changing \(z\), the delay until opportunity \(z\) (with type \(P_D\)) starts generating profits follows an exponential distribution with parameter \(\lambda\).\(^9\) When a \(P_D\) opportunity becomes profitable, we say that the firm has developed the promising opportunity. Note that the firm cannot develop \(P_N\) opportunities; that is, even if the firm incurs \(F\) and waits forever, a \(P_N\) opportunity will never become profitable.

**Profits.**— Both \(G\) and \(P_D\) opportunities have the same profit potential. We assume, however, that once the firm starts generating profits using a particular opportunity, profits decrease over time. The aim is to capture the fact that competitors can progressively imitate the firm’s success, leading to an erosion in the profits an opportunity can provide. Formally, defining \(T_{Z_t}\) as the first time in which the firm generated profits with opportunity \(Z_t\), i.e.,

\(^9\)Results do not change if, instead of a one-time implementation cost \(F\), the development of \(P_D\) opportunities required continuous effort and the probability of a breakthrough was increasing in the stock of accumulated effort.
$T_Z = \inf\{s \leq t : Z_s = Z_t, [\omega^Z_s = G] \lor [\omega^Z_s = P_D, N^Z_s > 0]\}$, then

$$\Pi_t = \begin{cases} 
\Pi e^{-\eta(t-T_Z)} & \text{if } T_Z \leq t \\
0 & \text{otherwise} 
\end{cases}$$

where $\eta > 0$ is the rate of depreciation of profits.

### 2.2 The Organization

The firm in question comprises two players: a principal (referred to here as she or her, as noted earlier), and an agent (he or him). Both players are risk-neutral and discount future payoffs at a rate of $r > 0$.

**The Principal.**— The principal’s role is to decide when the firm should change the current business opportunity. When the principal decides to change the opportunity being pursued, we say she has reorganized the firm. If at time $t$ the principal decides to continue with the current opportunity $Z_t = z$, we denote this action as $R_t = 0$. If she decides to reorganize the firm instead, we denote this action as $R_t = 1$.

If the principal reorganizes at $t$, then the firm immediately moves to the new opportunity $Z_{t+} = z + 1 \in \mathbb{N}$. Moreover, whenever the principal reorganizes the firm, she also needs to stipulate the new contract $C \in \mathbb{R}$ that will govern her relationship with the agent while the organization pursues the newly selected opportunity (the agent’s compensation is described in more detail below). We denote by $T_R^t = \{s \leq t : R_s = 1\} \cup \{0\}$ the set of all times up to $t$, including $t$, at which a reorganization took place (notice that the firm’s birth is considered the “first reorganization”).

To avoid some technical details (see Appendix A), we assume that the principal cannot reorganize more than once within the same instant, implying that $(Z_{t+} - Z_t) \in \{0, 1\}$ for all $t \in [0, +\infty)$. Formally, the principal is forced to wait for a small but strictly positive $\Delta > 0$ between two consecutive reorganizations. For ease of exposition, in the main text we heuristically work in the limit $\Delta = 0$. In the online Appendix we show, however, that the unique equilibrium when $\Delta$ is small converges to the equilibrium we characterize next as $\Delta \to 0$.

**The Agent.**— The agent’s role is to implement the opportunities pursued by the organization. More precisely, when the principal decides to pursue a promising opportunity $P = \{P_D, P_N\}$, the agent can incur $F$ to implement the opportunity, which we denote by $I_t = 1$, in the hope of developing it into a profitable opportunity. He can also decide not to do so, which we denote by $I_t = 0$.\(^{10}\) The agent’s implementation decision is assumed to be observable but not verifiable.

\(^{10}\)In management jargon, the principal is the leader, choosing the direction of the firm. The agent, instead, is a manager executing the leader’s vision: “Management is ensuring that the trains run on time; leadership is about ensuring that they are headed to the right destination. Management is about execution; leadership is about
Beliefs.— Actions by all players are perfectly observable, so there is no asymmetric information. Denote by $\mu_t$ the common belief that the opportunity $Z_t = z$ currently being pursued is type $P_D$. It is immediately apparent that $\mu_t = 0$ if $z$ was originally revealed to be $G$ or $B$ upon selection. While if $z$ was revealed to be $P = \{P_D, P_L\}$ then: (i) $\mu_t = \bar{\mu}$ if the agent has not incurred $F$; (ii) $\mu_t = 1$ if the agent incurred $F$ at $s \leq t$ and the firm is generating strictly positive profits at $t$; and (iii) $\mu_t$ is equal to

$$\frac{\bar{\mu}}{\bar{\mu} + e^{\lambda(t-s)}(1-\bar{\mu})}$$

if the agent incurred $F$ at $s \leq t$, but $z$ has not yet delivered profits.

Intuitively, whenever opportunity $z$ is revealed to be of type $P = \{P_D, P_L\}$, players initially assign probability $\bar{\mu}$ that $\omega_z = P_D$. If the agent does not implement the opportunity, no new information arrives, so no updating takes place. If the agent does implements it and $z$ starts generating profits, then the agent developed $z$, implying that $\omega_z = P_D$, necessarily. Finally, if the agent implements $z$ but profits fail to materialize, $\omega_z = P_N$ becomes increasingly more likely and players become more pessimistic about the feasibility of transforming $z$ into a profitable business opportunity.

Contracts.— To give the agent an incentive to implement a promising opportunity, the principal offers him a contract. We assume that contracts are valid until the firm changes the current business opportunity. The logic behind this assumption is that changes in the “business strategy” of a firm usually involve significant changes in the work environment that are difficult to specify and contract ex-ante.\(^\text{12}\)

Moreover, as already mentioned, we assume that the agent’s implementation decision is not verifiable. Hence, to motivate the agent, the principal offers him a bonus $C \in \mathbb{R}$, paid conditionally on developing the opportunity (alternative compensation schemes are considered in sections 4 and 5). More precisely, the currently promised bonus is paid whenever the event \(\{\Pi_t > 0, \Pi_{t-} = 0, Z_t = Z_{t-}\}\) occurs. We refer to this event as a breakthrough and denote by \(T_C^t = \{s \leq t : \Pi_s > 0, \Pi_{s-} = 0, Z_s = Z_{s-}\}\) the set of all breakthrough times up to $t$, including $t$.

Timing.— At every $\tau \in T_R^\infty$ at which a reorganization takes place, the regular time stops, and there are three logically sequential dates denoted by $(\tau, 0)$, $(\tau, 1)$, and $(\tau, 2)$. At $(\tau, 0)$, the game ends if the new opportunity selected is $B$, in which case both players receive a final payoff normalized to zero. Otherwise, players observe $\Pi_\tau$, the profits of the new opportunity

\(^{11}\)Recall that $\mathbb{P}(\omega_z = P_D | \omega_z = \{P_D, P_N\}) = \bar{\mu}$, so $\mu_t$ is consistent with our previous notation.

\(^{12}\)Alternatively, we could assume that the principal hires a different agent after each reorganization. The Markov Perfect Equilibria we characterize have the same outcomes in both cases.
just selected. At $(\tau, 1)$, the principal chooses the new bonus $C_\tau \in \mathbb{R}$ that will govern her relationship with the agent while the organization pursues the new opportunity. Finally, at $(\tau, 2)$, given $\Pi_\tau$ and $C_\tau$, the agent decides whether to incur the implementation cost $F$ or not. Afterwards, the regular times resumes.

![Figure 1: Timing of the Game](image)

Note that in our model there are three distinct types of uncertainties: First, when the principal embarks on a new reorganization, players are unsure about the next opportunity’s type. Second, when the new opportunity proves to be $P = \{P_D, P_N\}$, there is uncertainty as to whether the opportunity can be developed. Third and finally, even if the agent incurs $F$ and the underlying opportunity is $P_D$ (so it can be developed), there is uncertainty about the time at which the opportunity will be developed.

Because players are uncertain about the next opportunity’s type, reorganizations are risky enterprises. Nonetheless, the principal could still decide to reorganize the firm for three reasons. First, a profitable opportunity pursued a long time ago will eventually become obsolete and deliver low profits. Second, the agent might refuse to implement a promising opportunity, forcing the principal to reorganize the firm. Third, even if the agent implements a promising opportunity, the organization might appear to be unsuccessful in developing it, implying a high likelihood that the underlying opportunity is type $P_N$.

**Strategies and Payoffs** — The history up to time $t$, $h^t$ consists of (i) all opportunities that have been pursued up to time $t$, $Z^t = \{ z \in \mathbb{N} : Z_s = z, s \leq t \}$, (ii) all previous reorganization decisions prior to and including $t$, $T^t_R$, (iii) all previous bonuses offered, and implementation decisions made at those reorganizations, $\{C_\tau, I_\tau\}_{\tau \in T^t_R}$, and (iv) past and current profits, $\{\Pi_s\}_{s=0}^t$.

A strategy for the principal consists of two mappings, $R_t : h^{t^-} \to \{0, 1\}$ and $C_\tau : h^{t^-} \cup \{\Pi_\tau\} \to \mathbb{R}$, for $\tau \in T^\infty_R$. $R_t(h^{t^-})$ stipulates for every $t$ in the regular time a reorganization decision based on the history prior to $t$. $C_\tau(h^{t^-} \cup \{\Pi_\tau\})$, in turn, stipulates for each time $\tau \in T^\infty_R$ at which a reorganization takes place, a bonus $C_\tau \in \mathbb{R}$ based on (i) the history prior to the reorganization, and (ii) the profits of the new opportunity just selected. The principal’s strategy

---

13 Restricting the agent’s implementation to be immediately upon selection of the new opportunity is without loss of generality. The Markov Perfect Equilibria we characterize have the same outcomes, as the Markov Perfect Equilibria of a game in which the agent can also choose the timing of his implementation.
then induces a piecewise-constant, right-continuous function $C_t$, stipulating the promised bonus to be paid if a breakthrough occurs at time $t$.

A strategy for the agent, in turn, is a mapping $i_\tau : h^\tau - \cup \{(\Pi_\tau, C_\tau)\} \to [0, 1]$, for $\tau \in T^\infty_R$. This stipulates the probability $i_\tau = \mathbb{P}(I_\tau = 1)$ that the agent will incur the implementation cost $F$ based on (i) the history prior to the reorganization, (ii) the profits of the new opportunity selected, and (iii) the new contract offered by the principal.\footnote{We could also allow the principal to mix whether to reorganize the firm or not. However, as shown in Section 3, the principal never randomizes this decision in equilibrium. Consequently, to simplify notation, we assume that the principal does not randomize her reorganization decisions.}

Players’ strategies $(R, C) = \langle \{R_t\}_{t \geq 0}, \{C_\tau\}_{\tau \in T^\infty_R} \rangle$ and $i = \{i_\tau\}_{\tau \in T^\infty_R}$ uniquely pin down the stochastic process governing the evolution of $Z_t, T^R_t, T^C_t, \Pi_t, \mu_t, C_t, \{I_\tau\}_{\tau \in T^\infty_R}$, and $\tau_B$, where $\tau_B$ is the time at which the first bad opportunity is selected and the game ends, i.e., $\tau_B = \inf\{t : Z_t = z, \omega^z = B\}$. The principal’s and the agent’s ex-ante expected payoffs at time 0, $v_0$ and $u_0$, respectively, are then given by:

$$v_0 = \mathbb{E}_0\left[\int_0^{\tau_B} \Pi_t e^{-rt} dt - \sum_{s \in T^\infty_C} C_s e^{-rs}\right]$$

$$u_0 = \mathbb{E}_0\left[\sum_{s \in T^\infty_C} C_s e^{-rs} - \sum_{\tau \in T^\infty_R} F e^{-r\tau} I_\tau\right]$$

**Equilibrium Concept**— We restrict attention to Markov Perfect Equilibria. The payoff-relevant history for the principal at time $t$, $h^{P_t}$, where $t$ belongs to the regular time, is given by (i) $Z_t$, the current opportunity being pursued, (ii) $\Pi_t$, the firm’s current profits, (iii) $\mu_t$, the common belief that $\omega^{Z_t} = P_D$, and (iv) $(C_{\bar{\tau}_t}, I_{\bar{\tau}_t})$, where $\bar{\tau}_t \equiv \max T^\infty_R$, the last bonus committed by the principal and the last implementation decision made by the agent. The payoff-relevant history for the principal at times $\tau \in T^\infty_R$, $h^{P_\tau}$, is given by $\Pi_\tau$, the profits of the new opportunity just selected at $\tau$.

The payoff-relevant history for the agent at time $\tau \in T^\infty_R$, $h^{A_\tau}$, in turn, is given by (i) $\Pi_\tau$, the profits of the new opportunity just selected at $\tau$, and (ii) $C_\tau$, the new bonus just offered by the principal at $\tau$.

A Markov Perfect Equilibrium (from hereon an equilibrium) is a profile of strategies $(R, C) = \langle \{R_t\}_{t \geq 0}, \{C_\tau\}_{\tau \in T^\infty_R} \rangle$ and $i = \{i_\tau\}_{\tau \in T^\infty_R}$ progressively measurable with respect to the payoff-relevant histories, that are a perfect equilibrium of the game (Fudenberg and Tirole, 1991).

### 2.3 The First-Best/Complete-Contract Benchmark

As a benchmark, consider first the case in which the agent’s implementation decision is verifiable. The principal can then incentivize the agent to implement an opportunity by offering

\footnote{That is, before observing whether $Z_0 = 1$ is of type $G, B$, or $P = \{P_D, P_N\}$.}
him exactly $F$ in exchange for his effort. The principal’s problem is then equivalent to that of a single decision-maker (DM) deciding both the reorganization and implementation policies $R = \{ R_t \}_{t \geq 0}$ and $i = \{ i_\tau \}_{\tau \in T_\infty}$. This section characterizes the solution to this problem, which we call the first-best/complete-contract benchmark, for any given $F$ as a function of the remaining parameters.

Let $w_0^* \in \mathbb{R}$ be the DM’s value at time 0 from following an optimal policy, before observing whether $Z_0 = 1$ is type $G$, $B$, or $P = \{ P_D, P_N \}$:

$$w_0^* = \max_{(R,i)} \mathbb{E}_0 \left[ \int_0^{T_B} \Pi_t e^{-rt} dt - \sum_{\tau \in T_\infty} F e^{-r\tau} I_\tau \right]$$

Clearly, $w_0^* > 0$, as there is a strictly positive probability that $Z_0 = 1$ is of type $G$ (i.e., $p > 0$). However, $w_0^* < \Pi / r$ as the firm never obtains more than $\Pi$ per unit of time, and there is a strictly positive probability that the next opportunity is of type $B$ (i.e., $1 - p - q > 0$).

An important property of the environment is that the types and profits of unexplored opportunities are independent of previous history. Thus, $w_0^*$ also represents the DM’s reorganization value, that is, her ex-ante (optimal) continuation value from engaging in a reorganization. Therefore, $w_0^*$ satisfies

$$w_0^* = p W_0^G(w_0^*) + q W_0^P(w_0^*)$$

where $W_0^G(w_0^*)$ and $W_0^P(w_0^*)$ are the DM’s continuation values immediately after a reorganization, if the new opportunity is type $G$ and $P$, respectively.\(^{16}\)

**Lemma 1.** For a given $F$, there exists a unique $w_0^* \in (0, \Pi / r)$ that satisfies $w_0^* = p W_0^G(w_0^*) + q W_0^P(w_0^*)$. Furthermore,

(i) If $p \geq \lambda \bar{\mu}(1 - q) / (r + \lambda \bar{\mu})$, then the DM does not implement promising opportunities if they arise after a reorganization.

(ii) If $p < \lambda \bar{\mu}(1 - q) / (r + \lambda \bar{\mu})$, then there exists a unique $\hat{F} \in (0, +\infty)$, such that:

a. If $F < \hat{F}$, the DM implements promising opportunities if they arise after a reorganization.

b. If $F \geq \hat{F}$, the DM does not implement promising opportunities if they arise after a reorganization.

**Proof.** See Appendix B.

Lemma 1 is illustrated in Figure 1, which depicts the DM’s reorganization value $w_0^*$ as a function of $F$ when $p < \lambda \bar{\mu}(1 - q) / (r + \lambda \bar{\mu})$. Intuitively, when the DM encounters a promising

\(^{16}\)Notice that $W_0^B(w_0^*) = 0$ always.
The figure depicts the DM’s reorganization value $w_0^*$ as a function of $F$ when $p < \lambda \mu (1 - q)/(r + \lambda \mu)$. If $F < \hat{F}$, the DM implements promising opportunities. Hence, $w_0^*(F)$ is strictly decreasing in $F$, as a higher $F$ makes implementing this type of opportunity more costly. If $F \geq \hat{F}$, the DM does not implement promising opportunities, preferring to reorganize the firm instead. Consequently, $w_0^*(F)$ is constant in $F$. Finally, as $p \to \lambda \mu (1 - q)/(r + \lambda \mu)$ then $\hat{F} \to 0$, so if $p$ is sufficiently high, the DM never implements promising opportunities, irrespective of the value of $F$.

opportunity after a reorganization, she has two options. On the one hand, she can implement it, hoping it will develop into a profitable opportunity. On the other hand, she can abandon the opportunity in the hope that the next opportunity will not require any implementation. While the first option has cost $F$, the cost of the second option is the risk that the next opportunity will be of type $B$, causing the demise of the firm.

Not surprisingly, Lemma 1 states that when $p$ is high, that is, when it is very likely that the next opportunity will be $G$, the DM prefers to gamble with the firm’s survival and embark on a new reorganization. When $p$ is low, the decision depends on the level of $F$: when $F$ is high, implementing promising opportunities is too costly, so a new reorganization continues to be optimal. When $F$ is low, the DM prefers to implement a promising opportunity rather than reorganize the firm, risking its demise.

To add interest to the principal-agent problem, in what follows we restrict attention to parameter values so that in the first-best, it is optimal for the firm to implement promising opportunities. This parameter restriction implies that the agent plays a nontrivial role in the
game.

**Assumption 1.** \( p < \lambda \bar{\mu}(1 - q)/(r + \lambda \bar{\mu}) \) and \( F < \hat{F} \).

The next proposition characterizes the DM’s optimal behavior in the first-best under this assumption:

**Proposition 1.** Suppose Assumption 1 holds. At every \( \tau \in T_{\bar{R}}^\infty \) at which a reorganization takes place, then for \( \phi_E^* > 0 \) and \( \phi_{DP}^* > 0 \), in the first-best we have:

- If \( Z_\tau \) is \( G \), the DM reorganizes again at \( \tau + \phi_E^* \).
- If \( Z_\tau \) is \( P = \{P_D, P_N\} \), the DM implements the opportunity. She then reorganizes again at \( \tau + \phi_{DP}^* \) if no breakthrough occurs; and reorganizes again at \( t + \phi_E^* \) if a breakthrough occurs at \( t \in [\tau, \tau + \phi_{DP}^*] \).

**Proof.** See Appendix B.

\[ \square \]

### 3 Reorganization Inaction and Hyper-action

#### 3.1 Preliminaries

Suppose now that the agent’s implementation decision is not verifiable, so the principal relies on a bonus that is paid contingent on a breakthrough to motivate the agent. Let strategies \( \langle R^*, C^* \rangle = \langle \{R^*_t\}_{t \geq 0}, \{C^*_\tau\}_{\tau \in T_{\bar{R}}^\infty} \rangle \) and \( i^* = \{i^*_\tau\}_{\tau \in T_{\bar{R}}^\infty} \) constitute an equilibrium of the game. Players’ ex-ante equilibrium payoffs at time 0 are then:

\[
\begin{align*}
v^*_0 &= \mathbb{E}_0 \left[ \int_0^{\tau_0^*} \Pi_t e^{-rt} dt - \sum_{s \in T_{CG}^\infty} C^*_s e^{-rs} \right] \\
u^*_0 &= \mathbb{E}_0 \left[ \sum_{s \in T_{CG}^\infty} C^*_s e^{-rs} - \sum_{\tau \in T_{CR}^\infty} Fe^{-r\tau} I^*_\tau \right]
\end{align*}
\]

Clearly, \( v^*_0 + u^*_0 \leq w^*_0 \), as the principal’s and the agent’s combined payoffs cannot be higher in equilibrium than the DM’s in the first-best. Furthermore, \( v^*_0 > 0 \), as the principal can always offer a bonus of zero, and there is a strictly positive probability that \( Z_0 = 1 \) is of type \( G \). Finally, \( u^*_0 \geq 0 \), as the agent always has the option to never develop any opportunity selected by the principal.

Note that because we are restricting attention to Markov strategies, equilibrium strategies do not depend on the history prior to the last reorganization. Furthermore, because the types and profits of unexplored opportunities are also independent of prior history, \( v^*_0 \) and \( u^*_0 \) are also

---

\(^{17}\)See Appendix B for the precise condition that determines \( \hat{F} \in (0, +\infty) \).
the principal’s and the agent’s equilibrium reorganization values, respectively. Thus, \((v_0^*, u_0^*)\) satisfies:

\[
\begin{align*}
    v_0^* &= pV_0^G(v_0^*, u_0^*) + qV_0^P(v_0^*, u_0^*) \\
    u_0^* &= pU_0^G(v_0^*, u_0^*) + qU_0^P(v_0^*, u_0^*)
\end{align*}
\]

where \(V_0^G(v_0^*, u_0^*)\) and \(U_0^G(v_0^*, u_0^*)\) are the principal’s and the agent’s equilibrium continuation values, respectively, immediately after a reorganization has taken place when the newly selected strategy is \(G\), while \(V_0^P(v_0^*, u_0^*)\) and \(U_0^P(v_0^*, u_0^*)\) are their equilibrium continuation values immediately after a reorganization when the newly selected strategy is type \(P = \{P_D, P_N\}\). We will exploit the recursive nature of the game in our characterization of the equilibrium.

### 3.2 Overview of the Equilibrium

For the sake of convenience, we begin with a brief overview of the equilibrium, aided by Figure 2, which builds upon Figure 1. The dashed line depicts the first-best reorganization value \(w_0^*\) as a function of \(F\). The solid line depicts the principal’s equilibrium reorganization value \(v_0^*\) as a function of \(F\). As we will show later, the agent’s reorganization value is always zero in equilibrium, \(u_0^* = 0\), so the difference between \(w_0^*\) and \(v_0^*\) captures the inefficiency of the equilibrium compared to the first-best.

Because \(F < \hat{F}\) (Assumption 1), the firm will always implement promising opportunities when the agent’s implementation decision is verifiable. With incomplete contracts, however, this result no longer holds. The reason is that when the agent is compensated for achieving a breakthrough, it is harder to motivate him in the shadow of reorganizations.

More precisely, the equilibrium is characterized by two cutoffs, \(F_-\) and \(F_+\), which delimit three regions: (i) an implementation region (in which the agent implements \(P\) opportunities with probability 1); (ii) a mixing region (in which the agent mixes between implementing these opportunities or not); and (iii) a reorganization trap region (in which the agent never implements \(P\) opportunities). Furthermore, the equilibrium is inefficient for all \(F \in (0, \hat{F})\) even though equilibrium implementation coincides with the first-best when \(F \in (0, F_-)\). The reason is that in equilibrium, the principal always waits less for a breakthrough than prescribed by the first-best.

