Why Are Bad Products So Hard to Kill?

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It is puzzling that firms often continue to invest in product development projects even after they should know that demand will be low. We argue that bad products are hard to kill because firms face an inherent conflict when designing managers’ incentives. Rewarding success encourages managers to forge ahead even when demand is low. To avoid investing in low-demand products the firm must also reward decisions to kill products. However, rewarding managers for killing products effectively undermines the rewards for success. The inability to resolve this tension forces the firm to choose between paying an even larger bonus for success and accepting continued investment in low-demand products. We explore the boundaries of this argument by analyzing how the timing of demand information affects product investment decisions.

Key words: product development; managerial incentives; moral hazard; adverse selection; information acquisition
1. Introduction

This RCA example is far from unique. Many company histories include bad products they wished they had killed sooner. The inability to stop product development is amongst the most costly marketing mistakes that firms make. We argue that one reason for these “mistakes” is that firms face an inherent conflict when designing managers’ incentives. The firm rewards success by promising a bonus to the manager if the outcome is successful. This encourages the manager to continue as long as success is still possible. To avoid investing in low-demand products the firm must also pay a bonus when product development projects are terminated. However, rewarding managers for killing products effectively diminishes the rewards for success.

Rewards for success may serve different purposes. For example, they may motivate the manager to work hard or work on the right activities, or they may act as a screening mechanism helping the firm identify capable managers. Although we focus on the first motivation (inducing the manager to exert effort), the findings are not limited to this setting. In general, whenever the firm rewards success a similar tension arises, increasing the likelihood that the firm will make inefficient investments in bad products.

We motivate our analysis using examples obtained through interviews with participants in the product development process. The examples highlight different ways that product managers respond to unfavorable demand information. To prevent the firm from killing their products managers may suppress the information. However, where the information is provided by an outside research provider, it is often not possible to suppress it. Instead, reactions may include distorting the information, discrediting it, or simply not collecting information that might reveal demand is low. We show that these distortions may all contribute to continued investment in low-demand products.

We also explore the boundaries of the findings by studying how the timing of demand information affects the outcome. If the manager receives an early signal of demand before choosing effort, then the firm can ensure the manager uses this information to prevent inefficient investments in low-demand products. However, when the firm is uncertain about when demand information is received, the tension between rewarding success and killing bad products is amplified, making investments in bad products more likely. We summarize the key findings in Table 1.
Table 1: Summary of the Key Findings

Rewarding success makes it difficult to kill low-demand products if the manager can:

- Suppress or withhold unfavorable demand information.
- Distort information to make it appear demand is high.
- Discredit unfavorable demand information.
- Not collect information that may reveal demand is low.

Low-demand products are harder to kill when:

- The firm is uncertain when the manager receives information about demand.
- The manager has biased expectations about the likelihood of success.

Low-demand products are easier to kill when:

- The manager learns demand earlier in the process.
- The manager can control when to collect demand information.
- It is cost-effective for the firm to monitor the manager.
- The firm can severely punish the manager if the manager recommends continued investment but the project fails.

1.1 Psychological Biases

Previous explanations for overinvestment in bad products have focused on the psychology of the managers in charge. There is considerable evidence that decision makers have a tendency to escalate their commitment to failing courses of action (see for example Brockner and Rubin 1985; Brockner 1992). Escalation of commitment has been used to explain poor decision making in a variety of contexts, including business mergers, sports drafts, military decisions, software projects, politics and gambling. Notably, the first formal demonstration of the phenomenon (Staw 1976) involved a new product development setting. Student subjects continued to invest in a failing strategy, increasing their previous investments despite new evidence that their earlier decisions were probably wrong. Boulding, Morgan and Staelin (1997) replicate the effect using a large sample of full-time managers. They also demonstrate robustness; the effect survives a variety of mechanisms designed to overcome it, including the introduction of new decision makers and pre-commitment to intermediate benchmarks.

A leading explanation for the escalation of commitment to failing actions is the need for justification. Decision makers are unwilling to abandon previous decisions because doing so requires admitting to themselves or others that their earlier decisions were mistakes (Brockner 1992). Other explanations focus on errors in judgments about the probability the product will
succeed. Biyalagorsky, Boulding and Staelin (2006) argue that escalation of commitment can reflect the decision maker’s over-reliance on initial beliefs and ignorance of new information. Similarly, March and Shapira (1987) argue that managerial conceit may contribute to excessive optimism: “Managers believe, and their experience appears to have told them, that they can change the odds, that what appears to be a probabilistic process can usually be controlled” (at page 1414). If managers believe that they can control fate through their own actions, then they may unreasonably believe that they can prevent failure through hard work.