The equilibrium is, therefore, inefficient as the organization changes more often than it should when transitioning between two business opportunities. Too frequent changes occur either because the agent implements promising opportunities but the principal reorganizes sooner than it should; or because the agent refuses to implement \(P\) opportunities, leaving the principal no choice but to reorganize hoping that the next opportunity is type \(G\). In summary, the inefficiency is a result of the firm’s exhibiting reorganizational hyper-action during the
transition between two business opportunities. Interestingly, this implies that the firm will also exhibit the opposite tendency, reorganizational inaction, during the exploitation phases. Indeed, given how exceptionally tumultuous transitions are, the attractiveness of embarking on a reorganization when the firm is exploiting a profitable opportunity is lower in equilibrium, inducing the principal to exploit profitable opportunities longer, compared to the first-best. Thus, our model implies that inaction and hyper-action are opposite sides of the same coin. It also implies that if we analyzed the reorganization behavior of this organization without taking into account the incentive frictions, we would sometimes conclude that it is reorganizing too frequently and other times that it is not reorganizing frequently enough.

The remainder of this section is organized as follows. First, we characterize the principal’s equilibrium reorganization behavior for a given pair of equilibrium reorganization values \((v_0^*, u_0^*)\), as a function of the last bonus committed by the principal and the last implementation decision made by the agent. Then, to develop intuition, we move on to show the existence of an equilibrium in which the agent never implements promising opportunities when \(F > F_+\). Finally, we provide a complete characterization of the equilibrium (including uniqueness) for a general \(F\).

Figure 2: Overview of the Equilibrium
3.3 Equilibrium Reorganization Behavior

Fix a $\tau \in T_\infty^R$ and a pair of equilibrium reorganization values $(v_0^*, u_0^*)$, and consider the principal’s reorganization problem immediately after $\tau$, i.e., at time $\tau^+$. Suppose first that the new opportunity selected at $\tau$, $Z_\tau = z$, is type $G$, and the principal offered the bonus $C_\tau \in \mathbb{R}$ at $(\tau, 1)$. The fact that $z$ is $G$ has two implications. First, the agent’s implementation is irrelevant. Second, the promised bonus cannot be paid while the firm pursues $z$, as a breakthrough is a zero probability event.

It then follows that the principal’s problem at $\tau^+$ is to decide how long to exploit this $G$ opportunity, $\varphi_{EG} \geq 0$ (where $E$ stands for “exploit”), before reorganizing the firm again:

$$\max_{\varphi_{EG} \geq 0} \left\{ \int_{\tau}^{\tau + \varphi_{EG}} \Pi e^{-(r + \eta)(t-\tau)} dt + v_0^* e^{-r\varphi_{EG}} \right\} (1)$$

where $\varphi_{EG} = +\infty$ if the principal pursues this opportunity forever. Since the agent does not play during the interim between two reorganizations, the solution to this problem is time-consistent. The latter result, combined with the fact that profits evolve deterministically through time, allows us to maximize (1) directly.

The optimum then involves $\varphi_{EG}^*(v_0^*) = \eta^{-1} \ln(\Pi/rv_0^*)$, implying that the principal reorganizes sooner (i.e., $\varphi_{EG}^*(v_0^*)$ is lower) the higher (1) the depreciation rates of profits $\eta$, (2) the discount rate $r$, and (3) the reorganization value $v_0^*$ relative to $\Pi$. We then have that her continuation value at $\tau^+$ in this case is $E_G(v_0^*)$, where

$$E_G(v_0^*) = \int_{\tau}^{\tau + \varphi_{EG}^*(v_0^*)} \Pi e^{-(r + \eta)(t-\tau)} dt + v_0^* e^{-r\varphi_{EG}^*(v_0^*)}$$

With regard to the agent, since he receives no payment until the next reorganization, his continuation value at $\tau^+$, when $Z_\tau = z$ is type $G$, is equal to $u_0^* e^{-r\varphi_E(v_0^*)}$.

Consider now the principal’s problem at $\tau^+$, when $Z_\tau = z$ is revealed to be $P = \{P_D, P_N\}$, instead. Let $\bar{V}_0^P(v_0^*, u_0^*, C_\tau, I_\tau)$ and $\bar{U}_0^P(v_0^*, u_0^*, C_\tau, I_\tau)$ be players’ continuation values immediately after a reorganization (i.e., at $\tau^+$), when $Z_\tau = P = \{P_D, P_N\}$, the principal offered $C_\tau$ at $(\tau, 1)$, and the agent made implementation decision $I_\tau$ at $(\tau, 2)$.$^{18}$

If the agent does not implement the opportunity, then the principal will reorganize immediately. The reason is that the firm will never generate profits with $z$, and the principal’s equilibrium reorganization value $v_0^*$ is strictly positive. Hence, $\bar{V}_0^P(v_0^*, u_0^*, C_\tau, 0) = v_0^*$ and $\bar{U}_0^P(v_0^*, u_0^*, C_\tau, 0) = u_0^*$.

If the agent, in contrast, implements the opportunity at $\tau$, then at $\tau^+$ the principal must decide how long to (i) wait for a breakthrough, $\varphi_{DP} \geq 0$ (where $D$ stands for “develop”), and (ii) exploit the opportunity if it is developed, $\varphi_{EP} \geq 0$.

$^{18}$Consequently, $V_0^P(v_0^*, u_0^*) = \bar{V}_0^P(v_0^*, u_0^*, C_\tau^*, I_\tau^*)$ and $U_0^P(v_0^*, u_0^*) = \bar{U}_0^P(v_0^*, u_0^*, C_\tau^*, I_\tau^*)$
When the agent implements the opportunity at \(\tau\), the instantaneous probability of a breakthrough at \(t \geq \tau\), conditional on no breakthroughs between \(\tau\) and \(t\), is \(\lambda \mu_t\), where:

\[
\mu_t = \frac{\bar{\mu}}{\bar{\mu} + e^{\lambda(t-\tau)}(1 - \bar{\mu})}
\]  

Moreover, if the first breakthrough since \(\tau\) occurs at \(t\), the principal obtains \(E_P(v_0^*) - C_\tau\), where

\[
E_P(v_0^*) \equiv \max_{\varphi \geq 0} \left\{ \int_{\tau}^{t+\varphi} \Pi e^{-(r+\eta)(s-t)} ds + v_0^* e^{-r\varphi} \right\}
\]

Finally, because the probability that a breakthrough has not occurred between \(\tau\) and \(t\) is \(e^{-\int_{\tau}^{t} \lambda \mu_s ds}\), it then follows that at \(\tau^+\) the principal solves

\[
\max_{\varphi \geq 0} \left\{ \int_{\tau}^{T^+\varphi} \lambda \mu_t (E_P(v_0^*) - C_\tau) e^{-\int_{\tau}^{t}(\lambda \mu_s + r) ds} dt + v_0^* e^{-r\varphi} \right\}
\]

As before, because the agent does not play between reorganizations the solution to this problem is time-consistent. Furthermore, since profits and beliefs evolve deterministically over time, we can maximize this problem directly.

Clearly, it is optimal to set \(\varphi^*_{EP}(v_0^*) = \eta^{-1} \ln(\Pi/rv_0^*)\). Thus, the principal will exploit for the same amount of time a \(G\) opportunity and a \(P_D\) opportunity that is successfully developed, i.e., \(\varphi^*_{EG}(v_0^*) = \varphi^*_{EP}(v_0^*) \equiv \varphi^*_{E}(v_0^*)\), where

\[
\varphi^*_{E}(v_0^*) = \eta^{-1} \ln \left( \frac{\Pi}{rv_0^*} \right)
\]

This also implies that the principal’s continuation value of developing a promising opportunity, after committed payments are made, is the same as the continuation value of selecting a \(G\) opportunity for the first time:

\[
E_G(v_0^*) = E_P(v_0^*) = \frac{\Pi}{r + \eta} + \left( \frac{\eta}{r + \eta} \right) v_0^* e^{-r\varphi_{E}(v_0^*)} \equiv E(v_0^*)
\]

The same applies for the agent: his continuation value of developing a promising opportunity before committed payments is \(u_0^* e^{-r\varphi_{E}(v_0^*)}\).

Problem (3) can then be written as:

\[
\max_{\varphi \geq 0} \left\{ \int_{\tau}^{T^+\varphi} \lambda \mu_t (E(v_0^*) - C_\tau) e^{-\int_{\tau}^{t}(\lambda \mu_s + r) ds} dt + v_0^* e^{-r\varphi} \right\}
\]

Assuming an interior solution, in the optimum we have:

\[
\mu_{T^+\varphi_{DP}} = \frac{rv_0^*}{\lambda (E(v_0^*) - C_\tau - v_0^*)} \equiv \psi_e(v_0^*, C_\tau)
\]
so the principal’s behavior involves a cutoff strategy: wait for a breakthrough if $\mu_t > \psi_e(v_0^*, C_\tau)$, and reorganize otherwise. Intuitively, the principal is willing to wait as long as she remains sufficiently optimistic that a breakthrough can occur. The cutoff belief $\psi_e(v_0^*, C_\tau)$ is decreasing in $E(v_0^*) - C_\tau$ and increasing in $v_0^*$ (keeping $E(v_0^*)$ constant), so the principal waits longer when the value of a profitable opportunity, net of committed payments, is high relative to the value of a reorganization.

Using (2) and (5), we can recover the total amount of time the principal will optimally wait for a breakthrough from the moment the opportunity is implemented at $\tau$:

$$
\varphi_{DP}^*(v_0^*, C_\tau) = \lambda^{-1} \ln \left( \frac{\Omega(\psi_e(v_0^*, C_\tau))}{\Omega(\bar{\mu})} \right)
$$

where $\Omega(x) = (1 - x)/x$. Letting $\psi_e \equiv \psi_e(v_0^*, C_\tau)$, we then have that:

$$
\bar{V}_0^P(v_0^*, u_0^*, C_\tau, 1) = \int_\tau^{r+\varphi_{DP}^*(v_0^*, C_\tau)} \lambda \mu_t (E(v_0^*) - C_\tau) e^{-\int_r^{\tau} (\lambda \mu_s + r) ds} dt + v_0^* e^{-\int_r^{r+\varphi_{DP}^*(v_0^*, C_\tau)} (\lambda \mu_t + r) dt}
$$

$$
\bar{U}_0^P(v_0^*, u_0^*, C_\tau, 1) = \int_\tau^{r+\varphi_{DP}^*(v_0^*, C_\tau)} \lambda \mu_t (C_\tau + u_0^* e^{-r \varphi_E(v_0^*)}) e^{-\int_r^{\tau} (\lambda \mu_s + r) ds} dt + u_0^* e^{-\int_r^{r+\varphi_{DP}^*(v_0^*, C_\tau)} (\lambda \mu_t + r) dt}
$$

which can be written as:

$$
\bar{V}_0^P(v_0^*, u_0^*, C_\tau, 1) =
\begin{cases}
\frac{\lambda \bar{\mu} (E(v_0^*) - C_\tau)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \bar{x}} \right] & \text{if } \bar{\mu} > \psi_e \\
\frac{\lambda \bar{\mu} (C_\tau + u_0^*) e^{-r \varphi_E(v_0^*)}}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \bar{x}} \right] & \text{if } \bar{\mu} \leq \psi_e
\end{cases}
$$

(7)

$$
\bar{U}_0^P(v_0^*, u_0^*, C_\tau, 1) =
\begin{cases}
\frac{\lambda \bar{\mu} (E(v_0^*) - C_\tau)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \bar{x}} \right] & \text{if } \bar{\mu} > \psi_e \\
\frac{\lambda \bar{\mu} (C_\tau + u_0^*) e^{-r \varphi_E(v_0^*)}}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \bar{x}} \right] & \text{if } \bar{\mu} \leq \psi_e
\end{cases}
$$

(8)

We summarize the previous discussion in the following Lemma:

**Lemma 2.** Fix a $\tau \in T_\infty^R$ and a pair of equilibrium reorganization values $(v_0^*, u_0^*)$, and suppose that at $(\tau, 1)$ the principal offers the bonus $C_\tau$. Then, for $\varphi_{EP}^*(v_0^*)$ defined by (4) and $\varphi_{DP}^*(v_0^*, C_\tau)$ defined by (6), we have:

- If $Z_\tau = G$, the principal reorganizes again at $\tau + \varphi_{EP}^*(v_0^*)$. The principal’s and the agent’s continuation values at $\tau^+$ are then $E(v_0^*)$ and $u_0^* e^{-r \varphi_E(v_0^*)}$, respectively.
- If $Z_\tau = P = \{P_D, P_N\}$ and the agent does not implement the opportunity, the principal reorganizes immediately again. The principal’s and the agent’s continuation values at $\tau^+$ are then $v_0^*$ and $u_0^*$, respectively.
- If $Z_\tau = P = \{P_D, P_N\}$ and the agent implements the opportunity, the principal reorganizes...
again at $\tau + \varphi_{DP}^*(v_0^*, C_\tau)$ if no breakthrough occurs; and reorganizes again at $t + \varphi_{E}^*(v_0^*)$ if a breakthrough occurs at $t \in [\tau, \tau + \varphi_{DP}^*(v_0^*, C_\tau)]$. The principal’s and the agent’s continuation values at $\tau^+$ are $\tilde{V}_P^0(v_0^*, u_0^*, C_\tau, 1)$ and $\tilde{U}_P^0(v_0^*, u_0^*, C_\tau, 1)$, respectively, as given by (7) and (8).

### 3.4 Reorganization Traps

We are now in a position to characterize the equilibrium of the complete game. To develop intuition, we begin by showing the existence of an equilibrium in which the agent never implements promising opportunities when they arise. The reason is the principal’s inability to motivate the agent in the shadow of a reorganization.

**Candidate 1** (Reorganization Trap Equilibrium). At every $\tau \in T_R^\infty$, the principal offers $C_\tau^* = 0$ at $(\tau, 1)$, and the agent never incurs $F$ at $(\tau, 2)$. Furthermore,

- If $Z_\tau$ is $G$, the principal reorganizes again at $\tau + \varphi_{E}(v_0^*)$.
- If $Z_\tau$ is $P = \{P_D, P_N\}$ and the agent does not incur $F$, the principal reorganizes immediately.
- If $Z_\tau$ is $P = \{P_D, P_N\}$ and the agent incurs $F$, the principal reorganizes again at $\tau + \varphi_{DP}^*(v_0^*, 0)$ if no breakthrough occurs and reorganizes again at $t + \varphi_{E}(v_0^*)$ if a breakthrough occurs at $t \in [\tau, \tau + \varphi_{DP}^*(v_0^*, 0)]$.

The principal's equilibrium reorganization value $v_0^*$ is then equal to $v_0$, where $(1 - q)v_0 = pE(v_0)$, and the agent's equilibrium reorganization value is $u_0^* = 0$.

It is immediately apparent that the agent is playing his best response: given that the principal offers $C_\tau^* = 0$, the agent will never incur $F$ to implement an opportunity. This fact also implies that the agent’s reorganization value $u_0^*$ is equal to zero, as he never receives any payments on the path of play. Furthermore, conditional on $(v_0^* = v_0, u_0^* = 0, C_\tau^* = 0)$, the principal is also playing her “reorganization” best-response, as seen from Lemma 2. Finally, because on-path the principal obtains $E(v_0)$ every time $Z_\tau$ is $G$, and obtains $v_0$ every time $Z_\tau$ is $P = \{P_D, P_N\}$, the principal’s reorganization value $v_0^*$ is equal to $v_0$, where $(1 - q)v_0 = pE(v_0)$.

Hence, for Candidate 1 to be an equilibrium, we need only check to see whether the principal deviates from $C_\tau^* = 0$. Crucially, given that in the first-best implementing promising opportunities was optimal, why does the principal not deviate and incentivizes the agent to implement promising opportunities when they arise? The problem, as we now show, is that when $F$ is sufficiently high, no contract is capable of inducing the agent to undertake such action.

**Proposition 2.** There exists an $F_+ \in (0, \hat{F})$ such that, if $F > F_+$, then Candidate 1 is an equilibrium of the game.

**Proof.** See Appendix C.
To provide intuition, suppose that at some $\tau \in T_{\mathbb{R}}^\infty$, the principal deviates and offers $C'_\tau > 0$ at $(\tau, 1)$ after it is revealed that $Z_\tau$ is $P = \{P_D, P_N\}$. Since checking for “one-shot/reorganization” deviations is sufficient, assume further that the principal goes back to playing according to Candidate 1 after the next reorganization.

Clearly, the players’ reorganization values do not change. Hence, given $(v^*_0 = v_0, u^*_0 = 0)$ and the new contract $C'_\tau > 0$, we can use Lemma 2 to obtain the players’ continuation values after the principal deviates, as a function of the agent’s implementation decision. We then have that, if the agent does not implement the opportunity he gets $u^*_0 = 0$, while if he does implement it, he gets $\tilde{U}_0^P(v_0, 0, C'_\tau, 1) - F$, where:

$$\tilde{U}_0^P(v_0, 0, C'_\tau, 1) = \max \left\{ \frac{\lambda \bar{\mu} C'_\tau}{r + \lambda} \left[ 1 - \frac{\Omega(\bar{\mu})}{\Omega(\psi_e(v_0, C'_\tau))} \right]^{1+\frac{\tau}{r}}, 0 \right\}$$

and

$$\psi_e(v_0, C'_\tau) = \frac{r v_0}{\lambda (E(v_0) - C'_\tau - v_0)}$$

Not surprisingly, for the agent to implement a promising opportunity, the expected present value of $C'_\tau$ must be greater than or equal to the implementation cost $F$, i.e., $\tilde{U}_0^P(v_0, 0, C'_\tau, 1) \geq F$. The problem, however, is that the expected present value of $C'_\tau$ is non-monotonic in $C'_\tau$, implying that a higher bonus does not necessarily translate into stronger incentives for the agent (see Figure 3).

Figure 3: The Expected Present Value of $C'_\tau$
The expected present value of $C'_\tau$ is non-monotonic in $C'_\tau$ because an increase in $C'_\tau$ also increases the agent’s reorganization risk $\Omega(\tilde{\mu})/\Omega(\psi_0, (C'_\tau))^{1+\frac{\lambda}{\bar{\mu}}}$. That is, it increases the probability that the principal will reorganize the firm before a breakthrough, conditional on a breakthrough being possible, depriving the agent of an impending payment. An increase in $C'_\tau$ increases the agent’s reorganization risk because it makes reorganizing the firm relatively more attractive for the principal. The principal is therefore less willing to wait for a breakthrough.\textsuperscript{19}

The explanation above is incomplete, however. In particular, it does not address why the bonus $C'_\tau$ becomes a factor in the principal’s reorganization decision when contracts are incomplete, but not in the complete-contract benchmark. The key is that the principal is no longer the full residual claimant of profits stemming from promising opportunities. Indeed, when the agent’s implementation decision is verifiable, the principal/DM can incentivize the agent to implement a promising opportunity by offering a payment $F$ in exchange for his effort. This contract makes the principal/DM the full residual claimant of potential profits. In contrast, when the agent’s implementation decision is not verifiable, the principal is no longer the full residual claimant, as she now needs to pay the agent the promised bonus in case of a breakthrough.

Consequently, for a given reorganization value, the principal has incentive to reorganize sooner in this transition phase than the single DM would in the first-best once $F$ is incurred. The problem is then compounded by the fact that, anticipating the principal’s incentives, the agent will require a higher bonus in the first place, which, in turn, induces the principal to wait even less for the breakthrough to arrive. As Proposition 2 then states, if $F > F_+$, the problem unravels, as there is no bonus capable of inducing the agent to implement promising opportunities. When this is the case, we say that the firm has fallen victim to a reorganization trap, as the principal has no other choice but to reorganize the firm multiple times until a $G$ opportunity arrives.

Reorganization traps are obviously inefficient: because the agent is unwilling to implement promising opportunities, the principal is forced to reorganize whenever a newly selected opportunity turns out to be a promising opportunity. The first-best, in contrast, prescribes that the organization should try to develop these opportunities instead.

Finally, it is important to note that the wedge arising between the principal’s and the agent’s incentives appears only once the implementation cost $F$ is incurred. Hence, if she could, the principal would be better off committing to a reorganization policy in advance, as that would allow her to incentivize the agent in the most cost-efficient way.\textsuperscript{20} Thus, when dealing with reorganizations and incomplete contracts, the principal faces a classic time-inconsistency.

\textsuperscript{19} In fact, for $C'_\tau \geq \tilde{C}(\bar{v}_0) \equiv E(\bar{v}_0) - \bar{v}_0[1 + r/\bar{\mu}]$, the expected present value of $C'_\tau$ is actually zero, as the principal will reorganize immediately after the agent incurs $F$.

\textsuperscript{20} It is not difficult to prove that, under perfect commitment, the principal can implement the first-best and obtain the first-best payoff for herself.
Having understood the conflict that arises between the principal and the agent, we now characterize the equilibrium of the game for the entire parameter space.

3.5 Existence and Uniqueness of the Equilibrium for a General $F$

Take a $\tau \in T^\infty_R$ and consider the subsequent play for a given pair of equilibrium reorganization values, $(v^*_0, u^*_0)$. If $Z_\tau$ is type $G$, then we already have the equilibrium behavior in the ensuing subgame. Since no implementation is needed, no breakthrough is possible, and therefore any $C^*_\tau \in \mathbb{R}$ is best-response, as the bonus never gets paid. The agent, in turn, does not incur $F$, and the principal reorganizes again at $\tau + \varphi^*_E(v^*_0)$, as stated in Lemma 2. We then have that the players’ continuation values at $\tau$ are $V^G_0(v^*_0, u^*_0) = E(v^*_0)$ and $U^G_0(v^*_0, u^*_0) = u^*_0 e^{-\tau \varphi_E(v^*_0)}$. For future reference, we record this result in the following lemma:

**Lemma 3.** Fix a pair of equilibrium reorganization values, $(v^*_0, u^*_0)$. When at $\tau \in T^\infty_R$ the new opportunity selected $Z_\tau$ is $G$, the unique equilibrium of the ensuing subgame is as follows. The principal offers any $C^*_\tau \in \mathbb{R}$, the agent does not incur $F$, and the principal reorganizes again at time $\tau + \varphi^*_E(v^*_0)$.

**Proof.** Immediate from above. □

Now suppose instead that $Z_\tau$ is $P = \{P_D, P_N\}$. Consider first the agent’s implementation decision at $(\tau, 2)$ if the principal offers bonus $C_\tau$ at $(\tau, 1)$. According to Lemma 2, the agent receives a continuation value of $\bar{U}^P_0(v^*_0, u^*_0, C_\tau, 1) - F$ if he decides to implement the opportunity, and a continuation value of $u^*_0$ if he does not. Therefore, his optimal implementation decision, given $(v^*_0, u^*_0, C_\tau)$, is

$$i_\tau(v^*_0, u^*_0, C_\tau) = \begin{cases} 1 & \text{if } \bar{U}^P_0(v^*_0, u^*_0, C_\tau, 1) - F > u^*_0 \\ [0,1] & \text{if } \bar{U}^P_0(v^*_0, u^*_0, C_\tau, 1) - F = u^*_0 \\ 0 & \text{if } \bar{U}^P_0(v^*_0, u^*_0, C_\tau, 1) - F < u^*_0 \end{cases}$$

Examine now the principal’s contract design problem at $(\tau, 1)$. Suppose that, in equilibrium, the principal offers $C^*_\tau$ and the agent implements the opportunity with probability 1. In that case, the principal receives $\bar{V}^P_0(v^*_0, u^*_0, C_\tau, 1)$. But since $\bar{V}^P_0(v^*_0, u^*_0, C_\tau, 1)$ is strictly decreasing in $C_\tau$, the principal will never offer a $C^*_\tau$ such that $\bar{U}^P_0(v^*_0, u^*_0, C^*_\tau, 1) - F > u^*_0$; if that were the case, she could slightly decrease $C^*_\tau$, strictly increasing her own payoff, and still induce the agent to implement the opportunity with probability 1. Hence, in any equilibrium $\bar{U}^P_0(v^*_0, u^*_0, C^*_\tau, 1) - F \leq u^*_0$; that is, if the agent implements an opportunity, then he must be indifferent to implementing it or not. This fact has an important implication:

**Lemma 4.** The agent’s reorganization value is always zero in equilibrium, i.e., $u^*_0 = 0$. 

Proof. Given that, in equilibrium, \( \hat{U}_0^P(v_0^*, u_0^*, C_\tau^*, 1) - F \leq u_0^* \), then the agent’s continuation value at \( \tau \) when \( Z_\tau = P = \{ P_D, P_N \} \) is \( U_0^P(v_0^*, u_0^*) = \max \{ \hat{U}_0^P(v_0^*, u_0^*, C_\tau^*, 1) - F, u_0^* \} = v_0^* \). Since we also have that \( U_0^G(v_0^*, u_0^*) = u_0^*e^{-r\varphi_E(v_0^*)} \), and that \( u_0^* \) must satisfy \( u_0^* = pU_0^G(v_0^*, u_0^*) + qU_0^P(v_0^*, u_0^*) \), then \( u_0^*(1 - q) = pu_0^*e^{-r\varphi_E(v_0^*)} \) and therefore \( u_0^* = 0 \).

Because \( u_0^* = 0 \), we will omit, from here on, the dependency of the value functions in \( u_0^* \), e.g., \( V_0^G(v_0^*) = V_0^G(v_0^*, u_0^* = 0) \). Notice that, since \( u_0^* = 0 \) and \( v_0^* + u_0^* \leq w_0^* \), then \( v_0^* \leq w_0^* \). Furthermore, because the worst thing that could happen for the principal after a reorganization is to be forced to reorganize again, then \( v_0^* \geq pE(v_0^*) + qv_0^* \), or equivalently, \( v_0^* \geq v_0 \), where \( (1 - q)v_0 = pE(v_0) \). That is, from an ex-ante perspective, the principal can do no better than the first-best, but can do no worse than the reorganization trap equilibrium, either.

Now let us go back to the agent’s continuation value of implementing a promising opportunity when the principal offers an arbitrary bonus \( C_\tau \):

\[
\hat{U}_0^P(v_0^*, C_\tau, 1) = \max \left\{ \frac{\lambda \tilde{\mu} C_\tau}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\hat{\tilde{n}})}{\Omega(\psi(v_0^*, C_\tau))} \right)^{1+\frac{r}{\lambda}} \right], 0 \right\}
\]

For \( v_0^* \in [v_0, u_0^*] \), we then define:

\[
C^\dagger(v_0^*) = \arg \max_C \hat{U}_0^P(v_0^*, C, 1) \quad \quad \mathcal{C}(v_0^*, F) = \min \left\{ C : \hat{U}_0^P(v_0^*, C, 1) = F \right\}
\]

In other words, \( C^\dagger(v_0^*) \) is the bonus that maximizes the agent’s continuation value of implementing a \( P \) opportunity (which is unique, as we show below), while \( \mathcal{C}(v_0^*, F) \) is the minimum bonus capable of incentivizing the agent to implement the opportunity when the implementation cost is \( F \) (if such bonus exists). These two bonuses are illustrated in Figure 4.

The following lemma provides some important properties regarding \( \hat{U}_0^P(v_0^*, C_\tau, 1) \) and \( C^\dagger(v_0^*) \) that will be useful in constructing the equilibrium:

**Lemma 5.** For \( v_0^* \in [v_0, u_0^*] \), \( \hat{U}_0^P(v_0^*, C_\tau, 1) \) has the following properties:

- For a \( C_\tau \) such that \( \hat{U}_0^P(v_0^*, C_\tau, 1) > 0 \), then \( \hat{U}_0^P(v_0^*, C_\tau, 1) \) is strictly decreasing in \( v_0^* \).
- There exists a unique \( C^\dagger(v_0^*) \) that solves \( \max_C \hat{U}_0^P(v_0^*, C, 1) \).
- \( \hat{U}_0^P(v_0^*, C^\dagger(v_0^*), 1) \) is strictly greater than zero, and strictly decreasing in \( v_0^* \).

**Proof.** See the online Appendix. □

As discussed in the previous section, an increase in \( C_\tau \) generates two offsetting effects on \( \hat{U}_0^P(v_0^*, C_\tau, 1) \): On the one hand, it increases the nominal/face value of the promised bonus, which increases \( \hat{U}_0^P(v_0^*, C_\tau, 1) \). On the other hand, it also makes payment of the bonus less likely, as the principal will reorganize sooner. Lemma 5 then states that there is a unique \( C^\dagger(v_0^*) \) that maximizes the agent’s incentive to incur \( F \) when these two forces are considered.
The lemma also states that both $\bar{V}_0^P(v_0^*, C, 1)$ and $\bar{V}_0^P(v_0^*, C^\dagger(v_0^*), 1)$ are strictly decreasing in $v_0^*$. This is intuitive: a higher $v_0^*$ makes the principal less willing to wait for a breakthrough, which decreases the agent’s continuation value of implementing a $P$ opportunity.

The final Lemma before our main result provides some properties of the equilibrium bonus offered by the principal:

**Lemma 6.**

(i) If $C(v_0^*, F) \neq \emptyset$, then $\bar{V}_0^P(v_0^*, C(v_0^*, F), 1) > v_0^*$.

(ii) If $i^*_P \in (0, 1]$, then in equilibrium the principal necessarily offers $C^*_P = C(v_0^*, F)$.

(iii) If $i^*_P \in (0, 1)$, then in equilibrium the principal necessarily offers $C^*_P = C(v_0^*, F) = C^\dagger(v_0^*)$.

**Proof.** See the online Appendix.

The first part of Lemma 6 states that, if the principal is able to find a bonus that leaves the agent indifferent to incurring $F$ or not, then the principal’s continuation value, if she offers the minimum of such bonus and the agent incurs $F$, is strictly greater than her reorganization value $v_0^*$. Intuitively, for the agent to implement an opportunity, he must be sure that the principal is obtaining strictly more than $v_0^*$. Otherwise, the principal will reorganize immediately if the implementation does not produce a breakthrough instantaneously, and the agent will not be able to recoup his implementation $F > 0$.

The second part states that, in any equilibrium in which the agent implements $P$ opportunities with strictly positive probability, the principal will offer the lowest possible bonus that
leaves the agent just indifferent between implementing them or not. The intuition for this result has already been discussed. Finally, the third part of the lemma states that, if the agent is mixing, it must be that $C(v_0^*, F)$ coincides with $C^*(v_0^*)$. Otherwise, since $\hat{V}_0^P(v_0^*, C(v_0^*, F), 1) > v_0^*$ according to (i), the principal could increase the bonus slightly to break the agent’s indifference, inducing him to incur $F$ with probability 1, and strictly increase her profits.

**Proposition 3.** Let:

$$
(\bar{v}_0, F_-) : \begin{cases} 
F_- = \hat{U}_0^P(\bar{v}_0, C^*(\bar{v}_0), 1) \\
\bar{v}_0 = pE(\bar{v}_0) + q\hat{V}_0^P(\bar{v}_0, C^*(\bar{v}_0), 1)
\end{cases}
$$

$$
(\underline{v}_0, F_+) : \begin{cases} 
F_+ = \hat{U}_0^P(\underline{v}_0, C^*(\underline{v}_0), 1) \\
(1 - q)\underline{v}_0 = pE(\underline{v}_0)
\end{cases}
$$

where $0 < F_- < F_+ < \hat{F}$. When at $\tau \in T_R^\infty$ the new opportunity selected $Z_\tau$ is $P = \{P_D, P_N\}$, the unique equilibrium of the ensuing subgame is as follows:

(i) If $F \in (0, F_-]$, the principal offers $C_\tau^* = C(v_0^*, F) < C^*(v_0^*)$, and the agent plays $i_\tau^* = 1$. $v_0^*$ is then uniquely pinned down by $v_0^* = pE(v_0^*) + q\hat{V}_0^P(v_0^*, C(v_0^*, F), 1)$.

(ii) If $F \in (F_-, F_+]$, then the principal offers $C_\tau^* = C(v_0^*, F) = C^*(v_0^*)$, and the agent plays $i_\tau^* \in [0, 1]$. $(i_\tau^*, v_0^*)$ are uniquely pinned down by:

$$
(i_\tau^*, v_0^*) : \begin{cases} 
F = \hat{U}_0^P(v_0^*, C^*(v_0^*), 1) \\
v_0^* = pE(v_0^*) + q[i_\tau^*\hat{V}_0^P(v_0^*, C^*(v_0^*), 1) + (1 - i_\tau^*)v_0^*]
\end{cases}
$$

so $i_\tau^*$ is strictly decreasing in $F$, $i_\tau^* \to 1$ as $F \to F_-$, and $i_\tau^* \to 0$ as $F \to F_+$.

(iii) If $F \in (F_+, \hat{F})$, then the equilibrium involves a reorganization trap. The principal offers any $C_\tau^* \in \mathbb{R}$, and the agent plays $i_\tau^* = 0$. $v_0^*$ then satisfies $v_0^* = pE(v_0^*) + qv_0^*$, so $v_0^* = \underline{v}_0$.

**Proof.** See appendix C. \qed

Together with Lemmas 2 and 3, Proposition 3 completely characterizes the unique equilibrium of the game. The equilibrium is depicted in Figure 5. The intuition for Proposition 3 closely follows the intuition developed in Section 3.4. The starting point is that, for a given $v_0^*$, the bonus offered induces the principal to wait less for a breakthrough in case of promising opportunities. Hence, a higher bonus does not necessarily translate into stronger incentives for the agent, as it also increases the likelihood that the bonus will not be paid.

Now, when $F \in (0, F_-]$ implementing promising opportunities is not too costly. Hence, even though a bonus induces the principal to reorganize sooner, the effect is not sufficiently important
for the problem to unravel. That is, if we conjecture that in equilibrium the agent implements $P$ opportunities with probability 1 and calculate the principal’s equilibrium reorganization value:

$$v^*_0 = pE(v^*_0) + q\tilde{V}_0^P(v^*_0, C(v^*_0, F), 1)$$

then for such a $v^*_0$, it is always possible to find a contract that incentivizes the agent to implement the opportunity.

As $F$ increases, however, there exists a $F = F_-$ at which it is no longer possible to find such a contract. Thus, when $F > F_-$ it cannot be an equilibrium for the agent to always implement $P$ opportunities. Nevertheless, it is possible to find an equilibrium in which the agent mixes between implementing or not since the expectation that the agent will mix in future reorganizations lowers the principal’s equilibrium reorganization value $v^*_0$ today. The latter situation makes the principal more reluctant to reorganize the firm in the future and increases

Figure 5: Equilibrium and Welfare as a Function of $F$

The dashed line depicts the first-best reorganization value $w^*_0$ as a function of $F$. The solid line depicts the principal’s equilibrium reorganization value $v^*_0$ as a function of $F$. The figure also depicts $(\bar{v}_0, F_-)$ and $(\bar{v}_0, F_+)$, which delimit the three regions outlined in Proposition 3. The difference between $w^*_0$ and $v^*_0$ captures the inefficiency of the equilibrium when compared to the first-best. The equilibrium is more inefficient for intermediate values of $F$. There is no inefficiency (1) when $F \to 0$ because the agent implements $P$ opportunities for free, or (2) when $F = \hat{F}$, as implementing $P$ opportunities in the first-best is not optimal.
Thus, the firm wastes resources reorganizing more than it should in the face of promising less often than the first-best prescribes, forcing the principal to reorganize immediately again. First-best. Second, when arises and the agent implements it, the principal reorganizes too soon when compared to the first-best, exhibiting two distinct types of inefficiencies. First, when — Compared to the first-best, the equilibrium is inefficient, with the expectation of receiving a bonus for a breakthrough. This bonus, however, will not be paid if the principal reorganizes the firm, which explains why the agent opposes the principal’s reorganization decision and complains that the organization is “changing too soon.”

One potential criticism for our model is that the agent’s complaints occur only during the transition phases. This result, however, is an artifact of the lump-sum nature of the agent’s compensation considered thus far. In Section 5, we provide an alternative model in the same spirit as the model presented so far, but in which the agent will complain about the principal’s reorganization decision in both the transition and exploitation phases.

Efficiency.— Compared to the first-best, the equilibrium is inefficient, exhibiting two distinct though interrelated types of inefficiencies. First, when , if a promising opportunity arises and the agent implements it, the principal reorganizes too soon when compared to the first-best. Second, when , if a promising opportunity arises, the agent implements it less often than the first-best prescribes, forcing the principal to reorganize immediately again. Thus, the firm wastes resources reorganizing more than it should in the face of promising

21Thus, in this region, the agent’s “sharing rule” regarding whether to implement or not must be made “endogenous” (Simon and Zame, 1990) for the equilibrium to exist.

22Uniqueness is proven, at least heuristically, as follows. Suppose first that and that in equilibrium the agent is implementing opportunities with probability strictly less than 1. Then is such that the principal can always find a bonus capable of incentivizing the agent to implement these opportunities with probability 1. Using Lemma 6, one can then show that this deviation is strictly profitable. Hence, when the agent must be implementing opportunities with probability 1. Uniqueness then follows from Lemma 6, and the fact that a unique satisfies (which must hold due to Lemma 6).

By a similar argument, it cannot be that in equilibrium the agent never implements opportunities when . However, as seen already in the text, the agent cannot be implementing with probability 1, either. Hence, when the agent necessarily mixes in equilibrium. Uniqueness then ensues, as there is a unique that simultaneously satisfies (9) and (which must hold due to Lemma 6).

Finally, because , then , implying that for all , irrespective of the value of . Hence, when the reorganization trap is the only equilibrium, as .
opportunities.

Notice, however, that the efficiency loss is non-monotonic in $F$, the equilibrium being more inefficient for intermediate values of $F$, as Figure 5 shows. Indeed, when $F \to 0$, then $C^*_\tau \to 0$, as incentivizing the agent to implement opportunities is costless. Consequently, the equilibrium is efficient, as the principal is not tempted to reorganize sooner. When $F \to \hat{F}$, in turn, the cost of implementing $P$ opportunities is so high that the value of developing them goes to zero. Hence, no efficiency is lost by not implementing promising opportunities in equilibrium, as implementing them has no value in the first place.

**Turbulence of the External Environment.**— The equilibrium can also be described as a function of $\eta$. Remember that $\eta > 0$ was the rate of profits’ depreciation, so is a reduced-form way of capturing the rate of turbulence of the organization’s external environment.

The equilibrium as a function of $\eta$ follows closely the characterization made in Proposition 3 and is depicted in Figure 6. It is characterized by the cutoffs $(\eta_-, \eta_+, \hat{\eta})$, which are analogous to

![Figure 6: Equilibrium and Welfare as a Function of $\eta$](image)

The dashed line depicts the first-best reorganization value $w^*_0$ as a function of $\eta$. The solid line depicts the principal’s equilibrium reorganization value $v^*_0$ as a function of $\eta$. The figure also depicts the cutoffs $(\eta_-, \eta_+, \hat{\eta})$, which delimit the implementation, the mixing, and the reorganization trap regions. Note that, as $\eta$ grows, in equilibrium the agent cuts back his implementation (probabilistically speaking); thus, firms in more turbulent environments are more likely to fall into the reorganization trap. Note, however, that as $\eta \to 0$ the efficiency loss disappears, as the value of implementing promising opportunities goes to zero, given that profits from developing promising opportunities depreciate too quickly.
As shown in Figure 6, when $\eta \in [0, \eta_-]$, that is, when the organization’s external environment is relatively stable, in equilibrium the agent implements $P$ opportunities with probability 1. As the rate of turbulence $\eta$ grows, however, the firm enters the mixing region (when $\eta_- < \eta \leq \eta_+$), and then falls into the reorganization trap (when $\eta_+ < \eta \leq \hat{\eta}$).

Thus, not surprisingly, the more turbulent the firm’s external environment, the more likely it is that the principal will be unable to incentivize the agent to implement $P$ opportunities. This result is intuitive: the higher $\eta$ is, ceteris paribus, the lower will be the principal’s continuation value of developing a promising opportunity before committed payments $E(v^*_0)$, making the principal’s commitment problem worse. Note, however, that as $\eta \to \hat{\eta}$, the efficiency loss disappears, given that the value of developing promising opportunities goes to zero, as profits depreciate too quickly. Hence, in extremely turbulent environments, falling into a reorganization trap is irrelevant.\textsuperscript{23}

In summary, the model predicts that organizations operating in turbulent external environments are more likely to fall into an inefficient cycle of constant restructuring. The inefficiencies associated with such a cycle, however, tend to disappear in extremely turbulent environments. Consequently, the firms impacted more negatively by contractual frictions in the face of reorganizations are the ones operating in only moderately turbulent environments.

**Do Firms Reorganize Too Much or Too Little?** — As we have already seen, the equilibrium is inefficient, as the firm ends up wasting resources by reorganizing more often than it should in the face of promising opportunities. This occurs either because the agent implements but the principal reorganizes too soon; or because the agent refuses to do so, leaving the principal no choice but to reorganize again. In summary, inefficiency results from the firm’s exhibiting reorganizational hyper-action during the transition between two business opportunities.

Interestingly, the latter implies that the firm will also exhibit the opposite sort of behavior, reorganizational inaction, during exploitation phases. Indeed, recall that in equilibrium, the principal exploits profitable opportunities for $\varphi^*_E(v^*_0) = \eta^{-1} \ln (\Pi/\Pi v^*_0)$ amount of time. Furthermore, note that once an opportunity becomes profitable and the committed bonus is paid, the principal becomes the full residual claimant of the subsequent flow of profits until the next reorganization takes place. Hence, the principal’s problem at this stage is the same as that of a single DM in the first-best, the only difference being that the principal’s reorganization value is $v^*_0$, while the DM’s is $w^*_0 > v^*_0$.

This implies that the DM exploits profitable opportunities for $\psi^*_E = \varphi^*_E(w^*_0) = \eta^{-1} \ln (\Pi/\Pi w^*_0)$ amount of time in the first-best, which is strictly less than $\varphi^*_E(v^*_0)$, as $w^*_0 > v^*_0$ and $\varphi^*_E(x)$ is

\textsuperscript{23}Interestingly, the equilibrium inefficiency does not disappear at $\eta = 0$, as shown in Figure 6. While it is true that when $\eta = 0$ the firm never reorganizes again once it starts generating profits, the principal still reorganizes too soon when the organization tries to develop a promising opportunity.
Figure 7: Do Firms Reorganize Too Much or Too Little?

(a) Time Exploiting an Opportunity

(b) Time Waiting for a Breakthrough

These plots have been generated using \((\Pi, \eta, \lambda, \bar{\mu}, p, q, r) = (10, 1/4, 3/2, 1/2, 3/4, 1/4)\). The dotted lines depict \((F_-, F_+, \hat{F}) = (0.9830, 1.2893, 1.9816)\), which delimit the three regions of the equilibrium. Panel (a) shows the total time the organization exploits profitable opportunities, both in equilibrium \((\varphi^*_E)\) and in the first-best \((\varphi^*_B)\) from Proposition 1), as a function of \(F\). This plot shows that firms in equilibrium “reorganize too little” in the exploitation phase. Panel (b) shows the total time the organization will wait for a breakthrough when dealing with an implemented \(P\) opportunity, both in equilibrium \((\varphi^*_{PD})\) and in the first-best \((\varphi^*_{DP})\) from Proposition 1), as a function of \(F\). This plot shows that in equilibrium, firms “reorganize too much” when trying to develop a promising opportunity.

This finding might help to shed light on two commonly held perceptions that seem contradictory at first glance: that firm fail because they reorganize too much or because they do not reorganize enough. Although these perceptions can seem contradictory, they are, in fact, opposite sides of the same coin. It is the fear of reorganizational hyper-action which leads an organizational into reorganizational inaction when exploiting profitable opportunities. This result also implies that if we analyzed the reorganization behavior of this organization without taking into account the incentive frictions, we would sometimes conclude that it is reorganizing too frequently and other times that it is not reorganizing frequently enough.

4 Richer Contracts

Until now, we have allowed the agent’s compensation to be based only on achieving a breakthrough. This section considers how results change when the principal can offer richer types of contracts.
4.1 Severance Packages and Compensations for Reorganizations

Suppose that, in addition to the bonus $C_\tau$, the principal can also commit to compensating the agent an amount $\kappa_\tau \in \mathbb{R}$ if she ends up reorganizing the firm before the next breakthrough. That is, $\kappa_\tau$ is paid whenever the following event occurs: $\{\Pi_{t-} = 0, Z_{t+} \neq Z_t\}$. We call $\kappa_\tau$ a reorganization bonus to distinguish it from the breakthrough bonus $C_\tau$. Define, then, $T^k_t = \{s \leq t : \Pi_{s-} = 0, Z_{s+} \neq Z_s\}$ as the set of all times up to $t$, including $t$, at which a reorganization bonus was paid.

The idea underlying such a scheme is that the principal pre-commits to not reorganizing too soon after the agent incurs $F$. This type of contract is more likely to arise in the form of severance pay whenever a reorganization also involves the termination of the agent — a professional sports coach/manager, for example, or the CEO of a company in a reorganization that is tied to the CEO's tenure.

Note, however, that as currently defined, a reorganization bonus and a severance payment differ in one subtle but crucial respect: $\kappa_\tau$ is paid not at every reorganization, but only at those reorganizations that take place before the next breakthrough. We chose to define $\kappa_\tau$ this way since an all-event severance payment is not optimal in this setting, as it also distorts the exploitation of successfully developed promising opportunities. Nevertheless, as will become evident later, whether $\kappa_\tau$ is a reorganization bonus or an all-event severance pay does not change the qualitative nature of the results derived next.

Preliminaries.— In this scenario, the payoff-relevant history for the principal at time $t$, $\hat{h}^{Pt}$, where $t$ belongs to the regular time, consists of the same elements as in the previous sections plus the last reorganization bonus offered by the principal, $\kappa_{\bar{\tau}_t}$, where $\bar{\tau}_t = \max T^k_t$. That is,

$$\hat{h}^{Pt} = (Z_t, \Pi_t, \mu_t, C_{\bar{\tau}_t}, \kappa_{\bar{\tau}_t}, I_{\bar{\tau}_t})$$

while the-payoff relevant history for the principal at times $\tau \in T^\infty_R$ is given by $\Pi_\tau$, the profits of the new opportunity just selected at $\tau$.

The payoff-relevant history for the agent at time $\tau \in T^\infty_R$, in turn, is given by $(\Pi_\tau, C_\tau, \kappa_\tau)$. That is, it is equal to the profits of the new opportunity just selected, the new breakthrough bonus, and the new reorganization bonus just offered by the principal at $\tau$.

A a Markov strategy for the principal then consists of three mappings $R_t : \hat{h}^{Pt} \to \{0, 1\}$, $C_\tau : \Pi_\tau \to \mathbb{R}$, and $\kappa_\tau : \Pi_\tau \to \mathbb{R}$. The principal’s strategy induces two piecewise-constant, right-continuous functions $C_t$ and $\kappa_t$, stipulating the breakthrough and reorganization bonuses to be paid at time $t$. A Markov strategy for the agent, in turn, is a mapping $i_\tau : (\Pi_\tau, C_\tau, \kappa_\tau) \to [0, 1]$, for $\tau \in T^\infty_R$, stipulating the probability of implementation $i_\tau = \mathbb{P}(I_\tau = 1)$ at each reorganization.