Psychological biases can explain why managers make inefficient decisions, including their reluctance to kill bad products. However, they do not explain why firms do not take steps to prevent inefficient decisions by their managers. We will argue that if the firm can anticipate these distortions, it can adjust managers’ incentive contracts to accommodate them. The dilemma is why firms do not use appropriate contract design to deter continued investments in unpromising products.¹

Although firms can anticipate and accommodate psychological biases in managers’ incentive contracts, this does not mean that these biases are unimportant. If managers are overly optimistic about the likelihood a new product will succeed, the cost of ensuring low-demand products are killed is increased because an even larger termination bonus is required. We conclude that these biases play an important role in explaining why firms continue to invest in low-demand products. They complement the results in this paper by amplifying the tension between rewarding success and killing low-demand products.

1.1 Other Related Literature

Similar tensions have been studied in research on capital allocation. Bernardo, Cai and Luo (2001) investigate how a manager’s private information about the quality of a project may lead firms to under-invest in the project. For low-value projects the cost of providing information

¹ Career concerns and “implicit incentives” may also influence managers’ decisions if those decisions reveal information about their proficiency. For example, Zwiebel (1995) investigates how the decision to adopt new technology signals a manager’s private information about his proficiency. Prendergast and Stole (1996) demonstrate that managers, who wish to appear precise in judging market profitability, may initially exaggerate their own opinion, but subsequently ignore new information. Siemsen (2008) shows that career concerns may prompt less-capable managers to choose challenging projects, as the difficulty of the task may disguise their weak capabilities. However, in our setting we can show that career concerns are not sufficient on their own to explain firm’s continued investment in low-demand products. As with biases in managers’ beliefs, if the firm can anticipate the distortions introduced by career concerns, it can adjust manager’s incentive contracts to accommodate them.
rents to the manager may lead the firm to abandon the project altogether. In a more recent paper, Laux (2008) argues that imposing influence costs on an internal project manager may improve capital budgeting. By requiring that the manager spend time and effort developing internal support for a project, the firm can implement a screening mechanism. The manager is more willing to incur these costs if the quality of the project is favorable, and so his willingness to engage in influence-building activities reveals his private information about project quality. Bernardo, Cai and Luo (2001) and Laux (2008) both exploit an assumption that the manager enjoys private benefits from controlling more capital, reflecting a preference for “empire building” (see also Harris and Raviv 1998). As a result, the manager is biased in favor of the project.

This bias can be compared to other distortions that result from incompatible incentives. Desai and Srinivasan (1995) investigate a franchisor that has private information about the quality of a new product. Charging a high wholesale price and low fixed fee to signal quality undermines the franchisee’s incentives to sell the product. Hauser (1998) anticipates a similar tension in his review of R&D metrics: “To avoid false program choice the firm would want the weight on market outcomes to be small, but to induce the right research and process efforts the firm would want the weight on market outcomes to be large,” (at page 1680). He recommends that firms find metrics that are correlated with effort but uncorrelated with outcomes. To the extent that these metrics make effort verifiable, they relax the underlying tension between motivating effort and eliciting truthful report of demand. Other related papers include Shin (2008), who investigates a manager’s incentives to acquire information about the cost of implementing a project. If the manager is the residual claimant for any unspent budget then (s)he has an incentive to overstate this cost (see also Guo 2009). There is also a recent working paper investigating the role of incentives in the trade-off between exploration and exploitation in a multi-armed bandit model (Manso 2008).

Finally, the findings can also be compared with previous work on risk aversion. It is now well-established that risk aversion may act as a barrier to innovation. For example, Bergmann and Friedl (2008) consider a model in which a manager allocates effort between tasks given his private information about the profitability of a project. In equilibrium, the optimal contract depends upon the manager’s risk aversion. Sung (1995) studies a model in which a manager can choose a riskier high-NPV project or a safer low-NPV project. If the manager is risk averse, it is more costly to motivate the managers to work on risky projects. Other researchers have studied how risk aversion affects the profitability of delegating project selection to managers (Lambert 1986; De Paola and Scoppa 2006; and Bester and Krähmer 2008), and whether managers are more likely to be innovative if firms adopt long-term incentives that reduce risk by smoothing outcomes over time (Im and Nakata 2008; and Maine 2008).
Our paper differs from the previous literature in several important ways. We focus on the firm’s tradeoff between motivating effort and eliciting information. This distinguishes the paper from the earlier work on psychological biases exhibited by managers, although these biases complement our findings by making it more difficult to convince managers to terminate low-demand products. Second, we focus on the firm’s decision to make additional investments in product development projects. This is a different problem than the delegation of authority to managers. Finally, we do not rely on risk aversion. The manager in our model is risk-neutral, and so the findings do not depend upon the efficient allocation of risk between the manager and the firm.