The players’ strategies $(R, C) = \{(R_t)_{t\geq 0}, (C_\tau)_{\tau \in T^\infty_R}\}$, and $i = \{i_\tau\}_{\tau \in T^\infty_R}$ uniquely pin down
the stochastic process governing the evolution of \( Z_t, T^R_t, T^C_t, R^t, \Pi_t, \mu_t, C_t, \kappa_t, \{ I_t \}_{t \in T^R_t}, \) and \( \tau_B. \) The principal’s and the agent’s ex-ante expected payoffs at time 0 are then given by:

\[
\begin{align*}
\kappa_0 &= \mathbb{E}_0 \left[ \int_0^{\tau_B} \Pi_t e^{-r_t} \, dt - \sum_{s \in T^C_{\kappa}} C_s e^{-r_s} - \sum_{s \in T^R_{\kappa}} \kappa_s e^{-r_s} \right] \\
\kappa_0 &= \mathbb{E}_0 \left[ \sum_{s \in T^C_{\kappa}} C_s e^{-r_s} + \sum_{s \in T^R_{\kappa}} \kappa_s e^{-r_s} - \sum_{\tau \in T^R_{\kappa}} F e^{-r_\tau I_\tau} \right]
\end{align*}
\]

**Analysis.** — It is easily seen that the addition of \( \kappa_\tau \) does not alter the recursive structure of the game, so let \((v_0^*, u_0^*)\) be the players’ equilibrium reorganization values. Take, then, a \( \tau \in T^R_\infty \) and consider the subsequent play for a given \((v_0^*, u_0^*)\).

First, if \( Z_\tau \) is type \( G \), then any \((C_\tau^*, \kappa_\tau^*) \in \mathbb{R}^2 \) is best-response, as neither of the two bonuses ever gets paid. The agent then never incurs \( F \) and the principal reorganizes again at \( \tau + \varphi^E(v_0^*) \).

Players’ continuation values at \( \tau \) are then \( V^P_0(v_0^*, u_0^*) = E(v_0^*) \) and \( U^P_0(v_0^*, u_0^*) = u_0^* e^{-r \varphi^E(v_0^*)} \). Hence, \( \kappa_\tau \) influences the game only when a promising opportunity arises.

Suppose, therefore, that \( Z_\tau \) is type \( P = \{ P_D, P_N \} \), and consider the ensuing play after the principal offers \((C_\tau, \kappa_\tau)\) at \((\tau, 1)\). Following a derivation analogous to that provided in Section 3.3, we obtain that, if the agent implements the opportunity, the players then obtain a continuation value of:

\[
\begin{align*}
V^P_0(v_0^*, u_0^*, C_\tau, \kappa_\tau, 1) &= \left\{ \begin{array}{ll}
\frac{\lambda \mu(E(v_0^*) - C_\tau)}{r + \lambda} & \text{if } \xi \leq 0 \\
\frac{\lambda \mu(E(u_0^*) - C_\tau)}{r + \lambda} & \text{if } \xi > 0
\end{array} \right.
\]

\[
\begin{align*}
&\left[ 1 - \left( \frac{\Omega(\mu)}{\Omega(\xi)} \right)^{1+\xi} \right] + \frac{\mu(u_0^* - \kappa_\tau)}{\xi} \left( \frac{\Omega(\mu)}{\Omega(\xi)} \right)^{1+\xi} & \text{if } \xi \in (0, \bar{\mu})
\end{align*}
\]

\[
U^P_0(v_0^*, u_0^*, C_\tau, \kappa_\tau, 1) = \left\{ \begin{array}{ll}
\frac{\lambda \mu(C_\tau + u_0^* e^{-r \varphi^E(v_0^*)})}{r + \lambda} & \text{if } \xi \leq 0 \\
\frac{\lambda \mu(C_\tau + u_0^* e^{-r \varphi^E(v_0^*)})}{r + \lambda} & \text{if } \xi > 0
\end{array} \right.
\]

\[
\left[ 1 - \left( \frac{\Omega(\mu)}{\Omega(\xi)} \right)^{1+\xi} \right] + \frac{\mu(u_0^* + \kappa_\tau)}{\xi} \left( \frac{\Omega(\mu)}{\Omega(\xi)} \right)^{1+\xi} & \text{if } \xi \in (0, \bar{\mu})
\end{align*}
\]

where

\[
\xi = \frac{r(u_0^* - \kappa_\tau)}{\lambda(E(v_0^*) - C_\tau - v_0^* + \kappa_\tau)}
\]

If the agent does not implement the opportunity, however, then the players obtain \( V^P_0(v_0^*, u_0^*, C_\tau, \kappa_\tau, 0) = \max\{v_0^* - \kappa_\tau, 0\} \), and

\[
\begin{align*}
U^P_0(v_0^*, u_0^*, C_\tau, \kappa_\tau, 0) &= \left\{ \begin{array}{ll}
{u_0^* - \kappa_\tau} & \text{if } \kappa_\tau < v_0^* \\
0 & \text{if } \kappa_\tau \geq v_0^*
\end{array} \right.
\end{align*}
\]
Hence, the agent’s best-response, given \((v^0_0, u^0_0, C_\tau, \kappa_\tau)\), is

\[
i_\tau(v^*_0, u^*_0, C_\tau, \kappa_\tau) = \begin{cases} 
1 & \text{if } \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 1) - F > \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 0) \\
[0, 1] & \text{if } \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 1) - F = \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 0) \\
0 & \text{if } \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 1) - F < \tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 0)
\end{cases}
\]

Notice, then, that by setting \(\kappa_\tau\) high enough, the principal can now always find a \(C_\tau\) capable of incentivizing the agent to implement the opportunity. For instance, by setting \(\kappa_\tau \geq v^*_0\), then \(\xi \leq 0\), so a sufficient condition for the agent to incur the implementation cost \(F\) is:

\[
\frac{\lambda \bar{\mu}(C_\tau + u^*_0 e^{-r\phi E(v^*_0)})}{r + \lambda} - F > 0
\]

which can always be satisfied with a high enough \(C_\tau\). Intuitively, by committing to a high \(\kappa_\tau\), the principal can ameliorate her time-inconsistency problem, as a high \(\kappa_\tau\) lowers the attractiveness of reorganizing the firm for the principal.

There is, however, a problem. Adding the reorganization bonus to the agent’s compensation is not free. Either the principal sets \(\kappa_\tau \geq v^*_0\) and relinquishes all her flexibility, effectively committing to never reorganize again, or she sets \(0 < \kappa_\tau < v^*_0\), keeping some flexibility, but creating a moral hazard problem on the side of the agent.

Indeed, if \(0 < \kappa_\tau < v^*_0\), then the agent anticipates that if he does not implement the opportunity, then the principal will reorganize the firm immediately again. Hence, by not implementing the opportunity, the agent can secure the bonus \(\kappa_\tau\) without the need to disburse the implementation cost \(F\). Thus, a necessary condition for the agent to implement promising opportunities in this scenario is:

\[
\tilde{U}_0^P(v^*_0, u^*_0, C_\tau, \kappa_\tau, 1) - F \geq u^*_0 + \kappa_\tau
\]

which implies that the principal needs to leave strictly positive rents to the agent to incentivize him to implement an opportunity. From here it is immediately apparent that a contract of this type will not allow the organization to achieve the first-best. 24

A complete characterization of the equilibrium, in this case, is beyond the scope of this paper. We therefore will content ourselves by showing that an equilibrium without implementation continues to exist when \(F\) is high enough.

**Proposition 4.** There exists an \(F_{++} \in (F_+, \hat{F})\) such that if \(F > F_{++}\), then there exists an equilibrium in which the agent never implements promising opportunities.

**Proof.** See the online Appendix. 24

Indeed, for such a contract to achieve the first-best, the principal must retain a degree of flexibility, thus \(\kappa_\tau < v^*_0\). Furthermore, it must be that the agent is implementing \(P\) opportunities on-path, which implies that the agent will obtain strictly positive rents in equilibrium (as \(\kappa_\tau > 0\)), so \(u^*_0 > 0\). The latter implies that \(v^*_0 \leq w^*_0 - u^*_0 < w^*_0\), so there are paths of play in which the principal’s reorganization behavior will differ from that of the first-best; for instance, when a newly selected opportunity is \(G\).
Hence, according to Proposition 4, if $F > F_{++}$, there exists an equilibrium in which allowing the principal to offer compensations for reorganizations is irrelevant. Thus, our result concerning reorganizational inaction and hyper-action continues to hold in this region.

Finally, note that if $\kappa_\tau$ were instead an all-event severance payment, the results just derived would not change. Indeed, the moral hazard problem would still be present. Furthermore, by distorting the exploitation of successfully developed promising opportunities, an all-event severance package worsens the principal’s commitment problem and makes reorganizational inaction even more prominent compared to the case in which $\kappa_\tau$ is paid only for reorganizations occurring before a breakthrough.

### 4.2 Time-Dependent Bonuses

If one takes the model literally, it is possible to prove that the principal can achieve the first-best using time-dependent bonuses (see the online Appendix). The idea is to offer the agent a very high bonus if the breakthrough occurs shortly after implementation, but no payment if the breakthrough takes longer to arrive. This scheme then makes the principal the full residual claimant when players become more pessimistic about the possibility of a breakthrough, inducing the principal to reorganize at the “right” (i.e., the efficient) time.

Intuitively, however, this contract relies too much on specific assumptions of the model. Such a scheme would not work if, for instance, in addition to the up-front implementation cost $F$, a breakthrough required the agent to exert additional effort over time, or if the principal could “hide” or partially manipulate the arrival of a breakthrough.

### 5 (Seemingly) Premium Salaries

A valid criticism of our baseline model is that, in practice, big lump-sum bonuses are not always offered by organizations to help employees embrace change. In this section we show, however, that the lump-sum nature of the agent’s compensation is not essential for our main results. What is vital is the combination of front-loaded effort and incomplete contracting.

#### 5.1 Example: Constant Flow Payment

Consider, for instance, the following minimal modification of our baseline model: Instead of offering the agent a bonus for a breakthrough, the principal offers him a constant flow payment $c_\tau \in \mathbb{R}$ for as long as the organization pursues the current opportunity.

**Preliminaries.**— The players’ payoff-relevant histories are then defined analogously to what was outlined for our baseline model described in Section 2, except that instead of the last
equilibrium with implementation, the agent must be indifferent to implementing the opportunity. Moreover, if a given \( \tau \in \mathcal{T}_R^\infty \) at which a reorganization takes place, as a function of the principal’s payoff-relevant histories at \( t \) and \( \tau \), respectively. A Markov strategy for the agent, in turn, is a mapping that stipulates an implementation probability \( i_\tau = \mathbb{P}(I_\tau = 1) \) at each time \( \tau \in \mathcal{T}_R^\infty \), as a function of the agent’s payoff-relevant history at that time.

Players’ strategies \( (R, c) = \langle \{R_t\}_{t \geq 0}, \{c_\tau\}_{\tau \in \mathcal{T}_R^\infty} \rangle \) and \( i = \{i_\tau\}_{\tau \in \mathcal{T}_R^\infty} \) uniquely pin down the stochastic process governing the evolution of \( Z_t \), \( \mathcal{T}_R^1 \), \( \Pi_t \), \( \mu_t \), \( c_t \), \{\( I_t \)\}_{\tau \in \mathcal{T}_R^1} \), and \( \tau_B \). Ex-ante payoffs at time zero are then:

\[
\begin{align*}
v_0 &= \mathbb{E}_0 \left[ \int_0^{T_B} (\Pi_t - c_t)e^{-rt}dt \right] \\
u_0 &= \mathbb{E}_0 \left[ \int_0^{T_B} c_t e^{-rt}dt - \sum_{\tau \in \mathcal{T}_R^\infty} Fe^{-rt}I_\tau \right]
\end{align*}
\]

**Analysis.**— As in the previous section, it is easily seen that this alternative contractual arrangement does not alter the recursive structure of the game, so we define \((v_0^*, u_0^*)\) as the players’ equilibrium reorganization values. Take, then, a \( \tau \in \mathcal{T}_R^\infty \) and consider the subsequent play for a given \((v_0^*, u_0^*)\).

First, the principal is going to set \( c_\tau^* = 0 \) if \( Z_\tau \) is type \( G \), as there is no need to incentivize the agent to implement the opportunity. Moreover, if \( Z_\tau \) is type \( P = \{P_D, P_N\} \), then in any equilibrium with implementation, the agent must be indifferent to implementing the opportunity or not. These two results immediately imply that \( u_0^* = 0 \), as in the baseline model.

Following, then, with a derivation analogous to that of Section 3.3, we obtain that \( V_0^G(v_0^*) = E(v_0^*) \) and \( U_0^G(v_0^*) = 0 \); that \( V_0^P(v_0^*, c_\tau, 0) = v_0^* \) and \( U_0^P(v_0^*, c_\tau, 0) = 0 \); and that:

\[
\begin{align*}
V_0^P(v_0^*, c_\tau, 1) &= \begin{cases} -\frac{c_r}{r} + \left( \frac{\lambda}{r+\lambda} \right) \left[ E_P(v_0^*) + \frac{c_r}{r} \right] \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\mu)} \right)^{1+\frac{c_r}{r}} \right] + \frac{\bar{\mu}}{\chi} \left( v_0^* + \frac{c_r}{r} \right) \left( \frac{\Omega(\bar{\mu})}{\Omega(\mu)} \right)^{1+\frac{c_r}{r}} & \text{if } \chi < \bar{\mu} \\
v_0^* & \text{if } \chi \geq \bar{\mu}
\end{cases}
\end{align*}
\]

\[
\begin{align*}
U_0^P(v_0^*, c_\tau, 1) &= \begin{cases} \frac{c_r}{r} \left[ 1 - \left( \frac{\lambda}{r+\lambda} \right) e^{-rE_P(v_0^*, c_\tau)} + \frac{\bar{\mu}}{\chi} \left( \frac{\Omega(\bar{\mu})}{\Omega(\mu)} \right)^{1+\frac{c_r}{r}} \right] & \text{if } \chi < \bar{\mu} \\
0 & \text{if } \chi \geq \bar{\mu}
\end{cases}
\end{align*}
\]

where:

\[
\chi = \frac{rv_0^* + c}{\lambda(E_P(v_0^*, c_\tau) - v_0^*)} \quad \text{and} \quad E_P(v_0^*, c_\tau) = \frac{\Pi}{r+\eta} - \frac{c}{r} + \left( \frac{\eta}{r+\eta} \right) \left( v_0^* + \frac{c_r}{r} \right) e^{-rE_P(v_0^*, c_\tau)}
\]
with:
\[
\varphi_{EP}(v_0^*, c_r) = \eta^{-1} \ln \left( \frac{\Pi}{rv_0^* + c_r} \right)
\]

We can then derive an analogous version of Proposition 3, following the same reasoning developed in Section 3.5.

As Figure 8 shows, the equilibrium with flow payment scheme has some similarities to, as well as differences from, the equilibrium in which the principal offers a time-independent lump-sum bonus. As for the similarities, both equilibria are inefficient compared to the first-best and have a similar structure: the equilibrium with a flow payment is also defined by two cutoffs \( F_f^- \) and \( F_f^+ \), which delimit an implementation region \( (0 < F \leq F_f^f) \), a mixing region \( (F_f^- < F < F_f^+) \), and a reorganization trap region \( (F_f^+ \leq F < \hat{F}) \). The latter also implies that there is a region, when \( F > \max\{F_+, F_f^f\} \), in which both equilibria are indistinguishable.

Regarding the differences: First, when the principal compensates the agent with flow payments, the agent dislikes organizational change not only during the transitions between opportunities but also during the exploitation of successfully developed promising opportunities.

Second, when the principal offers a flow payment, it is no longer true that the principal exploits \( G \) opportunities for the same amount of time as successfully developed \( P \) opportunities. The reason is that in the latter case, the principal still needs to pay the agent the flow \( c_r \), inducing her to reorganize earlier. As seen in Figure 8, this effect is substantial enough to overturn our reorganizational inaction result regarding promising opportunities. In this case,

**Figure 8: Premium Salaries v. Bonuses**

(a) Time Exploiting an Opportunity

(b) Time Waiting for a Breakthrough

These plots have been generated using \((\Pi, \eta, \lambda, \bar{\mu}, p, q, r) = (10, 1/4, 3/2, 1/2, 1/4, 3/4, 1/4)\). Panel (a) shows the total time the organization exploits the different types of profitable opportunities under different scenarios: (i) in the first-best \( (\varphi_{EG} = \varphi_{EP} = \phi_E^*) \); (ii) in the bonus equilibrium \( (\varphi_{EG} = \varphi_{EP} = \phi_E^b) \); and (iii) in the flow payment equilibrium \( (\varphi_{EG} = \varphi_{EP}) \). Panel (b) shows the total time the organization will wait for a breakthrough when dealing with an implemented \( P \) opportunity, in those same three scenarios.
we must add the following qualification to our inaction result: when \( F \in (0, F_f^+) \) reorganizational inaction occurs for the exploitation of \( G \) opportunities but not \( P = \{P_D, P_N\} \) opportunities.\(^{25}\)

Third and finally, the fact that \( c_\tau \) induces the principal to exploit promising opportunities for less time also explains why this equilibrium is more inefficient than the one with a lump-sum bonus: \( c_\tau \) also distorts the exploitation of profitable promising opportunities, lowering the principal’s continuation value of developing them and inducing her to wait even less for a breakthrough than if she were to offer a lump-sum bonus. The latter has two implications: (i) \( F_f^- < F_-, \) and \( F_f^+ < F_+ \), so the reorganization trap region is larger; and (ii) when \( F \in (0, F_f^+) \) reorganizational inaction of \( G \) opportunities is even more pronounced than when the principal offered the bonus.

Because compensating the agent with a flow payment is more inefficient than doing so with the bonus, in equilibrium we would not expect to see the former type of compensation when the latter is available. Note, however, that in many instances breakthroughs might not be verifiable, or could potentially be manipulated by the principal, so offering a bonus for a breakthrough might be unfeasible. In such situations, therefore, the principal might have no other choice than to offer this less efficient type of compensation.

As one final observation, an interesting implication of our base model revised to admit flow payments is that, if we analyze the organization’s wages at a generic point in time without taking into account the previous history of the company, we would conclude that the organization is paying seemingly above market rates. That is, we would conclude that the organization is paying seemingly premium salaries or efficiency wages. From an ex-ante perspective, of course, this is fair compensation for the front-loaded effort and the agent’s reorganization risk. Thus, in a dynamic setting, the need for front-loaded effort coupled with incomplete contracting could be another explanation for what might appear to be efficiency wages in the data.

6 Conclusions

Are organizations able to change efficiently and in a timely manner? This question has long been debated among management academics and practitioners alike. Some argue that organizations do not change enough and their inability to change explains many of the most prominent firm failures in history. Others, however, warn that organizations sometimes reorganize too much, leading to subpar performance and also, in extreme cases, failure.

In this paper, we proposed a fully rational dynamic model of reorganizations capable of reconciling these two seemingly contradictory ideas. The model relies on four natural ingredients (delegation, uncertainty, front-loaded effort, and incomplete contracts) and explains why the

\(^{25}\text{When } F \geq F_f^+, \text{ reorganizational inaction occurs in every exploitation phase, as the principal exploits only } G \text{ opportunities on the path of play.}\)
same organization will at some times reorganize too frequently and at other times not frequently enough. More precisely, compared to the first-best, reorganizational hyper-action describes an organization’s behavior during the transition between two businesses, while reorganizational inaction describes its behavior once the transition is over and the exploitation phase begins. Our results thus imply that both sides of the reorganization debate have some merit: each position describes a different phase of the firm’s reorganization cycle. The model, moreover, provides a new, rational explanation as to why employees and middle managers often complain about organizational change: when effort must be front-loaded and contracts are incomplete, employees act with the expectation of future benefits, which are curtailed when the organization changes direction.

It is important to note that, even though the argument developed in this paper appears to rely heavily on the existence of explicit monetary transfers, these are not essential for our result. The same inefficiencies would arise if, instead of monetary transfers, the organization’s leadership offered division managers and employees perks, such as more funding and resources or greater autonomy. If these additional perks are distortionary for the organization as a whole, then, just as in the model with monetary transfers, the organization’s leadership would have an incentive to cut short implementation. But if they do so, the various divisions would demand higher perks from the outset, leading to a higher distortion of profits, a shorter implementation period, and so on. Thus, we hypothesize that this alternative model with implicit distortionary transfers would yield similar qualitative results.

Given that reorganizations have not been subject to much formal economic analysis, they offer many unanswered questions and exciting avenues for research. First, reorganizations are about not only timing, but also jump size and direction. Should an organization follow an incremental approach, building upon a progressively obsolete core business, or radically transform itself in various ways? Second, this paper has modeled reorganizations in a reduced-form way. The next natural step would be to incorporate the organizational structure explicitly. For instance, is it the same for an organization to move from a centralized structure to a decentralized one, and vice-versa? Third and finally, we have assumed so far that the organization’s leadership directly observes the external environment. How does organizational structure affect learning about the environment, and with that, the organization’s ability to change?
Appendix A  The Principal’s Strategy: Technical Details

If the principal can reorganize the firm more than once within an instant, a strategy for the principal, as defined in Section 2, is not well defined. The reason is that the game history does not keep track of multiple reorganizations occurring at the same instant.

Because redefining the game history to include the possibility of multiple reorganizations within the same instant involves a fair amount of additional notation, to address this issue we follow an alternative approach: we assume that the principal is forced to wait for $\Delta > 0$ between two consecutive reorganizations. In this appendix, we formally describe the game away from the limit $\Delta = 0$ and provide a proposition (proved in the online Appendix) stating that the (unique) equilibrium with $\Delta > 0$, but $\Delta \approx 0$, converges as $\Delta \to 0$ to the equilibrium in the limit $\Delta = 0$ characterized in the main text.

A.1  The Auxiliary $\Delta$-Game

The only modification to the model presented in Section 2 is that we make explicit the principal’s being forced to wait for $\Delta > 0$ between two consecutive reorganizations. Under this modification, only the definition of the principal’s strategy changes: let $T_A = \{ t \geq 0 : t \notin [\tau, \tau + \Delta), \tau \in T^\infty_R \}$. A strategy for the principal stipulates: (i) for each $h^t_A$ (where $h^t$, for $t$ in the regular time, is defined as it was in Section 2) a reorganization decision $R^t_A = \{ 0, 1 \}$, for $t_A \in T_A$; and (ii) for each $h^\tau \cup \{ \Pi^\tau \}$ a bonus $C^\tau \in \mathbb{R}$, for $\tau \in T^\infty_R$.

As in the main text, the players’ strategies $\langle R, C \rangle = \langle \{ R^t \}_{t_A \in T_A}, \{ C^\tau \}_{\tau \in T^\infty_R} \rangle$ and $i = \{ i^\tau \}_{\tau \in T^\infty_R}$ uniquely pin down the evolution of $Z_t$, $\Pi_t$, $\mu_t$, $C_t$, and $\{ I^\tau \}_{\tau \in T^\infty_R}$, and the principal’s and agent’s expected payoff at time 0, are again given by:

$$v_0 = \mathbb{E}_0 \left[ \int_0^{\tau_B} \Pi_t e^{-rt} dt - \sum_{s \in T^\infty_C} C_s e^{-rs} \right]$$

$$u_0 = \mathbb{E}_0 \left[ \sum_{s \in T^\infty_C} C_s e^{-rs} - \sum_{\tau \in T^\infty_R} F e^{-r\tau} I^\tau \right]$$

Finally, a Markov Perfect Equilibrium of the $\Delta$-game is a profile of strategies $\langle R, C \rangle$ and $i$ progressively measurable with regard to the payoff-relevant histories $h^{PT_A}$, $h^{PT}$, and $h^{AT}$ (all defined as in Section 2), respectively, that are a perfect equilibrium of the game.