1.2 Structure of the Paper

The paper proceeds in Section 2 with the introduction of a formal model. We begin with several examples that help to motivate and illustrate the key assumptions. The analysis starts in Section 3, where we illustrate how the tension between rewarding success and truthful reporting of demand can lead to continued investment in low-demand products. We begin by focusing on settings in which managers may suppress or withhold information. We then demonstrate that the findings are easily extended to describe other types of managerial responses, including distorting, discrediting or simply not collecting information.

In Section 4 we explore the robustness of the main results by evaluating how they change when we relax a range of assumptions. The remaining sections of the paper investigate the timing of demand information. In Section 5 we recognize that the manager may learn about demand before choosing his level of effort. If the firm knows (with certainty) that the manager receives the demand signal before choosing effort, it can avoid inefficient investment in low-demand products. In practice, firms will often be unsure about the timing of demand information. Perhaps surprisingly, mere uncertainty about this timing can make it harder to kill low-demand products (compared to when the timing is known with certainty). In Section 6 we consider settings in which the timing of demand information is endogenous, by allowing the manager to determine when demand information is received. We begin by evaluating the manager’s incentives to acquire this information before choosing effort. We then investigate how the firm can influence the manager’s preferences. The paper concludes in Section 7 with a summary of the findings and a review of future research opportunities.

2. A Principal-Agent Model of Product Development

To motivate our model we begin with several examples that arose during background interviews for this research. We will then present the formal model assumptions and provide interpretation for them.
2.1 Examples

The first example involves a multi-national food products company that is developing a new range of healthy snacks. To head the project it hired a manager with experience leading product development projects for other consumer goods companies. The manager’s contract pays a very large bonus if three-year revenue goals are met. This has led to at least one positive outcome: the product development team has coalesced into a dedicated group that works long hours focused on achieving the revenue goal. However, other outcomes are less positive. The manager is unwelcoming of evidence that will slow or impede the launch process. She has argued against conducting market tests, instead favoring a larger-scale launch. The interview subject, who is part of the team, believes that launch is inevitable. Opinions that the product should be killed meet resistance from the manager, even if supported by evidence.

A key feature of this story is the bonus for success. This has proven to be an effective mechanism to motivate the manager and (in turn) the entire product development team. However, the larger the rewards for success, the more likely the manager will favor continued investment in the product even when the likelihood of success is low. The firm can mitigate this tendency by also offering a bonus if the product is killed. However, because killing the product does not require effort, a termination bonus undermines the incentive to succeed. The inability to resolve this tension forces the firm to choose between paying an even larger bonus for success, and accepting that it will continue to invest in some bad products.²

While the manager in this example chose not to collect information, our interviews also revealed other types of managerial responses. For example, managers may simply suppress information that indicates demand will be low. This is easier if the research has been collected informally; when the firm has contracted with an outside research provider, suppressing the findings is more difficult. Instead, managers may resort to other alternatives, including distorting the information. Our interviews revealed one example of distortion involving a field test for a new cleaning product. Sales in the test market were very high - so high that the independent research firm working on the test was prompted to investigate. It discovered that the project manager had personally visited the test stores and installed end of aisle displays and point of sale promotions to ensure the test market yielded a favorable result. Interviews with other independent research managers revealed that it is common for product managers to

² The example also highlights the manager’s supervisory role. In practice, success generally depends upon the efforts of an entire team, who work jointly on collecting demand information and developing the product. Although we will not explicitly model the supervisory relationship between the manager and the team, we can interpret the manager’s efforts in our model as time spent monitoring the activities of team members. Under this interpretation, the contribution of the manager’s effort reflects the collective contribution of the entire team.
announce in advance what they want the research to reveal. One interview subject reported this was so common that his research firm joked internally that their tagline should read: “The number you want, when you want it, just give us a hint.” Product managers would repeatedly exaggerate inputs to the forecasting model, such as expected distribution and awareness levels, to ensure that the resulting forecast was high enough to justify product launch. As another interview subject put it, “They’d find a way to convince themselves they could get 80% awareness with an advertising plan that had never achieved anything more than 50%. And all this with an ad that didn’t yet exist or, if it did, one that wasn’t testing very well.”

If none of these approaches yield the desired outcome, the product manager can turn to another solution: discredit the research process. Product managers who are disappointed with the outcome of the research process are apparently quick to argue that their new product is “too different” for the forecasts to be reliable. This is particularly common in markets for new technologies, where the product managers can cite the absence of comparable products.