Proposition 5. There exists a $\bar{\Delta} > 0$ such that if $\Delta \in (0, \bar{\Delta})$ the equilibrium of the $\Delta$-game is unique. Furthermore, this equilibrium converges to the (unique) equilibrium characterized in the main text as $\Delta \to 0$.

Proof. See the online Appendix.

$\square$
Appendix B  The First-Best/Complete Contract Benchmark

Preliminaries

Lemma B.1. \( W_0^G(w_0^*) = E(w_0^*) \) and \( W_0^P(w_0^*) = \max\{D(w_0^*) - F, w_0^*\} \), where

\[
E(w_0^*) = \frac{\Pi}{r + \eta} + \left( \frac{\eta}{r + \eta} \right) w_0^* e^{-\phi_B(w_0^*)}
\]

and

\[
D(w_0^*) = \begin{cases} 
\frac{\lambda \tilde{\mu} E(w_0^*)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\tilde{\mu})}{\Omega(w_0^*)} \right)^{1+\frac{x}{\lambda}} \right] + \frac{\mu w_0^*}{\psi(w_0^*)} \left( \frac{\Omega(\tilde{\mu})}{\Omega(w_0^*)} \right)^{1+\frac{x}{\lambda}} & \text{if } \tilde{\mu} > \psi(w_0^*) \\
\frac{\mu w_0^*}{\psi(w_0^*)} & \text{if } \tilde{\mu} \leq \psi(w_0^*) 
\end{cases}
\]

with

\[
\phi_B(w_0^*) = \eta^{-1} \ln \left( \frac{\Pi}{r w_0^*} \right) \\
\psi(w_0^*) = \frac{r w_0^*}{\lambda(E(w_0^*) - w_0^*)} \\
\Omega(x) = \frac{1 - x}{x}
\]

Proof. See the online Appendix. \( \square \)

Intuitively, \( E(w_0^*) \) is the DM's total value of exploiting a profitable opportunity (i.e., the expected present value of all profits from the moment the opportunity first generated a profit). Hence, the DM obtains \( E(w_0^*) \) when the new opportunity after a reorganization is type \( G \), so \( W_0^G(w_0^*) = E(w_0^*) \); or when she is able to develop a promising opportunity. \( D(w_0^*) \), in turn, is the DM’s continuation value of implementing a promising opportunity immediately after the implementation cost is incurred.

Consider the DM’s implementation decision when faced with a promising opportunity. Clearly, the DM will reorganize if she decides not to implement the opportunity, as \( w_0^* > 0 \) and the firm will never generate profits pursuing this opportunity, given the lack of implementation. Consequently, the DM obtains \( D(w_0^*) - F \) if she implements, and \( w_0^* \) if she does not, so \( W_0^P(w_0^*) = \max\{D(w_0^*) - F, w_0^*\} \).

For what follows, we define for convenience \( \bar{w} \) as \( D(\bar{w}) = \tilde{w} \), or equivalently, \( \bar{w} \) is such that \( \psi(\bar{w}) = \tilde{\mu} \). As the following lemma shows \( \bar{w} \in (0, \Pi / r) \) is unique. Furthermore, \( D(w_0^*) > w_0^* \) if and only if \( w_0^* < \bar{w} \). Hence, a necessary condition for implementation to be optimal, given that \( F > 0 \), is for \( w_0^* < \bar{w} \).

Claim B.1. There exists a unique \( \bar{w} \in (0, \Pi / r) \) such that \( \psi(\bar{w}) = \tilde{\mu} \), where

\[
\psi(w_0^*) = \frac{r w_0^*}{\lambda(E(w_0^*) - w_0^*)}
\]

Furthermore, \( D(w_0^*) > w_0^* \) if and only if \( w_0^* < \bar{w} \).

Proof. Notice first that \( D(w_0^*) > w_0^* \iff \psi(w_0^*) < \tilde{\mu} \). Now, for \( w_0^* \in (0, \Pi / r) \), let \( \Upsilon(w_0^*) \equiv \psi(w_0^*) - \tilde{\mu} \). Since \( E(w_0^*) > w_0^* \) for all \( w_0^* \in (0, \Pi / r) \), we have that \( \Upsilon(w_0^*) \) is continuous in \( w_0^* \), for \( w_0^* \in (0, \Pi / r) \). Furthermore, notice that \( \Upsilon(w_0^*) \to -\tilde{\mu} < 0 \) as \( w_0^* \to 0 \); that \( \Upsilon(w_0^*) \to +\infty \) as \( w_0^* \to \Pi / r \); and that

\[
\Upsilon'(w_0^*) = \frac{r \Pi (r + \eta)}{\lambda (\Pi + \eta w_0^* (1 - e^{-\phi_B(w_0^*)}))} \left[ 1 - \left( \frac{r w_0^*}{\Pi} \right)^{1+\frac{x}{\lambda}} \right] > 0 \text{ for } w_0^* \in (0, \Pi / r)
\]

Hence, we conclude that there exists a unique \( \bar{w} \in (0, \Pi / r) \) such that \( \psi(\bar{w}) = \tilde{\mu} \), and that \( \psi(w_0^*) < \tilde{\mu} \iff w_0^* < \bar{w} \), which implies that \( D(w_0^*) > w_0^* \) if and only if \( w_0^* < \bar{w} \). \( \square \)
We now characterize the DM’s optimal implementation policy as a function of \((w_0^*, F)\).

**Lemma B.2.** Let
\[
\tilde{F} \equiv \left( \frac{\lambda \mu}{r + \lambda} \right) \left( \frac{\Pi}{r + \eta} \right)
\]
We then have,
- If \(F \geq \tilde{F}\), then \(D(w_0^*) - F < w_0^*\) for all \(w_0^* \in (0, \Pi/r]\).
- While if \(F < \tilde{F}\), there exists a unique \(w(F) \in (0, \Pi/r]\) defined by \(D(w(F)) - F = w(F)\), such that \(D(w_0^*) - F > w_0^* \iff w_0^* < w(F)\). Furthermore, \(w(F)\) has the following properties:
  - (i) \(w(F) < \tilde{w}\), and \(w'(F) < 0\).
  - (ii) \(w(F)\) as \(F \to 0\); and \(w(F) \to 0\) as \(F \to \tilde{F}\).

**Proof.** See the online Appendix. \(\Box\)

Lemma B.2 states that if \(F \geq \tilde{F}\), then irrespective of \(w_0^* \in (0, \Pi/r]\), the DM does not implement promising opportunities, while whenever \(F < \tilde{F}\), the DM implements them if and only if the firm’s reorganization value is sufficiently low, i.e., \(w_0^* < w(F)\), where \(D(w(F)) - F = w(F)\).

**Proof of Lemma 1**

We begin by showing the first part of the statement, i.e., that for any given \(F\) there exists a unique \(w_0^* \in (0, \Pi/r]\) that satisfies \(w_0^* = pW_G^0(w_0^*) + qW_P^0(w_0^*)\).

**Part 1.** For \(w_0 \in [0, \Pi/r]\), we define:
\[
\Lambda(w_0) \equiv pW_G^0(w_0) + qW_P^0(w_0)
\]
\[
= w_0 - pE(w_0) - q \max \{D(w_0) - F, 0\}
\]

The equilibrium reorganization value \(w_0^*\) must satisfy \(\Lambda(w_0^*) = 0\).

Now, if \(F \geq \tilde{F}\), then \(\max \{D(w_0) - F, 0\} = w_0\), so \(\Lambda(w_0) = (1 - q)w_0 - pE(w_0)\). We then have \(\Lambda(0) = -pE(0) < 0\) and \(\Lambda(\Pi/r) = (1 - p - q)(\Pi/r)\), so at least one \(w_0^* \in (0, \Pi/r]\) satisfies \(\Lambda(w_0^*) = 0\).

To show uniqueness, it suffices to show that \(\Lambda(w_0)\) is strictly increasing in \(w_0\):
\[
\Lambda'(w_0) = (1 - p - q) + p(1 - E'(w_0)) = (1 - p - q) + p(1 - e^{-rP_E(w_0)}) > 0
\]

In contrast, if \(F < \tilde{F}\), then by Lemma B.2, we know that \(D(w_0) - F \geq w_0\) if and only if \(w_0 \leq w(F)\). Hence, \(\Lambda(w_0)\) can be rewritten as:
\[
\Lambda(w_0) = \begin{cases} 
  w_0 - pE(w_0) - q(D(w_0) - F) & \text{if } w_0 < w(F) \\
  (1 - q)w_0 - pE(w_0) & \text{if } w_0 \geq w(F)
\end{cases}
\]

(11)

It is easy to see that \(\Lambda(w_0)\) is continuous in \(w_0 \in [0, \Pi/r]\). Furthermore, we have that
\[
\Lambda(0) = -pE(0) - q(\tilde{F}) < 0
\]
\[
\Lambda(\Pi/r) = (1 - p - q)(\Pi/r) > 0
\]

Hence, there exists at least one \(w_0^*\) that satisfies \(\Lambda(w_0^*) = 0\), and all \(w_0^*\) are strictly between 0 and \(\Pi/r\).
To show uniqueness, we again show that $\Lambda(w_0)$ is strictly increasing in $w_0$. Take a $w_0 < w(F)$, and notice that $\Lambda(w_0)$ can then be written as $\Lambda(w_0) = (1 - p - q)w_0 + p(w_0 - E(w_0)) - q\Gamma(w_0; F)$, where $\Gamma(w_0; F) \equiv D(w_0) - F - w_0$ is defined as in Lemma B.2. But if so, then $\Lambda'(w_0) = (1 - p - q) + p(1 - e^{-\tau\phi_{\bar{w}}(w_0)}) - q\Gamma'(w_0; F) > 0$, as $\Gamma'(w_0; F) < 0$. When $w_0 > w(F)$, $\Lambda(w_0)$ can be written as $\Lambda(w_0) = (1 - p - q)w_0 + p(w_0 - E(w_0))$, so $\Lambda'(w_0) = (1 - p - q) + p(1 - e^{-\tau\phi_{\bar{w}}(w_0)}) > 0$. Hence, $\Lambda(w_0)$ is strictly increasing in $w_0$, and therefore $w_0^*$ is uniquely determined. □

Part 2. Notice first that if $F \geq \hat{F}$, then we know by Lemma B.2 that the DM never implements promising opportunities. Hence, we focus on $F \in (0, \hat{F})$. For what follows, the preliminary claim below will be useful.

Claim B.2. For $F \in (0, \hat{F})$, define

$$\Phi(F) \equiv \Lambda(w(F)) = w(F)(1 - q) - pE(w(F))$$

where $w(F)$ is defined as in Lemma B.2. Then,

(i) If $p \geq \lambda\mu(1 - q)/(r + \lambda\mu)$, then $\Phi(F) \leq 0$ for all $F \in (0, \hat{F})$.

(ii) If $p < \lambda\mu(1 - q)/(r + \lambda\mu)$, then $\Phi(F) > 0$ for $F \in (0, \hat{F})$, while $\Phi(F) \leq 0$ for $F \in [\hat{F}, \bar{F})$, where $\hat{F} \in (0, \hat{F})$ is the unique solution to $\Phi(\hat{F}) = 0$.

Proof. See the online Appendix. □

Now, for the proof of Part 2, fix an $F \in (0, \hat{F})$ and remember that in this case: (i) the DM implements $P$ opportunities whenever $w_0^* < w(F)$, and (ii) the equilibrium value for $w_0^*$ solves $\Lambda(w_0^*) = 0$, where $\Lambda(w_0)$ is defined by (11). But since $\Lambda'(w_0) > 0$, this implies that $w_0^* < w(F)$ if and only if $\Lambda(w(F)) = \Phi(F) > 0$.

Consequently, if $p \geq \lambda\mu(1 - q)/(r + \lambda\mu)$ then $\Phi(F) \leq 0$ for all $F \in (0, \hat{F})$ (Claim B.2), so implementing $P$ opportunities is never optimal for the DM. The first-best then involves reorganizing immediately again whenever the new opportunity selected after a reorganization is a promising opportunity. If, however, $p < \lambda\mu(1 - q)/(r + \lambda\mu)$, then by Claim B.2 we know that $\Phi(F) > 0$ for $F \in (0, \hat{F})$, and $\Phi(F) \leq 0$ for $F \in [\hat{F}, \bar{F})$. Hence, the DM always implements promising opportunities if $F \in (0, \hat{F})$, while she does not implement them and reorganizes again immediately if $F \in [\hat{F}, \bar{F})$. □

As already mentioned in the main text, Lemma 1 states that, for implementation of $P$ opportunities to be optimal, both $p$ and $F$ must be below some threshold. Assumption 1 can then be written as:

Assumption 1 (Alternative Version). $p < \lambda\mu(1 - q)/(r + \lambda\mu)$ and $F < \hat{F}$, where $\hat{F} \in (0, \bar{F})$ is defined by

$$(1 - q)\bar{w}(\hat{F}) = pE(\bar{w}(\hat{F}))$$

and where $w(F)$ solves $w(F) = D(w(F)) - F$.

Appendix C  Reorganization Inaction and Hyper-action

Proof of Proposition 2

As stated in the main text, we need only check whether the principal deviates from $C_\tau = 0$. So, suppose that at some $\tau \in T_R^e$, the principal deviates and offers $C'_\tau > 0$ at $(\tau, 1)$, after it is revealed that $Z_{\tau}$ is
Step 3. Use the definition \( \psi\) to solve for \( E(\psi_0)\), and write \( \hat{U}_0^P(\psi_0, 0, C'_\tau, 1)\) and \( \hat{F} \) only as functions of \( \psi'_e \) and \( \psi_0 \):

\[
\hat{U}_0^P(\psi_0, 0, C'_\tau, 1) = \frac{r \psi_0}{\psi_0 \psi'_e (r + \lambda)} \left[ 1 - \left( \frac{\Omega(\hat{\mu})}{\Omega(\psi'_e)} \right)^{1+\hat{\tau}} \right] \psi_0 \]

\[
\hat{F} = \frac{\psi_0 (r + \lambda \psi_0)}{\psi (r + \lambda)} \left[ 1 - \left( \frac{\Omega(\hat{\mu})}{\Omega(\psi)} \right)^{1+\hat{\tau}} \right] - \psi_0 \left[ 1 - \frac{\hat{\mu}}{\psi} \left( \frac{\Omega(\hat{\mu})}{\Omega(\psi)} \right)^{1+\hat{\tau}} \right]
\]
Step 4. Finally, notice that:

\[ \hat{U}_0^P(\underline{v}_0, 0, C_r', 1) - \hat{F} = \underline{v}_0 \left[ 1 - \frac{\bar{\mu}}{\psi_e} + \left( \frac{\lambda \bar{\mu} \Omega(\psi)}{r + \lambda} \right) \left( 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi)} \right)^{1+\frac{\psi}{\psi_e}} + \frac{r(\psi_e' - \psi)}{\lambda \bar{\mu} \psi_e'(1 - \psi)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e')} \right)^{1+\frac{\psi}{\psi_e'}} \right] \right) \right] \]

where the first inequality follows since \( \hat{U}_0^P(\underline{v}_0, 0, C_r', 1) - \hat{F} \) is strictly increasing in \( \psi \), and \( \psi < \psi_e \) (given that \( C_r' > 0 \)), and the last inequality follows since the first expression in the second line is strictly increasing in \( \psi_e \), and \( \psi_e' < \bar{\mu} \). Hence, \( \hat{U}_0^P(\underline{v}_0, 0, C_r', 1) - \hat{F} < 0 \).

\[ \square \]

**Proof of Proposition 3**

For ease of exposition, we split the proof into several smaller steps.

**Claim C.1.** For \( x \in (0, \bar{w}) \), where \( \bar{w} \) is defined as in Claim B.1 let

\[
\begin{align*}
J_1(x) &\equiv x - pE(x) - q\hat{V}_0^P(x, C^1(x), 1) \\
J_2(x) &\equiv x(1-q) - pE(x) \\
J_3(x) &\equiv x - pE(x) - q[i\hat{V}_0^P(x, C^1(x), 1) + (1 - i)x] , \text{ where } i \in (0,1)
\end{align*}
\]

There exists a unique \( x_i \in (0, \bar{w}) \) such that \( J_i(x_i) = 0 \). Furthermore, \( x_2 < x_3 < x_1 \), and \( J_1(x) < 0 \) for \( x < x_i \), and \( J_1(x) > 0 \) for \( x > x_i \).

**Proof.** See the online Appendix.

**Lemma C.2.** \((\bar{v}_0, F_-) \) and \((\underline{v}_0, F_+) \) are uniquely determined and well defined. Furthermore, \( \underline{v}_0 < \bar{v}_0 \) and \( F_- < F_+ < \hat{F} \).

**Proof.** First, we show that the pair \((\bar{v}_0, F_-) \) is uniquely determined and well defined. We then do the same for \((\underline{v}_0, F_+) \). Finally, we show that \( \underline{v}_0 < \bar{v}_0 \) and that \( F_- < F_+ < \hat{F} \).

Consider \((\bar{v}_0, F_-) \). Note that \( \bar{v}_0 \) must satisfy \( J_1(\bar{v}_0) = 0 \), so by Claim C.1, we know that \( \bar{v}_0 \) is well defined and unique. Furthermore, since \( \hat{U}_0^P(\bar{v}_0, C^1(\bar{v}_0), 1) \) is bounded and strictly greater than zero (see Lemma 1), there exists a unique \( F_- \in (0, \infty) \) such that \( F_- = \hat{U}_0^P(\bar{v}_0, C^1(\bar{v}_0), 1) \).

The proof for \((\underline{v}_0, F_+) \) is identical, except that \( \underline{v}_0 \) satisfies \( J_2(\underline{v}_0) = 0 \).

Now, since \( J_1(\bar{v}_0) = 0 \) and \( J_2(\underline{v}_0) = 0 \), by Claim C.1 we have \( \bar{v}_0 > \underline{v}_0 \). But because we know by Lemma 1 that \( \hat{U}_0^P(x, C^1(x), 1) \) is strictly decreasing in \( x \), we then have \( F_- = \hat{U}_0^P(\bar{v}_0, C^1(\bar{v}_0), 1) < \hat{U}_0^P(\underline{v}_0, C^1(\underline{v}_0), 1) = F_+ \), so \( F_- < F_+ \). Notice, moreover, that for all \( F > F_+ = \hat{U}_0^P(\underline{v}_0, C^1(\underline{v}_0), 1) \), it is impossible incentivize the agent to implement \( P \) opportunities if the principal’s reorganization value is \( \underline{v}_0 \), as \( \hat{U}_0^P(\underline{v}_0, C, 1) \leq \hat{U}_0^P(\underline{v}_0, C^1(\underline{v}_0), 1) = F_+ < F \) for all \( C \in \mathbb{R} \). Hence, \( F_+ \) coincides with the cutoff determined in Proposition 2, so \( F_+ < \hat{F} \). Therefore, \( F_- < F_+ < \hat{F} \).

\[ \square \]

**Lemma C.3.** If \( F \in (F_+, \hat{F}) \), then the equilibrium involves a reorganization trap. The principal offers any \( C^*_r \in \mathbb{R} \), and the agent plays \( \hat{i}^*_r = 0 \). \( v_0^* \) then satisfies \( v_0^* = pE(v_0^*) + qv_0^* \), so \( v_0^* = \underline{v}_0 \).

46
Proof. If $F \in (F_+, \bar{F})$, then $\tilde{U}_0^P(\xi_0, C, 1) \leq \tilde{U}_0^P(\xi_0, C^l(\xi_0), 1) = F_+ < F$ for all $C \in \mathbb{R}$. Hence, $\tilde{U}_0^P(\xi_0, C, 1) < F$ for all $C \in \mathbb{R}$. Furthermore, since $\tilde{U}_0^P(v_0^*, C, 1)$ is strictly decreasing in $v_0^*$, we have also that $\tilde{U}_0^P(v_0^*, C, 1) < F$ for all $C \in \mathbb{R}$. Thus, when $F \in (F_+, \bar{F})$, it is impossible to give the agent sufficient incentive to implement $P$ opportunities. This implies that any $C_2^* \in \mathbb{R}$ is best-response for the principal, and that the principal’s equilibrium reorganization value must be equal to $v_0^* = \bar{v}_0$.

\begin{lemma}
If $F \in (F_-, F_+)$, then the principal offers $C_2^* = C(v_0^*, F) = C^l(v_0^*)$, and the agent plays $i^*_t \in [0, 1)$. $(i^*_t, v_0^*)$ are uniquely pinned down by:

\begin{equation}
(i^*_t, v_0^*) : \begin{cases}
F = \tilde{U}_0^P(v_0^*, C^l(v_0^*), 1) \\
v_0^* = pE(v_0^*) + q[i^*_t \tilde{V}_0^P(v_0^*, C^l(v_0^*), 1) + (1 - i^*_t)v_0^*]
\end{cases}
\end{equation}

so $i^*_t$ is strictly decreasing in $F$, $i^*_t \to 1$ as $F \to F_-$ and $i^*_t \to 0$ as $F \to F_+$.

Proof. Consider $F \in (F_-, F_+)$ ($F = F_+ \text{ will be analyzed later}$). We begin by showing that if $F \in (F_-, F_+)$, then the agent must necessarily be mixing, implementing $P$ opportunities with probability $i^*_t \in (0, 1)$. Indeed, suppose by contradiction that there exists an equilibrium in which the agent implements these opportunities with probability 1. Then, $C_2^* = C(v_0^*, F)$ and the principal’s reorganization value $v_0^*$ must satisfy $J_4(v_0^*) = 0$, where $J_4(x) \equiv x - pE(x) - q\tilde{V}_0^P(x, C(x, F), 1)$. Because $C(x, F) \leq C^l(x)$, then $\tilde{V}_0^P(x, C(x, 1)) \geq \tilde{V}_0^P(x, C^l(x), 1)$, as $\tilde{V}_0^P(x, C, 1)$ is decreasing in $C$. Hence,

$J_4(x) - J_1(x) = -q[\tilde{V}_0^P(x, C(x, 1)) - \tilde{V}_0^P(x, C^l(x), 1)] \leq 0$

which implies, given that $J_1(x)$ crosses zero from below, that $\bar{v}_0 \leq v_0^*$. But if so, then:

$F = \tilde{U}_0^P(v_0^*, C(v_0^*, F), 1) \leq \tilde{U}_0^P(v_0^*, C^l(v_0^*), 1) \leq \tilde{U}_0^P(\bar{v}_0, C^l(\bar{v}_0), 1) = F_-$

that is, $F \leq F_-$, which is a contradiction.

Consider instead an equilibrium without implementation of $P$ opportunities. Then $v_0^* = \bar{v}_0$. But because $F \leq F_+ = \tilde{U}_0^P(\xi_0, C^l(\xi_0), 1)$, this implies that for $F < F_+$, there exists a bonus $C$ capable of leaving the agent strictly better off if he decides to incur $F$ and, therefore, that would give the principal $\tilde{V}_0^P(\xi_0, C) > \bar{v}_0$ (by Lemma 6). Thus, for $F \in (F_-, F_+)$, it cannot be an equilibrium for the agent not to implement $P$ opportunities.

Hence, for $F \in (F_-, F_+)$, if an equilibrium exists, it must involve (strict) mixing from the side of the agent. From Lemma 6, we then have $C_2^* = C(v_0^*, F) = C^l(v_0^*)$, so the principal’s reorganization value must then satisfy $v_0^* = pE(v_0^*) + q[i^*_t \tilde{V}_0^P(v_0^*, C^l(v_0^*), 1) + (1 - i^*_t)v_0^*]$. Since the principal clearly is playing optimally (either increasing or decreasing $C_2^*$ would induce the agent not to implement these opportunities) and so is the agent (he is indifferent to implementing or not), then to show existence and uniqueness of the equilibrium, it suffices to show that there exists a unique $(i_t^*, v_0^*)$ satisfying (14).

But showing this is easy: First, since $\tilde{U}_0^P(v_0^*, C^l(v_0^*), 1)$ is strictly decreasing in $v_0^*$, there exists a unique $v_0^*$ such that $\tilde{U}_0^P(v_0^*, C^l(v_0^*), 1) = F$. Furthermore, since $F \in (F_-, F_+)$, we have that $v_0^* \in (\xi_0, \bar{v}_0)$. For $x \in [0, 1]$, define then:

$M(x; v_0^*) = v_0^* - pE(v_0^*) - q[x\tilde{V}_0^P(v_0^*, C^l(v_0^*), 1) + (1 - x)v_0^*]$

We then have that $M(0; v_0^*) > 0$, given that $v_0^* > \xi_0$; that $M(1; v_0^*) < 0$, given that $v_0^* < \bar{v}_0$; and that
Proof. From the properties of \( M(x; v_0^*) \) and the fact that \( M(i^*_x; v_0^*) = 0 \), it is then easy to prove that \( i^*_x \) is strictly decreasing in \( F \), \( i^*_x \to 1 \) as \( F \to F_- \), and \( i^*_x \to 0 \) as \( F \to F_+ \).

Now considering \( F = F_+ \), we claim that in such a case, the unique equilibrium is for the agent to not implement \( P \) opportunities (i.e., \( i^*_x = 0 \)), despite the existence of a bonus that makes him indifferent between implementing or not (and that, if accepted, would make the principal strictly better off). Indeed, because \( F_+ = \tilde{U}_0^P(\tilde{v}_0, C^I(\tilde{v}_0), 1) \), then a bonus \( \tilde{C}(v_0^*, F) \neq \emptyset \) if and only if \( v_0^* = \tilde{v}_0 \). Additionally, in any equilibrium in which the agent implements \( P \) opportunities with strictly positive probability, \( v_0^* > 2\tilde{v}_0 \). Thus, when \( F = F_+ \), the equilibrium involves no implementation by the agent, despite the existence of a bonus making him indifferent between incurring \( F \) or not. It is important to note, finally, that the equilibrium is continuous, given that \( i^*_x \to 0 \) as \( F \to F_+ \).

\[ \text{Lemma C.5. If } F \in (0, F_-], \text{ the principal offers } C^*_x = \tilde{C}(v_0^*, F) < C^I(v_0^*) \text{ and the agent plays } i^*_x = 1. \]

\[ \text{Proof.} \text{ We begin by showing that in any equilibrium, the agent must be implementing } P \text{ opportunities with probability } 1. \text{ Suppose first that in equilibrium, the agent never implements this type of opportunity. The principal’s reorganization value is then } v_0. \text{ But since } \tilde{U}_0^P(v_0^*, C^I(v_0^*)) \text{ is strictly decreasing in } v_0^*, \text{ and } v_0 < v_0 \text{, we have } \tilde{U}_0^P(v_0^*, C^I(v_0^*), 1) > \tilde{U}_0^P(v_0, C^I(v_0), 1) = F_- \geq F. \text{ This implies that when the principal’s reorganization value is } v_0, \text{ there exists a bonus } C \text{ capable of inducing the agent to incur } F \text{ with probability } 1. \text{ Thus, it cannot be an equilibrium from the agent not to incur } F, \text{ as the principal would deviate and offer the bonus } C, \text{ given that } \tilde{U}_0^P(v_0, C, 1) > v_0 \text{ (by Lemma 6).} \]

Suppose instead that in equilibrium, the agent mixes between implementing or not. Then \( C^*_x = \tilde{C}(v_0^*, F) = C^I(v_0^*) \), so the principal’s reorganization value must satisfy:

\[ v_0^* = pE(v_0^*) + q[\tilde{i}^*_x \tilde{V}_0^P(v_0^*, C^I(v_0^*), 1) + (1 - i^*_x)v_0^*] \]

But if so, then \( v_0^* < v_0 \) (by Claim C.1) and therefore:

\[ F = \tilde{U}_0^P(v_0^*, C^I(v_0^*), 1) > \tilde{U}_0^P(v_0, C^I(v_0), 1) = F_- \]

that is, \( F > F_- \); a contradiction. Hence, when \( F \in (0, F_-] \) in any equilibrium, the agent must be incurring \( F \) with probability 1.

Fix then a \( F \in (0, F_-] \), and suppose that the agent is incurring \( F \) with probability 1. By Lemma 6, we know that \( C^*_x = \tilde{C}(v_0^*, F) \). Notice then that \( \tilde{C}(x, F) \neq \emptyset \) if and only if \( x \in [0, \bar{x}] \), where \( \bar{x} \equiv \bar{x}(F) \) is given by \( F = \tilde{U}_0^P(\bar{x}, C^I(\bar{x}), 1) \). Moreover, \( \tilde{C}(x, F) < C^I(x) \) for all \( x < \bar{x} \), and \( \tilde{C}(\bar{x}, F) = C^I(\bar{x}) \). Furthermore, since \( F < F_- \), then \( \bar{x} > v_0 \).

The principal’s reorganization value \( v_0^* \) must then satisfy \( J_4(v_0^*) = 0 \), where \( J_4(x) = x - pE(x) - q\tilde{V}_0^P(x, \tilde{C}(x, F), 1) \). Suppose that such \( v_0^* \) exists. Clearly, both players are playing optimally, given \( v_0^* \); the principal has no incentive to increase or decrease \( C^*_x = \tilde{C}(v_0^*, F) \), and the agent is indifferent to incurring \( F \) or not. Hence to show existence and uniqueness of the equilibrium, it suffices to show that there exists a unique \( v_0^* \), satisfying \( J_4(v_0^*) = 0 \). We will do this in two steps. First, we will show that if such \( v_0^* \) exists, then it must be unique. Afterward, we will show its existence.

\[ \text{Claim C.2. Fix a } F \in (0, F_-]. \text{ If there exists a } v_0^* \text{ satisfying } J_4(v_0^*) = 0, \text{ then such } v_0^* \text{ is unique.} \]

\[ \text{Proof.} \text{ See the online Appendix.} \]
Hence, if a $v_0^*$ such that $J_4(v_0^*) = 0$ exists, then it must be unique. Finally, we tackle existence. We claim that $J_4(\bar{v}_0) \leq 0$ and that $J_4(\bar{x}) \geq 0$, implying that there exists a $v_0^*$ such that $J_4(v_0^*) = 0$. Indeed, notice that:

$$J_1(\bar{v}_0) - J_4(\bar{v}_0) = q[V_0^P(\bar{v}_0, C(\bar{v}_0, F), 1) - \bar{V}_0^P(\bar{v}_0, C(\bar{v}_0), 1)] \geq 0$$

given that $C(\bar{v}_0, F) \leq C(\bar{v}_0)$, and the fact that $\bar{V}_0^P(\bar{v}_0, C, 1)$ is strictly decreasing in $C$. But $J_1(\bar{v}_0) = 0$, hence $J_4(\bar{v}_0) \leq 0$. Also notice that $J_4(\bar{x}) = J_1(\bar{x}) \geq 0$, given that $C(\bar{x}, F) = C(\bar{x})$, and that $\bar{x} \geq \bar{v}_0$. Hence, there exists a $v_0^*$ such that $J_4(v_0^*) = 0$. \qed
References


1 Convergence of the Auxiliary $\Delta$-Game

Suppose that the principal is forced to wait at least $\Delta > 0$ between two different reorganizations. Fix then a $\tau \in T^\infty_R$ and a pair of equilibrium reorganization values $(v_0^*, u_0^*)$, and consider the principal’s reorganization problem immediately after $\tau$, i.e., at time $\tau^+$. Using the same procedure as the one developed in section 3.3 it is easy to prove the following Lemma:

**Lemma O.1.** Fix a $\tau \in T^\infty_R$ and a pair of equilibrium reorganization values $(v_0^*, u_0^*)$, and suppose that at $(\tau, 1)$ the principal offers the bonus $C_\tau$. Then, for $\varphi_E^*(v_0^*)$ defined by (4) and $\varphi_{DP}^*(v_0^*, C_\tau)$ defined by (6), we have:

- If $Z_\tau$ is $G$, the principal reorganizes again at $\tau + \max\{\Delta, \varphi_E^*(v_0^*)\}$.
- If $Z_\tau$ is $P = \{P_D, P_N\}$, and the agent does not implement the opportunity, the principal reorganizes again at $\tau + \Delta$.
- If $Z_\tau$ is $P = \{P_D, P_N\}$, and the agent implements the opportunity, the principal reorganizes again at $\tau + \max\{\varphi_{DP}^*(v_0^*, C_\tau), \Delta\}$ if no breakthrough arrives; and reorganizes again at $t + \max\{\varphi_E^*(v_0^*), \Delta\}$ if a breakthrough occurs at $t \in [\tau, \max\{\varphi_{DP}^*(v_0^*, C_\tau), \Delta\}]$.

Now, we know that $v_0^* < \Pi/r$ which implies that $\varphi_E^*(v_0^*) > 0$. Hence, there exists a $\tilde{\Delta} > 0$, such $\Delta \leq \varphi_E^*(v_0^*)$, for all $\Delta \leq \tilde{\Delta}$. Therefore, when $\Delta \leq \tilde{\Delta}$, the principal’s and the agent’s continuation values at $\tau^+$ when $Z_\tau$ is $G$ are then $E(v_0^*)$ and $u_0^* e^{-r \varphi_E^*(v_0^*)}$, respectively, just as in the main text. Furthermore, it is not difficult to prove that in any equilibrium in which the agent implements a $P$ opportunity with strictly positive probability, he must be indifferent between implementing or not. The latter immediate implies that $u_0^* = 0$.

Fix then $\Delta \leq \tilde{\Delta}$. We then have that $V_0^G(v_0^*; \Delta) = E(v_0^*)$ and $U_0^G(v_0^*; \Delta) = 0$; that $\tilde{V}_0^P(v_0^*, C_\tau, 0; \Delta) = v_0^* e^{-r \Delta}$ and $\tilde{U}_0^P(v_0^*, C_\tau, 0; \Delta) = 0$; and that:

\[
\tilde{V}_0^P(v_0^*, C_\tau, 1; \Delta) = \begin{cases}
\frac{\lambda \tilde{\mu}(E(v_0^*) - C_\tau)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\tilde{\mu})}{\Omega(\psi_e)} \right)^{1+\frac{1}{2}} \right] + \frac{\tilde{\mu} v_0^*}{\psi_e} \left( \frac{\Omega(\tilde{\mu})}{\Omega(\psi_e)} \right)^{1+\frac{1}{2}} & \text{if } \tilde{\mu} - \varepsilon(\Delta) > \psi_e \\
\frac{\lambda \tilde{\mu} C_\tau}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\tilde{\mu})}{\Omega(\psi_e)} \right)^{1+\frac{1}{2}} \right] & \text{if } \tilde{\mu} \leq \psi_e
\end{cases}
\]

\[
\tilde{U}_0^P(v_0^*, C_\tau, 1; \Delta) = \begin{cases}
\frac{\lambda \tilde{\mu} C_\tau}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\tilde{\mu})}{\Omega(\psi_e)} \right)^{1+\frac{1}{2}} \right] & \text{if } \tilde{\mu} - \varepsilon(\Delta) > \psi_e \\
0 & \text{if } \tilde{\mu} \leq \psi_e
\end{cases}
\]

where:

\[
\psi_e \equiv \psi_e(v_0^*, C_\tau) = \frac{r v_0^*}{\lambda(E(v_0^*) - C_\tau - v_0^*)}
\]

and $\varepsilon(\Delta) > 0$, but $\lim_{\Delta \to 0} \varepsilon(\Delta) = 0$.

Define then:

\[
C^I(v_0^*; \Delta) \equiv \arg\max_{C_\tau} \tilde{U}_0^P(v_0^*, C, 1; \Delta) \quad C(v_0^*, F; \Delta) \equiv \min \{ C : \tilde{U}_0^P(v_0^*, C, 1; \Delta) = F \}
\]

It is then not difficult to derive Lemmas analogous to Lemmas 5 and 6. We then have the following Proposition:
Proposition O.1. Let

\[
\begin{align*}
(i_0^\Delta, F^-) : & \quad F^\Delta = \bar{U}_0^r(v_0^\Delta, C^r(v_0^\Delta; \Delta), 1; \Delta) \\
& \quad \bar{v}_0^\Delta = pE(v_0^\Delta) + q\bar{V}_0^r(v_0^\Delta, C^r(v_0^\Delta; \Delta), 1; \Delta) \\
(ii_0^\Delta, F^-) : & \quad F^\Delta = \bar{U}_0^r(v_0^\Delta, C^r(v_0^\Delta; \Delta), 1; \Delta) \\
& \quad (1 - q)v_0^\Delta = pE(v_0^\Delta) + qv_0^\Delta (1 - e^{-r\Delta})
\end{align*}
\]

where \( 0 < F^\Delta < F^\Delta_- < F^\Delta_+ \). When at \( \tau \in T^\infty_R \) the new opportunity selected \( Z_\tau \) is \( P = \{P_D, P_N\} \), the unique equilibrium of the ensuing subgame is as follows:

(i) If \( F \in (0, F^\Delta_+) \), the principal offers \( C^r_\tau = \mathbb{C}(v_0^\Delta, F; \Delta) < C^r(v_0^\Delta; \Delta) \), and the agent plays \( i_\tau^* = 1 \). \( v_\tau^* \) is then uniquely pinned down by \( v_\tau^* = pE(v_\tau^*0) + q\bar{V}_0^r(v_\tau^*0, \mathbb{C}(v_\tau^*0, F), 1; \Delta) \).

(ii) If \( F \in (F^\Delta_+, F^\Delta) \), then the principal offers \( C^r_\tau = \mathbb{C}(v_0^\Delta, F; \Delta) = C^r(v_0^\Delta; \Delta) \), and the agent plays \( i_\tau^* \in [0, 1) \). \( (i_\tau^*, v_\tau^*) \) are uniquely pinned down by:

\[
(i_\tau^*, v_\tau^*) : \quad \begin{cases} 
F = \bar{U}_0^r(v_\tau^*, C^r(v_\tau^*; \Delta), 1; \Delta) \\
v_\tau^* = pE(v_\tau^*0) + q(i_\tau^*\bar{V}_0^r(v_\tau^*0, C^r(v_\tau^*0), 1) + (1 - i_\tau^*)v_\tau^*0e^{-r\Delta})
\end{cases}
\]

so \( i_\tau^* \) is strictly decreasing in \( F \), \( i_\tau^* \rightarrow 1 \) as \( F \rightarrow F^\Delta_+ \), and \( i_\tau^* \rightarrow 0 \) as \( F \rightarrow F^\Delta_- \).

(iii) If \( F \in (F^\Delta_+, F^\Delta) \), then the equilibrium involves a reorganization trap. The principal offers any \( C^r_\tau \in \mathbb{R} \), and the agent plays \( i_\tau^* = 0 \). \( v_\tau^* \) then satisfies \( v_\tau^* = pE(v_\tau^*0) + qv_\tau^*0e^{-r\Delta} \), so \( v_\tau^* = v^\Delta_\tau \).

Proof. The proof is almost identical to the one of Proposition 3, and is therefore omitted.

Thus when \( \Delta \leq \hat{\Delta} \) the equilibrium is unique, and when we take \( \Delta \rightarrow 0 \), it coincides with the equilibrium we characterized in the first-best.

2 Remaining Proofs of Section 2.3

Proof of Lemma B.1

Fix a reorganization value \( w_0 \in (0, \Pi/r] \), and consider the DM’s problem at time \( T_\tau \) at which opportunity \( z \) started delivering profits for the first time. Notice that at \( T_\tau \) either (i) \( z \) was just selected, and it turned out to be \( G \); or (ii) \( z \) was first selected prior to \( T_\tau \), is type \( P = \{P_D, P_N\} \), and the firm was able to successfully develop it. Thus \( T_\tau \in T^\infty_R \cup T^\infty_C \).

The DM then has to decide how long to exploit this opportunity, \( \phi_E \geq 0 \), before reorganizing the firm again:

\[
\max_{\phi_E \geq 0} \left\{ \int_{T_\tau}^{T_\tau + \phi_E} \Pi e^{-(r + \eta)(t - T_\tau)} dt + w_0^*e^{-r\phi_E} \right\}
\]

where \( \phi_E = +\infty \) if the DM chooses to pursue this opportunity forever. Solving we obtain \( \phi^*_E(w_0^*) = \eta^{-1} \ln(\Pi/rw_0^*) \), so the DM’s continuation value at \( T_\tau \) is:

\[
\int_{T_\tau}^{T_\tau + \phi^*_E(w_0^*)} \Pi e^{-(r + \eta)(t - T_\tau)} dt + w_0^*e^{-r\phi^*_E(w_0^*)} = \frac{\Pi}{r + \eta} + \left( \frac{\eta}{r + \eta} \right) w_0^*e^{-r\phi^*_E(w_0^*)} \equiv E(w_0^*)
\]
Thus, the DM obtains $E(w^*_0)$ whenever she reorganizes the firm and the new opportunity selected is $G$, i.e., $W^G_0(w^*_0) = E(w^*_0)$; or when she is able to successfully develop a promising opportunity.

Consider now the DM’s problem at $\tau \in T_R^*$, that is, immediately after a reorganization, when $Z_\tau$ is type $P = \{P_D, P_N\}$. The DM must decide whether to implement this opportunity or not.

When the DM implements at $\tau$, her problem at $\tau^+$ is to decide how long to wait for a breakthrough. Thus, the DM solves:

$$\max_{\phi_{DP} \geq 0} \left\{ \int_\tau^{\tau + \phi_{DP}} \lambda \mu_t E(w^*_0)e^{-\int_\tau^{\tau + \phi_{DP}} (\lambda \mu_t + \tau)dt} + w^*_0 e^{-\int_\tau^{\tau + \phi_{DP}} (\lambda \mu_t + \tau)dt} \right\}$$

where

$$\mu_t = \frac{\bar{\mu}}{\bar{\mu} + e^{\lambda(t - \tau)}(1 - \bar{\mu})}$$

The solution then involves a cutoff strategy: wait for a breakthrough if $\mu_t > \psi(w^*_0)$, and reorganize otherwise, where:

$$\psi(w^*_0) \equiv \frac{rw^*_0}{\lambda(E(w^*_0) - w^*_0)}$$

So the DM waits:

$$\phi^*_{DP}(w^*_0) = \lambda^{-1} \ln \left( \frac{\Omega(\psi(w^*_0))}{\Omega(\bar{\mu})} \right)$$

for a breakthrough since the moment the implementation is made at $\tau$, and where $\Omega(x) = (1 - x)/x$. The DM’s continuation value at $\tau^+$ if the she decides to implement is then:

$$D(w^*_0) = \int_\tau^{\tau + \phi^*_{DP}(w^*_0)} \lambda \mu_t E(w^*_0)e^{-\int_\tau^{\tau + \phi^*_{DP}(w^*_0)} (\lambda \mu_t + \tau)dt} + w^*_0 e^{-\int_\tau^{\tau + \phi^*_{DP}(w^*_0)} (\lambda \mu_t + \tau)dt}$$

which can be written as:

$$D(w^*_0) = \left\{ \begin{array}{ll}
\frac{\lambda \bar{\mu} E(w^*_0)}{r+\lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi(w^*_0))} \right)^{1+\frac{1}{\lambda}} \right] + \frac{\bar{\mu}w^*_0}{\psi(w^*_0)} \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi(w^*_0))} \right)^{1+\frac{1}{\lambda}} & \text{if } \bar{\mu} > \psi(w^*_0) \\
w^*_0 & \text{if } \bar{\mu} \leq \psi(w^*_0) \end{array} \right.$$ 

Consider then the decision of whether to implement at $\tau$ or not. Clearly, the DM is going to reorganize if she does not incurs $F$. This is because the firm will never generate profits pursuing the new opportunity just selected, and the reorganization value of the firm is strictly positive $w^*_0 > 0$. Consequently, the DM obtains $D(w^*_0) - F$ in she implements, and $w^*_0$ if she does not. Thus, $W^F_0(w^*_0) = \max\{D(w^*_0) - F, w^*_0\}$.

\[\square\]

**Proof of Lemma B.2**

For $w^*_0 \in [0, \Pi/r]$ define $\Gamma(w^*_0; F) \equiv D(w^*_0) - F - w^*_0$. Clearly, $\Gamma(w^*_0; F)$ is continuous. Furthermore

$$\Gamma(0; F) = \left( \frac{\lambda \bar{\mu}}{r+\lambda} \right) \left( \frac{\Pi}{r+\eta} \right) - F = \hat{F} - F$$

(where we are using the fact that $\psi(0) = 0$)

$$\Gamma(w^*_0; F) = -F < 0$$

for $w^*_0 \in [\bar{w}, \Pi/r]$
Moreover, notice that for \( w_0^* \in [0, \bar{w}) \) we have:

\[
\Gamma'(w_0^*; F) = \left( \frac{\bar{\mu}}{\psi(w_0^*)} \right) \left( \frac{r + \lambda \psi(w_0^*) e^{-r \phi_E(w_0^*)}}{r + \lambda} \right) - \frac{\left( r + \lambda \bar{\mu} e^{-r \phi_E(w_0^*)} \right)}{r + \lambda}
\]

But \( \Gamma'(w_0^*; F) \) is increasing in \( \psi(w_0^*) \), and \( \psi(w_0^*) < \bar{\mu} \) (as \( w_0^* < \bar{w} \)). Thus:

\[
\Gamma'(w_0^*; F) < \left( \frac{r + \lambda - \lambda \bar{\mu} e^{-r \phi_E(w_0^*)}}{r + \lambda} \right) - \left( \frac{r + \lambda - \lambda \bar{\mu} e^{-r \phi_E(w_0^*)}}{r + \lambda} \right) = 0
\]

so \( \Gamma(w_0^*; F) \) is strictly decreasing in \([0, \bar{w})\).

Consequently, if \( \bar{F} \leq F \), then \( \Gamma(0; F) \leq 0 \) so \( \Gamma(w_0^*; F) < 0 \) for all \( w_0^* \in (0, \Pi/r) \). While if \( \bar{F} > F \), then there exists a unique \( \bar{w}(F) \) defined by \( D(\bar{w}(F)) - F = \bar{w}(F) \), which lies strictly between 0 and \( \bar{w} \), such that \( \Gamma(w_0^*; F) > 0 \iff w_0^* < \bar{w}(F) \).

Finally, from \( \Gamma(w(F); F) = 0 \), the fact that \( \Gamma'(w(F); F) < 0 \), and that \( \Gamma(w_0^*; F) \) is strictly decreasing in \( F \), we immediately get \( \bar{w}'(F) < 0 \). Furthermore as \( F \to 0 \), then the only way for \( \Gamma(w(F); F) \to 0 \) is that \( D(\bar{w}(F)) \to \bar{w}(F) \), implying that \( \psi(\bar{w}(F)) \) must be converging to \( \bar{\mu} \), or equivalently, that \( \bar{w}(F) \to \bar{w} \).

And as \( F \to \bar{F} \), then \( \Gamma(0; F) \to 0 \), implying that \( \bar{w}(F) \to 0 \).

\[ \square \]

**Proof of Claim B.2**

Remember that by Lemma B.2, we have that \( \bar{w}(F) \to \bar{w} \) as \( F \to 0 \); and \( \bar{w}(F) \to 0 \) as \( F \to \bar{F} \), and that \( \bar{w}'(F) < 0 \). But then:

\[
\Phi(0) \equiv \lim_{F \downarrow 0} \bar{w}(1 - q) - pE(\bar{w}) \geq 0
\]

\[
\Phi(\bar{F}) \equiv \lim_{F \uparrow \bar{F}} -pE(0) < 0
\]

\[
\Phi'(F) = \bar{w}'(F) \left[ 1 - q - p e^{-r \phi_E(\bar{w}(F))} \right] < 0
\]

Because \( \Phi'(F) < 0 \), whenever \( \Phi(0) \leq 0 \) then \( \Phi(F) < 0 \) for all \( F \in (0, \bar{F}) \). While, if \( \Phi(0) > 0 \), then because \( \Phi(\bar{F}) < 0 \), we know that there exists a unique \( \tilde{F} \in (0, \bar{F}) \) such that \( \Phi(\tilde{F}) = 0 \), and that \( \Phi(F) > 0 \) for \( F \in (0, \tilde{F}) \), and \( \Phi(F) \leq 0 \) for \( F \in (\tilde{F}, \bar{F}) \).

Finally, notice that \( \bar{w} \) satisfies \( \psi(\bar{w}) = \bar{\mu} \) (see Claim B.1), that is:

\[
\psi(\bar{w}) = \frac{r \bar{w}}{\lambda (E(\bar{w}) - \bar{w})} = \bar{\mu} \implies E(\bar{w}) = \bar{w} \left( 1 + \frac{r}{\lambda \bar{\mu}} \right)
\]

Therefore,

\[
\Phi(0) = \bar{w}(1 - q) - pE(\bar{w}) = \frac{\bar{w}(\lambda \bar{\mu}(1 - q) - (r + \lambda \bar{\mu})p)}{\lambda \bar{\mu}}
\]

But since \( \bar{w} > 0 \), then \( \Phi(0) \leq 0 \) if and only if \( p \geq \lambda \bar{\mu}(1 - q)/(r + \lambda \bar{\mu}) \).

\[ \square \]

**Proof of Proposition 1**

Given Assumption 1, we know that the DM always implement \( P \) opportunities. Then from the proof of Lemma B.1 we conclude that that at every \( \tau \in T_R^\infty \) at which a reorganization takes place:

- If \( Z_\tau \) is \( G \), the DM reorganizes again at \( \tau + \phi_E \).
If \( Z_\tau \) is \( P = \{P_D, P_N\} \), the DM incurs \( F \). She then reorganizes again at \( \tau + \phi_{DP}^* \) if no breakthrough arrives; and reorganizes again at \( t + \phi_E^* \) if a breakthrough occurs at \( t \in [\tau, \tau + \phi_{DP}^*] \).

Where \( \phi_E^* \equiv \phi_E^*(w_0^*) = \eta^{-1}(\Pi/w_0^*) > 0 \), and

\[
\phi_{DP}^* \equiv \phi_{DP}^*(w_0^*) = \lambda^{-1} \ln \left( \frac{\Omega(\psi(w_0^*))}{\Omega(\bar{\psi})} \right)
\]

where \( \Omega(\bar{\psi}) = \frac{1 - x}{x} \).

\[\square\]

### 3 Remaining Proofs of Section 3

#### Proof of Lemma 5

**Part (i)** Fix a \( C_\tau \) such that \( \tilde{U}_0^P(v_0^*, C_\tau, 1) > 0 \). Then:

\[
\frac{\partial}{\partial v_0} \tilde{U}_0^P(v_0^*, C_\tau, 1) = -\frac{(1 - \bar{\mu})C_\tau}{(1 - \psi_\bar{v}(v_0^*, C_\tau))^2} \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_\bar{v}(v_0^*, C_\tau))} \right)^{1+\bar{\tau}} \frac{\partial}{\partial v_0} \psi_\bar{v}(v_0^*, C_\tau)
\]

which is strictly negative, as:

\[
\frac{\partial}{\partial v_0} \psi_\bar{v}(v_0^*, C_\tau) = \psi_\bar{v}(v_0^*, C_\tau) \left( 1 + \frac{\lambda \psi_\bar{v}(v_0^*, C_\tau)(1 - e^{-\bar{v}_e(v_0^*)})}{\bar{\tau}} \right) > 0
\]

\[\square\]

**Part (ii)** Because we will need some additional properties, we will actually prove the following stronger result:

**Lemma 1.** For a given \( v_0^* \in [v_0, \bar{w}] \), where \( \bar{w} \) is defined as in Claim B.1, there exists a unique \( C_1^*(v_0^*) \) that solves \( \max_C \tilde{U}_0^P(v_0^*, C, 1) \). \( C_1^*(v_0^*) \) is necessarily contained in the open interval \( (0, \tilde{C}(v_0^*)) \), where \( \tilde{C}(v_0^*) \equiv E(v_0^*) - v_0^*[1 + r/\lambda\bar{\mu}] > 0 \), and satisfies the first-order necessary condition. Furthermore \( \tilde{U}_0^P(v_0^*, C_1^*(v_0^*), 1) \) is strictly greater than zero, and strictly decreasing in \( v_0^* \). Finally \( \psi_\bar{v}(v_0^*, C_1^*(v_0^*)) \) is strictly increasing in \( v_0^* \), and:

\[
(C_1^*(v_0^*), \psi_\bar{v}(v_0^*, C_1^*(v_0^*))) \to (0, \bar{\mu}) \text{ as } v_0^* \to \bar{w}
\]

where \( \bar{w} \) is defined as in Claim B.1, that is, it solves:

\[
\bar{\mu} = \frac{r\bar{w}}{\bar{\lambda}(E(\bar{w}) - \bar{w})}
\]

Notice that under Assumption 1 then \( D(w_0^*) - F > w_0^* \) always. But this immediately implies that \( \psi(w_0^*) < \bar{\mu} \), or equivalently \( w_0^* < \bar{w} \), where \( \psi(\bar{w}) = \bar{\mu} \). Hence, the interval \([v_0, w_0^*]\) is contained in \([v_0, \bar{w}]\).

**Proof.** Fix a \( v_0^* \in [v_0, \bar{w}] \). We first show that \( \max_C \tilde{U}_0^P(v_0^*, C, 1) \) has a local maxima \( C_1^*(v_0^*) \in (0, \tilde{C}(v_0^*)) \), where \( \tilde{C}(v_0^*) \equiv E(v_0^*) - v_0^*[1 + r/\lambda\bar{\mu}] > 0 \), satisfying the necessary first-order condition. Notice that \( \tilde{C}(v_0^*) > 0 \) follows from \( v_0^* < \bar{w} \). We then show that such local maxima is indeed the unique optimum. Finally, we use the envelop theorem to show that \( \tilde{U}_0^P(v_0^*, C_1^*(v_0^*), 1) \) is strictly decreasing in \( v_0^* \).

Begin by restricting attention to \( C \in (0, \tilde{C}(v_0^*)) \). Using \( \psi_\bar{v}(v_0^*, C) \) to solve for \( C \), we get \( C = \)
Notice then that
\[ C \left[ \lambda \right] \] implying that
\[ K \left[ \psi \right] \] condition
\[ \psi \] which implies, given that \[ \psi \] and that \[ \psi \] envelope theorem to obtain:
\[ \frac{r \bar{\mu} v_0^*}{(r + \lambda) \psi_e^2} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} \right] - \frac{\bar{\mu}}{\Omega(\psi_e) \psi_e^2} \left[ E(v_0^*) - v_0^* \left( 1 + \frac{r}{\lambda \psi_e} \right) \right] \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} = K(\psi_e; v_0^*) \]

Then:
\[ K(\psi(v_0^*); v_0^*) = \frac{\lambda^2 \bar{\mu} (E(v_0^*) - v_0^*)^2}{rv_0^*(r + \lambda)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi(v_0^*))} \right)^{1+\tilde{z}} \right] > 0 \]
\[ K(\bar{\mu}; v_0^*) = -\left( \frac{1}{1 - \bar{\mu}} \right) \left[ E(v_0^*) - v_0^* \left( 1 + \frac{r}{\lambda \psi_e} \right) \right] < 0 \]

which implies that there exists at least one \( \psi_e^* \) strictly between \( \psi(v_0^*) \) and \( \bar{\mu} \), such that the first-order condition \( K(\psi_e^*; v_0^*) = 0 \) is satisfied. To show that \( \psi_e^* \) is unique, notice that:
\[ K'(\psi_e^*; v_0^*) = -\frac{rv_0^* \psi_e^*}{\lambda(\psi_e^2)^4 \Omega(\psi_e^2)(r + \lambda)} \left[ r + 2\lambda + r \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e^2)} \right)^{1+\tilde{z}} \right] < 0 \]

implying that \( K(\psi_e; v_0^*) \) crosses zero once, and that \( \psi_e^* \) is a local maximum. Furthermore, since \( \psi_e^* > \psi(v_0^*) \), and the objective is zero when \( \psi_e = \psi(v_0^*) \), we conclude that in this local maxima the objective is strictly greater than zero.

Finally, notice that:
\[ \frac{\partial}{\partial v_0^*} K(\psi_e; v_0^*) \]
\[ = \frac{r \bar{\mu}}{(\psi_e^2)^2 (r + \lambda)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} \right] + \frac{r}{\psi_e^*(1 - \psi_e^*)} \left[ 1 + \frac{r}{\lambda \psi_e^*} - E'(v_0^*) \right] \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} \]
\[ = \frac{r \bar{\mu}}{(\psi_e^2)^2 (r + \lambda)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} \right] + \frac{r}{\psi_e^*(1 - \psi_e^*)} \left[ 1 + \frac{r}{\lambda \psi_e^*} - e^{-r \varphi E(v_0^*)} \right] \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1+\tilde{z}} > 0 \]

which implies, given that \( K(\psi_e; v_0^*) \) cuts zero from above, that \( \psi_e^* \) is strictly increasing in \( v_0^* \). Hence, we know that \( \tilde{U}_0^P (v_0^*, C, 1) \) has a local maxima \( C^1(v_0^*) \in (0, \tilde{C}(v_0^*)) \), which satisfies the necessary first-order condition, and that \( \tilde{U}_0^P (v_0^*, C^1(v_0^*), 1) > 0 \) and \( \psi_e^* = \psi_e(v_0^*, C^1(v_0^*)) \) are strictly increasing \( v_0^* \).

To show that such candidate is indeed the optimum, notice that \( \tilde{U}_0^P (v_0^*, C, 1) = 0 \) for all \( C \geq \tilde{C}(v_0^*) \), hence \( C^1(v_0^*) \) strictly dominates all \( C \geq \tilde{C}(v_0^*) \). And \( \tilde{U}_0^P (v_0^*, C, 1) \leq 0 \) for \( C \leq 0 \), so \( C^1(v_0^*) \) strictly dominates them as well. And because \( C^1(v_0^*) \) satisfies the necessary first order condition, we can use the envelope theorem to obtain:
\[ \frac{\partial}{\partial v_0^*} \tilde{U}_0^P (v_0^*, C^1(v_0^*), 1) = -\left( \frac{r \bar{\mu}}{(r + \lambda)} \right) \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e^2)} \right)^{1+\tilde{z}} \right] \left[ 1 + \frac{r}{\lambda \psi_e^*} - e^{-r \varphi E(v_0^*)} \right] < 0 \]
where $\psi^*_e \equiv \psi_e(v_0^*, C^i(v_0^*))$. Thus $\bar{U}_0^P(v_0^*, C^i(v_0^*), 1)$ is strictly decreasing in $v_0^*$.

Finally, notice that $\bar{C}(v_0^*) \to 0$, and that $\psi(v_0^*) \to \bar{\mu}$, as $v_0^* \to \bar{w}$. Since $C^i(v_0^*) \in (0, \bar{C}(v_0^*))$, and $\psi_e(v_0^*, C^i(v_0^*)) \in (\psi(v_0^*), v_0^*)$, then $C^i(v_0^*) \to 0$, and $\psi_e(v_0^*, C^i(v_0^*)) \to \bar{\mu}$, as $v_0^* \to \bar{w}$.

\begin{proof}[Proof of Lemma 6]

\textbf{Part (i).} Notice first that $\bar{V}_0^P(v_0^*, C, 1) > v_0^*$ if and only if $\psi_e(v_0^*, C) < \bar{\mu}$. Now if $\{ C : \bar{U}_0^P(v_0^*, C, 1) = F \} \neq \emptyset$, then for all $C' \in \{ C : \bar{U}_0^P(v_0^*, C, 1) = F \}$ we have $\psi_e(v_0^*, C') < \bar{\mu}$; otherwise $\bar{U}_0^P(v_0^*, C', 1) = 0 < F$, a contradiction. But then $\bar{V}_0^P(v_0^*, C') > v_0^*$ for all $C' \in \{ C : \bar{U}_0^P(v_0^*, C, 1) = F \}$.

\textbf{Part (ii).} Suppose there is an equilibrium where at $\tau \in T^\infty_\tau$ the principal offers $C^*_\tau$ and the agent implements $P$ opportunities with strictly positive probability. Then $\bar{U}_0^P(v_0^*, C^*_\tau, 1) \geq F$. But we already saw that in any equilibrium $\bar{U}_0^P(v_0^*, C^*_\tau, 1) \leq F$. Hence, it must be that $C^*_\tau$ is such that $\bar{U}_0^P(v_0^*, C^*_\tau, 1) = F$.

Moreover, since $\bar{V}_0^P(v_0^*, C, 1)$ is strictly decreasing in $C$, in equilibrium the principal necessarily offers $C^*_\tau = \min\{ C : \bar{U}_0^P(v_0^*, C, 1) = F \} = \bar{C}(v_0^*, F)$.

\textbf{Part (iii).} Suppose there is an equilibrium where at $\tau \in T^\infty_\tau$ the principal offers $C^*_\tau$ and the agent implements $P$ opportunities with probability $i^*_\tau \in (0, 1)$. Since $i^*_\tau > 0$, then by (ii) we have that $C^*_\tau = \bar{C}(v_0^*, F)$ and the agent is indifferent between implementing them or not, i.e., $\bar{U}_0^P(v_0^*, C^*_\tau, 1) = F$.

The principal’s expected continuation value after offering $C^*_\tau$ is then $i^*_\tau \bar{V}_0^P(v_0^*, C^*_\tau, 1) + (1 - i^*_\tau) v_0^*$, which is strictly less than $\bar{V}_0^P(v_0^*, C^*_\tau, 1)$ as $i^*_\tau > 0$ and $\bar{V}_0^P(v_0^*, C^*_\tau, 1) > v_0^*$ by (i).

Suppose then by contradiction that $C^*_\tau = \bar{C}(v_0^*, F) \neq C^i(v_0^*)$. Because $\bar{U}_0^P(v_0^*, C, 1)$ has a unique maximum $C^i(v_0^*)$ which furthermore is interior, and given that $\bar{U}_0^P(v_0^*, C = 0, 1) = 0$, then it must be that $C^*_\tau = \bar{C}(v_0^*, F)$ is to the left of $C^i(v_0^*)$ (i.e., $C^*_\tau = \bar{C}(v_0^*, F) < C^i(v_0^*)$), and that the partial derivative of $\bar{U}_0^P(v_0^*, C, 1)$ with respect to $C$ is strictly positive at $C = C^*_\tau = \bar{C}(v_0^*, F)$ (i.e., $\bar{U}_0^P(v_0^*, C, 1) - F$ cross zero from below at $C^*_\tau = \bar{C}(v_0^*, F)$). But if so, then $\lim_{\epsilon \downarrow 0} \bar{U}_0^P(v_0^*, \bar{C}(v_0^*, F) + \epsilon, 1) - F > 0$, so the principal could slightly increase the bonus $C^*_\tau = \bar{C}(v_0^*, F)$ in a $\epsilon > 0$ but small, break the agent’s indifference. This deviation would then give that principal an expected continuation value of $\lim_{\epsilon \downarrow 0} \bar{V}_0^P(v_0^*, C^*_\tau + \epsilon, 1) = \bar{V}_0^P(v_0^*, C^*_\tau, 1)$ which is strictly greater than $i^*_\tau \bar{V}_0^P(v_0^*, C^*_\tau, 1) + (1 - i^*_\tau) v_0^*$.

Contradiction.

\end{proof}

\begin{proof}[Proof of Claim C.1]

\textbf{Claim C.1.} For $x \in (0, \bar{w})$, where $\bar{w}$ is defined as in Claim B.1 let:

$$J_1(x) \equiv x - pE(x) - q\bar{V}_0^P(x, C^i(x), 1)$$

$$J_2(x) \equiv x(1 - q) - pE(x)$$

$$J_3(x) \equiv x - pE(x) - q\bar{V}_0^P(x, C^i(x), 1) + (1 - i)x$$,

where $i \in (0, 1)$

There exists a unique $x_i \in (0, \bar{w})$ such that $J_i(x_i) = 0$. Furthermore, $x_2 < x_3 < x_1$, and $J_i(x) < 0$ for $x < x_i$, and $J_i(x) > 0$ for $x > x_i$.

\textbf{Proof.} Consider first $J_1(x)$. Notice $J_1(0) = -pE(0) - q\bar{V}_0^P(0, C^i(0), 1) < 0$, given that $E(0) = \Pi/(r + \eta)$, and that $\bar{V}_0^P(0, C^i(0), 1) > 0$. And that:

$$\lim_{x \to \bar{w}} J_1(x) = (1 - q)\bar{w} - pE(\bar{w}) = \frac{\bar{w}(\lambda\bar{\mu}(1 - q) - (r + \lambda\bar{\mu})p)}{\lambda\bar{\mu}} > 0$$
Where the first equality comes from the fact that \( \hat{V}_0^P(x, C^\dagger(x), 1) \to \bar{w} \) as \( x \to \bar{w} \), since:

\[
(C^\dagger(x), \psi_e(x, C^\dagger(x))) \to (0, \bar{\mu}) \text{ as } x \to \bar{w}
\]

by Lemma 1. The second equality comes from \( \psi(\bar{w}) = \bar{\mu} \). And third, \( \lambda \bar{\mu}(1 - q) - (r + \lambda \bar{\mu})p > 0 \) comes from Assumption 1. Hence, there exists at least one \( x_1 \) such that \( J_1(x_1) = 0 \).

To show uniqueness, we will prove that \( J_1^*(x_1) > 0 \), implying that \( J_1(x) \) can cross zero only once. Notice that \( J_1(x_1) = 0 \) implies:

\[
\hat{V}_0^P(x_1, C^\dagger(x_1), 1) = \frac{x_1 - pE(x - 1)}{q}
\]

Furthermore, it is possible to prove that:

\[
\frac{d}{dx} \hat{V}_0^P(x, C^\dagger(x), 1) = \frac{\hat{V}_0^P(x, C^\dagger(x), 1)}{x} - \frac{r \mu}{(\psi_e)^2(r + \lambda)} \left[ 1 - \left( \frac{\Omega(\mu)}{\Omega(\psi_e)} \right)^{1 + \frac{r}{\lambda}} \right] \frac{d\psi_e^*}{dx}
\]

where \( d\psi_e^*/dx > 0 \) by Lemma 1. Consequently,

\[
J_1'(x_1) = 1 - pE'(x_1) - q \frac{d\hat{V}_0^P}{dx} \bigg|_{x=x_1}
= \frac{p}{x_1} \left[ E(x_1) - x_1E'(x_1) \right] + \frac{q r x_1 \bar{\mu}}{(\psi_e)^2(r + \lambda)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \frac{r}{\lambda}} \right] \frac{d\psi_e^*}{dx} \bigg|_{x=x_1} > 0
\]

Given that:

\[
E(x_1) - x_1E'(x_1) = \left( \frac{p}{r + \eta} \right) \left[ \eta \left( \frac{r x_1}{\Pi} \right)^{\frac{r}{\lambda}} + \frac{\Pi}{x_1} \left( 1 - \left( \frac{r x_1}{\Pi} \right)^{1 + \frac{r}{\lambda}} \right) \right] > 0
\]

Consider then \( J_2(x) \). We have \( J_2(0) = -pE(0) < 0 \),

\[
\lim_{x \to \bar{w}} J_2(x) = (1 - q)\bar{w} - pE(\bar{w}) = \lim_{x \to \bar{w}} J_1(x) > 0
\]

and \( J_2'(x) = 1 - p - q + p(1 - E'(x)) > 0 \), given that \( E'(x) = e^{-r\phi_e^*(x)} < 1 \). So there exists a unique \( x_2 \), strictly between 0 and \( \bar{w} \), such that \( J_2(x_2) = 0 \).

Now consider \( J_3(x) \). Notice \( J_3(x) = iJ_1(x) + (1 - i)J_2(x) \). Consequently, \( J_3(0) < 0 \), and \( \lim_{x \to \bar{w}} J_3(x) > 0 \). Hence there exists at least one \( x_3 \) such that \( J_3(x_3) = 0 \). Furthermore,

\[
J_3'(x_3) = \frac{p}{x_3} \left[ E(x_3) - x_3E'(x_3) \right] + \frac{i q r x_3 \bar{\mu}}{(\psi_e)^2(r + \lambda)} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\psi_e)} \right)^{1 + \frac{r}{\lambda}} \right] \frac{d\psi_e^*}{dx} \bigg|_{x=x_3} > 0
\]

Hence \( x_3 \) is also unique.

Because \( x_i \) is unique, and \( J_i(0) < 0 \), and \( J_i(x) > 0 \) as \( x \to \bar{w} \), we have \( J_i(x) < 0 \) for \( x < x_i \), and \( x > x_i \). Finally to show that \( x_2 < x_3 < x_1 \), we will show that \( x_2 < x_1 \), which immediately implies that \( x_3 \in (x_2, x_1) \) given that \( J_3(x) = iJ_1(x) + (1 - i)J_2(x) \) where \( i \in (0, 1) \). Notice that by Lemma 1 we have that \( C^\dagger(x) \in (0, \bar{C}(x)) \), and therefore \( \psi_e(x, C^\dagger(x)) < \bar{\mu} \). This implies that \( \hat{V}_0^P(x, C^\dagger(x), 1) > x \). But if so, then:

\[
J_1(x) - J_2(x) = -p[\hat{V}_0^P(x, C^\dagger(x), 1) - x] < 0
\]

Since \( J_1(x) \) and \( J_2(x) \) cross zero from below, this immediately implies that \( x_2 < x_1 \). □
Proof of Claim C.2

Claim C.2. Fix a $F \in (0, F_-)$. If there exists a $v^*_0$ satisfying $J_4(v^*_0) = 0$, then such $v^*_0$ is unique.

Proof. We will show that $J'_4(v^*_0) > 0$, implying that $J_4(x)$ crosses zero at most once. We first claim that $(\partial/\partial x)C(x, F) > 0$, for all $x < \bar{x}$, and that this implies that $\psi_x \equiv \psi_x(x, C(x, F))$, is strictly increasing in $x$. Indeed, because $\bar{U}_0^p(x, 0, 1) = 0$, then $\bar{U}_0^p(x, C, 1)$ cuts $F$ from below at $C = \underline{C}(x, F)$. And since $\bar{U}_0^p(x, C, 1)$ is strictly decreasing in $x$, the fact that $\bar{U}_0^p(x, C, 1)$ cuts $F$ from below implies that $(\partial/\partial x)\underline{C}(x, F) > 0$. But then,

$$
\frac{d\psi_x}{dx} = \frac{\psi_x}{x} + \frac{\lambda \psi_x^2}{r^2} \left[ 1 - E'(x) + \frac{\partial}{\partial x} \underline{C}(x, F) \right] > 0
$$

Now, notice that $J_4(v^*_0) = 0$ implies:

$$
\bar{V}_0^p(v^*_0, \underline{C}(v^*_0, F), 1) = \frac{v^*_0 - pE(v^*_0)}{q}
$$

Furthermore, it is possible to prove that:

$$
\frac{d}{dx} \bar{V}_0^p(x, \underline{C}(x, F), 1) = \frac{\bar{V}_0^p(x, \underline{C}(x, F), 1)}{x} - \frac{rx\mu}{(\psi_x)^2(r + \lambda)} \left[ 1 - \frac{\Omega(\bar{\mu})}{\Omega(\psi_x)} \right]^{1+\frac{1}{\pi}} \frac{d\psi_x}{dx}
$$

Consequently,

$$
J'_4(v^*_0) = 1 - pE'(v^*_0) - q \frac{d\bar{V}_0^p}{dx} \bigg|_{x=v^*_0} = \frac{p}{v^*_0} [E(v^*_0) - v^*_0E'(v^*_0)] + \frac{qrv^*_0\bar{\mu}}{(\psi_x)^2(r + \lambda)} \left[ 1 - \frac{\Omega(\bar{\mu})}{\Omega(\psi_x)} \right]^{1+\frac{1}{\pi}} \frac{d\psi_x}{dx} \bigg|_{x=v^*_0} > 0
$$

Given that $d\psi_x/dx > 0$, and:

$$
E(v^*_0) - v^*_0E'(v^*_0) = \left( \frac{p}{r + \eta} \right) \left[ \eta \left( \frac{rv^*_0}{\Pi} \right)^{\frac{1}{\pi}} + \frac{\Pi}{v^*_0} \left( 1 - \left( \frac{rv^*_0}{\Pi} \right)^{1+\frac{1}{\pi}} \right) \right] > 0
$$

\[\square\]

4 Richer Contracts

Proof of Proposition 4

Our goal is to prove that there exists an $F_{++} \in (F_+, \hat{F})$ such that if $F > F_{++}$ then the following Candidate is an equilibrium of the game.

Candidate. At every $\tau \in T_R^\infty$ the principal offers $(C^*_\tau, \kappa^*_\tau) = (0, 0)$ at $(\tau, 1)$, and the agent never incurs $F$ at $(\tau, 2)$. Furthermore,

- If $Z_\tau$ is $G$, the principal reorganizes again at $\tau + \varphi^*_L$.
- If $Z_\tau$ is $P = \{P_D, P_N\}$ and the agent does not incur $F$, the principal reorganizes immediately.
• If $Z_\tau$ is $P = \{P_D, P_N\}$ and the agent incurs $F$, the principal reorganizes again at $\tau + \varphi_{DP}$ if no breakthrough arrives. And reorganizes again at $t + \varphi_E^\ast$ if a breakthrough occurs at $t \in [\tau, \tau + \varphi_{DP}]$.

Where $\varphi_E^\ast = \eta^{-1} \ln(\Pi/r_{u_0})$ and

$$
\varphi_{DP} = \lambda^{-1} \ln \left( \frac{\Omega(\xi)}{\Omega(\mu)} \right)
$$

and $\Omega(x) = (1 - x)/x$. The principal’s equilibrium reorganization value $v_0^\ast$ is then equal to $v_0$, where $(1 - q)v_0 = pE(v_0)$, and the agent’s equilibrium reorganization value is $u_0^\ast = 0$.

It is easy to see that we only need to check that the principal does not deviate from $(C_r^\ast, \kappa_r^\ast) = (0, 0)$ to try to elicit the agent to implement a promising opportunity. Moreover, we know that if $F < F_+$ the above is not an equilibrium of the game, as a contract with $C_r^\ast > 0$ and $\kappa_r^\ast = 0$ provides the principal with a strictly positive deviation.

So take an $F \geq F_+$. By Proposition $2$ we then have that deviations involving only $C_r$ are not profitable. Hence, suppose that at some $\tau \in T_R^\infty$ the principal deviates and offers $C_r^0 > 0$ and $\kappa_r^0 > 0$ at $(\tau, 1)$, after it is revealed that $Z_\tau$ is $P = \{P_D, P_N\}$. Assume further that the principal goes back to play according to the above candidate after the next reorganization, so players’ reorganization values do not change, i.e., $(v_0^0, u_0^0) = (v_0, 0)$. We then have two different cases to consider: $\kappa_r'^0 \geq v_0$, and $0 < \kappa_r'^0 < v_0$.

Case 1: $\kappa_r'^0 \geq v_0$ — If $\kappa_r'^0 \geq v_0$ then $\tilde{U}_0^P(v_0, 0, C_r', \kappa_r', 1) = (\lambda \mu C_r')(r + \lambda)^{-1}$. For the agent to implement $Z_\tau$ with probability $\hat{i}_\tau^0 > 0$ a necessary condition is $\tilde{U}_0^P(v_0, 0, C_r', \kappa_r', 1) - F \geq 0$, in which case the principal obtains:

$$
i_{\tau}^0 \tilde{V}_0^P(v_0, 0, C_r', \kappa_r', 1) + (1 - i_{\tau}^0)0 = \frac{i_{\tau}^0 \lambda \mu (E(v_0) - C_r')}{r + \lambda} \leq \frac{\lambda \mu E(v_0)}{r + \lambda} - F
$$

We then claim that there exists a $F_{++}^{(1)} \in [F_+, \hat{F})$ such that:

$$
\frac{\lambda \mu E(v_0)}{r + \lambda} - F < v_0, \forall F \in (F_{++}^{(1)}, \hat{F})
$$

implying that this deviation is not profitable.

Because the expression is decreasing and continuous in $F$, it suffices to show that $\lambda \mu E(v_0)(r + \lambda)^{-1} - \hat{F} < v_0$. But $\hat{F} = D(v_0) - v_0$, hence:

$$
\frac{\lambda \mu E(v_0)}{r + \lambda} - \hat{F} - v_0 = -\frac{\lambda \mu}{r} \left( \frac{\lambda E(v_0)}{r + \lambda} - v_0 \right) \left( \frac{\Omega(\mu)}{\Omega(J_0)} \right)^{1 + \frac{r}{\mu}} < 0
$$

given that:

$$
\frac{\lambda E(v_0)}{r + \lambda} - v_0 = v_0 \left[ \frac{\lambda (1 - q) + 1}{p(r + \lambda) - 1} \right] > 0 \iff p < \frac{\lambda (1 - q)}{r + \lambda} \quad \text{(which hold given Assumption 1)}
$$

and where we are using the fact that $v_0(1 - q) = pE(v_0)$. Thus, if $F > F_{++}^{(1)}$ a deviation to $\kappa_r'^0 \geq v_0$ is never profitable for the principal.
Case 2: $0 < \kappa'_r < \underline{v}_0$ — In this case we have:

$$U_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) = \lambda \bar{\mu} C'_r \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\xi')} \right)^{1+\frac{\xi'}{\xi'}} \right] + \frac{\lambda \bar{\mu} C'_r}{\lambda(E(\underline{v}_0) - C'_r - \underline{v}_0 + \kappa'_r)}$$

where:

$$\xi' = \frac{r(\underline{v}_0 - \kappa'_r)}{\lambda(E(\underline{v}_0) - C'_r - \underline{v}_0 + \kappa'_r)}$$

For the agent to invest with probability $i'_r > 0$ a necessary condition is $\hat{V}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) - F \geq \kappa'_r$, in which case the principal obtains $i'_r \hat{V}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1)$, where:

$$\hat{V}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) = \frac{\lambda \bar{\mu} E(\underline{v}_0) - C'_r}{\lambda + \lambda(\Omega(\underline{v}_0) - C'_r - \underline{v}_0 + \kappa'_r)}$$

Notice then that:

$$i'_r \hat{V}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) \leq \hat{V}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) + \hat{U}_0^P(\underline{v}_0, 0, C'_r, \kappa'_r, 1) - F - \kappa'_r$$

We then claim that there exists a $F^{(2)}_{++} \in \{F_+, \hat{F}\}$ such that:

$$\frac{\lambda \bar{\mu} E(\underline{v}_0)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\xi')} \right)^{1+\frac{\xi'}{\xi'}} \right] + \frac{\lambda \bar{\mu} E(\underline{v}_0)}{\lambda(\Omega(\underline{v}_0) - C'_r - \underline{v}_0 + \kappa'_r)} - F - \kappa'_r < \underline{v}_0$$

Imposing that this deviation is not profitable.

Because the expression is decreasing and continuous in $F$, it suffices to show that:

$$\frac{\lambda \bar{\mu} E(\underline{v}_0)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(\bar{\mu})}{\Omega(\xi')} \right)^{1+\frac{\xi'}{\xi'}} \right] + \frac{\lambda \bar{\mu} E(\underline{v}_0)}{\lambda(\Omega(\underline{v}_0) - C'_r - \underline{v}_0 + \kappa'_r)} - F - \kappa'_r - \underline{v}_0 < 0$$

Since $\hat{F} = D(\underline{v}_0) - \underline{v}_0$ the above expression can be written as $\Theta(\xi') - \Theta(\psi(\underline{v}_0)) - \kappa'_r$, where:

$$\Theta(x) \equiv \frac{\lambda \bar{\mu} E(\underline{v}_0)}{r + \lambda} \left[ 1 - \frac{\Omega(\bar{\mu})}{\Omega(x)} \right] + \frac{\lambda \bar{\mu} E(\underline{v}_0)}{r + \lambda} \left( \frac{\Omega(\bar{\mu})}{\Omega(x)} \right)^{1+\frac{\xi'}{\xi'}}$$

But $\Omega(x)$ has a unique maximum when $x = \psi(\underline{v}_0)$, which implies that:

$$\Theta(\xi') - \Theta(\psi(\underline{v}_0)) - \kappa'_r \leq \kappa'_r < 0$$

Thus, if $F > F^{(2)}_{++}$ a deviation to $\kappa'_r \in (0, \underline{v}_0)$ is never profitable for the principal.

Wrapping up — Consequently, when $F > F_{++}$, where the latter is defined as $F_{++} \equiv \max\{F^{(1)}_{++}, F^{(2)}_{++}\} \in (F_+, \hat{F})$, there are no profitable deviations for the principal. Hence our Candidate is indeed an equilibrium.

\[\square\]
Time-Dependent Bonuses

In this appendix we show that the principal can achieve the first-best with a time-dependent bonus. The game is exactly as our baseline model in the main text, except that the bonus for a breakthrough is allowed to depend on time. That is, at every \( t \in \mathcal{T}_R^\infty \) the principal commits to a bonus \( C_\tau(t) \in \mathbb{R} \) for \( t \geq \tau \), stipulating the bonus the agent will receive if a breakthrough occurs at \( t \geq \tau \).

The first thing to notice is that if \( C_\tau(t) \) is unrestricted it is easy to find a contract that implements the first-best: whenever \( Z_\tau \) is type \( P \), the principal offers an arbitrary high payment for an arbitrary small period of time such that the expected value of \( C_\tau(t) \) is equal to \( F \) if the agent implements \( Z_\tau \):

\[
C_\tau(t) = \begin{cases} 
C & \text{if } t \in [\tau, \tau + \delta] \\
0 & \text{otherwise}
\end{cases}
\]

with \( \delta \rightarrow 0 \) and \( \mathbb{E}(C_\tau(t)) = F \) if the agent implements \( Z_\tau \).

The idea behind this scheme is to induce the agent to implement a \( P \) opportunity, while making the principal the full residual claimant “almost immediately” after the agent incurs \( F \).

To make things more interesting, however, we will assume that the principal cannot borrow more than the expected present value of future payments, hence we are going to impose the restriction \( C_\tau(t) \leq E(v_0^*) \), where, remember, \( E(x) \) was the principal’s continuation value of exploiting a profitable opportunities when her reorganization value is \( x \):

\[
E(x) \equiv \frac{\Pi}{r + \eta} + \left( \frac{\eta}{r + \eta} \right) xe^{-r\varphi^*_w(x)}
\]

We will show that even after imposing this “borrowing constraint”, there still exists a time-dependent bonus capable of implementing the first-best.

Indeed consider the following equilibrium candidate:

**Candidate.** At every \( \tau \in \mathcal{T}_R^\infty \),

- At \((\tau, 1)\):
  - If \( Z_\tau \) is \( G \), the principal offers \( C_\tau^*(t) = 0 \ \forall \ t \geq \tau \).
  - If \( Z_\tau \) is \( P = \{P_D, P_N\} \), the principal offers:

\[
C_\tau^*(t) = \begin{cases} 
E(w_0^*) - [D(w_0^*) - F] \left[ 1 + \frac{r(\bar{\mu} + e^{\lambda(t-\tau)}(1 - \bar{\mu}))}{\lambda \bar{\mu}} \right] & \text{if } t < \tau + \lambda^{-1} \ln \left( \frac{\Omega(\xi)}{\Omega(\bar{\mu})} \right) \\
0 & \text{otherwise}
\end{cases}
\]

Where \( w_0^* \) solves \( w_0^* = pE(w_0^*) + q(D(w_0^*) - F) \), and \( \xi \in (\psi(w_0^*), \bar{\mu}) \) is the unique solution to \( \tilde{D}(\xi; w_0) = D(w_0^*) - F \), with:

\[
\tilde{D}(x; w_0^*) \equiv \begin{cases} 
\frac{\lambda \bar{\mu} E(w_0^*)}{r + \lambda} \left[ 1 - \left( \frac{\Omega(x)}{\Omega(\psi(w_0^*))} \right)^{1+\bar{x}} \right] + \frac{xw_0^*}{\psi(w_0^*)} \left( \frac{\Omega(x)}{\Omega(\psi(w_0^*))} \right)^{1+\bar{x}} & \text{if } \bar{\mu} > \psi(w_0^*) \\
w_0^* & \text{if } \bar{\mu} \leq \psi(w_0^*)
\end{cases}
\]

and where \( D(w_0^*) \equiv \tilde{D}(\bar{\mu}; w_0) \) is the continuation of a single DM immediately after implementing a profitable opportunity (see section 2 of this online Appendix).

- At \((\tau, 2)\): the agent incurs \( F \) if and only if \( \tilde{U}(w_0^*, 0, C_\tau^*(t), 1) - F \geq 0 \), where:
\[
\bar{U}(w_0^*, 0, C_\tau^*(t), 1) = \begin{cases} 
\frac{\lambda \mu E(w_0^*)}{r + \lambda} - D(w_0^*) + F + \frac{\bar{\mu}}{\xi} \left( \frac{\bar{\mu}}{\Omega(\xi)} \right)^{1+\tau} & \text{if } \bar{\mu} > \xi \\
0 & \text{if } \bar{\mu} \leq \xi
\end{cases}
\]

- And at \( t > \tau \) the principal’s reorganization strategy is:
  - If \( Z_\tau \) is \( G \), the principal reorganizes again at \( \tau + \phi_E^* \), where \( \phi_E^* = \eta^{-1} \ln(\Pi/rw_0^*) \), so the principal’s and the agent’s continuation values at \( \tau^+ \) are \( E(w_0^*) \) and 0, respectively.
  - If \( Z_\tau \) is \( P \), then
    * If the agent implements, the principal reorganizes again at \( \tau + \phi_{DP}^* \) if no breakthrough arrives. And reorganizes again at \( t + \phi_E^* \) if a breakthrough occurs at \( t \in [\tau, \tau + \phi_{DP}^*) \), where:
      \[
      \phi_{DP}^* = \lambda^{-1} \ln \left( \frac{\Omega(\psi(w_0^*))}{\Omega(\bar{\mu})} \right) \quad \psi(w_0^*) = \frac{rw_0^*}{\lambda(E(w_0^*) - w_0^*)}
      \]
    and \( \Omega(x) = (1 - x)/x \). The principal’s and the agent’s continuation values at \( \tau^+ \) are then \( D(w_0^*) - F \) and 0, respectively.
    * While if the agent does not implement, then the principal reorganizes immediately again, the principal’s and the agent’s continuation values at \( \tau^+ \) are then \( w_0^* \) and 0, respectively.

Finally, on path the agent does not incur \( F \) if \( Z_\tau \) is \( G \), so the principal’s and the agent’s continuation values at \( \tau^+ \) are \( E(w_0^*) \) and 0, respectively. While the agent incurs \( F \) if \( Z_\tau \) is \( P \), so the principal’s and the agent’s continuation values at \( \tau^+ \) are then \( D(w_0^*) - F \) and 0, respectively. The principal’s equilibrium reorganization value is then \( v_0^* = w_0^* \), while the agent’s is \( w_0^* = 0 \).

First, we show that \( \xi \in (\psi(w_0^*), \bar{\mu}) \) is well-defined and unique. Indeed, define \( \Theta(x) = \bar{D}(x; w_0^*) - D(w_0^*) + F \). Then, \( \Theta(\bar{\mu}) = F > 0 \), and \( \Theta(\psi(w_0^*)) = -(D(w_0^*) - F - w_0^*) < 0 \) (given that in the first-best the DM always implements \( P \) opportunities). It is then not difficult to prove that \( \partial \bar{D}/x < 0 \), implying that \( \Theta'(x) < 0 \), so \( \xi \) exists, is unique, and belongs to \( (\psi(w_0^*), \bar{\mu}) \).

Now, it is clear that the on-path behavior described in the candidate above coincides with the first-best. Hence, we only need to check whether players are playing their best-responses. Moreover, if the principal is implementing the first-best with \( C_\tau^*(t) \), then \( C_\tau^*(t) \) must be optimal. Hence, we only need to check the principal’s reorganization behavior and the agent’s implementation decision.

Regarding the principal’s reorganization behavior, it is easy to see that if \( Z_\tau \) is \( G \), or if \( Z_\tau \) is \( P \) and the breakthrough arrived, the principal is playing optimally. Therefore, we only focus here on checking the case in which \( Z_\tau \) is \( P \) before the breakthrough arrives. Although in the text we maximized the principal’s objective directly, with a time dependent bonus it is easier to work using dynamic programming using \( \mu_t \) as the state variable. Indeed, notice is that \( C_\tau^*(t) \) can also be written as a function of the belief \( \mu_t \):

\[
C_\tau^*(t) = C_\tau^*(\mu_t) = \begin{cases} 
E(w_0^*) - [D(w_0^*) - F] \left[ 1 + \frac{r}{\lambda \mu_t} \right] & \text{if } \mu_t > \xi \\
0 & \text{otherwise}
\end{cases}
\]

where:

\[
\mu_t = \frac{\bar{\mu}}{\bar{\mu} + e^{\lambda(t-\tau)}(1 - \bar{\mu})}
\]
We then claim that the principal’s optimal value when waiting for a breakthrough as a function of \( \mu \), is given as follows:

\[
\tilde{V}^P(\mu; w_0^* ) = \begin{cases} 
D(w_0^*) - F & \text{if } \mu \geq \xi \\
\tilde{D}(\mu; w_0^*) & \text{if } \mu \in (\psi(w_0^*), \xi) \\
w_0^* & \text{if } \mu \leq \psi(w_0^*)
\end{cases}
\]

Indeed, if \( \mu \geq \xi \), the HJB equation of the principal’s value function is:

\[
0 = \lambda \mu [E(w_0^*) - C_\tau^*(\mu) - \tilde{V}^P(\mu; w_0^*)] - r \tilde{V}^P(\mu; w_0^*) - \lambda \mu (1 - \mu) d\tilde{V}^P / d\mu
\]

with border condition \( \tilde{V}^P(\xi; w_0^*) = \tilde{D}(\xi; w_0^*) = D(w_0^*) - F \), and where the last equality follows the definition of \( \xi \). Solving we then get \( \tilde{V}^P(\mu; w_0^*) = D(w_0^*) - F \).

While if \( \mu \in (\psi(w_0^*), \xi) \) the HJB equation of the principal’s value function is:

\[
0 = \lambda \mu [E(w_0^*) - \tilde{V}^P(\mu; w_0^*)] - r \tilde{V}^P(\mu; w_0^*) - \lambda \mu (1 - \mu) d\tilde{V}^P / d\mu
\]

with border conditions \( \tilde{V}^P(\psi(w_0^*); w_0^*) = w_0^* \) (value-matching), and \( \tilde{V}^P(\xi; w_0^*) = 0 \) (smooth-pasting). Solving we then get \( \tilde{V}^P(\mu; w_0^*) = \tilde{D}(\mu; w_0^*) \).

Finally, since \( \tilde{V}^P(\mu; w_0^*) > w_0^* \) for all \( \mu > \psi(w_0^*) \), the cutoff policy just-described is optimal and since it takes:

\[
\phi_{\text{D}P} = \lambda^{-1} \ln \left( \frac{\Omega(\psi(w_0^*))}{\Omega(\tilde{\mu})} \right)
\]

amount of time for the belief to go from \( \mu_i = \tilde{\mu} \) to \( \mu_i = \psi(w_0^*) \), we have that the principal’s reorganization strategy in this case is indeed optimal, and at \( \tau^+ \) she is getting \( \tilde{V}^P(\tilde{\mu}; w_0^*) = D(w_0^*) - F \) as conjectured.

Now we analyze the agent’s implementation decision. We claim that his optimal value when waiting for a breakthrough as a function of \( \mu \) is:

\[
\bar{U}^P(\mu; w_0^*) = \begin{cases} 
\frac{\lambda \mu E(w_0^*)}{r + \lambda} - D(w_0^*) + F + \frac{\mu}{\bar{\Omega}(\xi)} \left[ D(w_0^*) - F - \frac{\lambda \xi E(w_0^*)}{r + \lambda} \right] & \text{if } \mu > \xi \\
0 & \text{if } \mu \leq \xi
\end{cases}
\]

Indeed, if \( \mu \leq \xi \) then \( C_\tau^*(\mu) = 0 \) so \( \bar{U}^P(\bar{\mu}; w_0^*) = 0 \). While if \( \mu > \xi \), then the HJB of his value function is given by:

\[
0 = \lambda \mu [C_\tau^*(\mu) - \bar{U}^P(\mu; w_0^*)] - r \bar{U}^P(\mu; w_0^*) - \lambda \mu (1 - \mu) d\bar{U}^P / d\mu
\]

with border condition \( \bar{U}^P(\xi; w_0^*) = 0 \). Solving we get:

\[
\bar{U}^P(\mu; w_0^*) = \frac{\lambda \mu E(w_0^*)}{r + \lambda} - D(w_0^*) + F + \frac{\mu}{\bar{\Omega}(\xi)} \left[ D(w_0^*) - F - \frac{\lambda \xi E(w_0^*)}{r + \lambda} \right]
\]

Hence, if the agent implements a \( P \) opportunity he obtains \( \bar{U}^P(\bar{\mu}; w_0^*) - F = \bar{U}(w_0^*, 0, C_\tau^*(t), 1) - F \), while if he does not implement, he gets zero. Thus, his best response is to implement whenever \( \bar{U}(w_0^*, 0, C_\tau^*(t), 1) - F \geq 0 \); that is, whenever:

\[
\frac{\lambda \bar{\mu} E(w_0^*)}{r + \lambda} - D(w_0^*) + \bar{\mu} \left( \frac{\bar{\mu}}{\bar{\Omega}(\xi)} \right)^{\frac{1}{\tau^+}} \left[ D(w_0^*) - F - \frac{\lambda \xi E(w_0^*)}{r + \lambda} \right] \geq 0
\]
But using $D(w_0^*) - F = \tilde{D}(\xi; w_0^*)$, then:

$$\frac{\lambda \mu E(w_0^*)}{r + \lambda} - D(w_0^*) + \frac{\bar{\mu}}{\xi} \left( \frac{\bar{\mu}}{\Omega(\xi)} \right)^{1+\frac{1}{\lambda}} \left[ \tilde{D}(\xi; w_0^*) - \frac{\lambda \xi E(w_0^*)}{r + \lambda} \right] = 0$$

so the agent is also playing his best-response, and our candidate is indeed an equilibrium.

Consequently, even with borrowing constraints, the principal can use time-dependent bonuses to implement the first-best in this case. □