We begin our analysis by focusing on situations in which managers suppress or withhold unfavorable information. However, we also want to establish that the model can encompass other types of managerial responses. For this reason, we extend the analysis to consider settings in which information is distorted, discredited or not collected (Section 3.4). We motivate these extensions by returning to the examples discussed above.

We next present the basic set up of the model. We will then discuss two key assumptions, concerning the observability of the manager’s effort, and the observability of demand.

2.2 The Model

Our model focuses on a risk-neutral firm (the principal) that hires a risk-neutral manager (the agent) to develop a product. After investing effort in the development process and obtaining a better understanding of market conditions, the manager makes a recommendation about whether product development should continue. The firm’s goal is to ensure that the manager works diligently on developing the product, and truthfully reveals when market conditions are unfavorable. We will show that these two incentives are inherently inconsistent, and this inconsistency may lead to firms allowing continued investment in products that are likely to fail.

The product development process yields a return of $Y > 0$ upon success, and zero upon failure. Product success depends on two factors: the discretionary effort from the manager, and the intrinsic demand for the product. We model the contribution of effort and demand by allowing the probability of success to depend on each factor (see Table 2).
Table 2: Probability of Product Success

<table>
<thead>
<tr>
<th></th>
<th>Effort</th>
<th>No Effort</th>
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<tbody>
<tr>
<td>High Demand</td>
<td>a</td>
<td>b_D</td>
</tr>
<tr>
<td>Low Demand</td>
<td>b_E</td>
<td>0</td>
</tr>
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</table>

We assume that effort always increases the probability of success, so that \(0 < b_i < a < 1\), for \(i = \{D, E\}\).

Although the “no effort” and “zero probability of success” interpretations aid our exposition, they may appear somewhat unrealistic. As we will discuss, it is hard to imagine a situation in which the firm does not recognize when a manager exerts no effort; or that there is ever a truly zero probability of success. Fortunately, the results do not depend upon these modeling conveniences. We observe the same tension when the manager chooses between “high” and “very high” effort (rather than effort and no effort) or when there is always a small probability of success. In Section 4 we will illustrate these alternative assumptions in a more general model, in which effort and demand are continuous.

We adopt the standard principal-agent assumption that the manager’s effort level is not observed by the firm. Effort does not guarantee success (or prevent failure), and so even after observing the outcome, the firm cannot be sure whether the manager exerted effort. As a result, the firm must motivate the manager by constructing a contract under which it is in the manager’s interests to exert effort. We also assume that the manager has private information about demand. However, the firm and the manager share the same prior beliefs that demand is high with probability \(0 < s < 1\) and low with probability \(1 - s\). These two assumptions about the observability of the manager’s effort and the observability of demand are key aspects of our model. We provide additional justification and interpretation for both assumptions at the end of this section.

Investment in continued product development is costly. We denote this investment as \(Z > 0\). The most favorable state is if demand is high and the manager has exerted effort. Products in this state will be successful with probability \(a\) (see Table 2). We assume that it is efficient for the firm to continue investing in these products: \(Z < aY\). Notice that the outcome remains stochastic, and so even when the manager exerts effort and demand is high the product may not succeed. If demand is low or the manager does not exert effort we will assume that it is not...
efficient for the firm to make additional investments. It follows that the firm will always want the manager to exert effort as without effort a product is never worth continuing. However, as we shall see, the firm may not always kill low-demand products. We summarize these assumptions as Condition (1):

\( b_i Y < Z < aY, \ i = \{D, E\} \).

Both the firm and the manager know the values of \( Y, Z, s, a, b_D \) and \( b_E \).

2.3 Timing of the Game

We will consider two alternative timing sequences. We begin by assuming that the manager chooses effort before observing demand. It leads to the following sequence of actions:

1. A manager is hired to lead development of the new product. The firm and manager both know that demand for this new product will be high with probability \( s \).
2. The manager chooses whether to exert effort. The manager’s cost of effort is \( c > 0 \).
3. Demand is observed by the manager.
4. The manager recommends whether to kill the product.
5. If the firm kills the product the manager receives a fixed “termination bonus” \( X \geq 0 \); otherwise the product continues and the firm invests \( Z \).
6. Following investment the product either succeeds or fails. The manager receives \( W > 0 \) upon success and 0 upon failure.

In Section 5 we will investigate what happens when the manager observes demand before choosing his effort level. This effectively reverses Steps 2 and 3 in the sequence. We further extend the model in Section 6, where we allow the manager to determine when he receives demand information.

2.4 The Compensation Scheme

The firm has two parameters to determine: \( W \) and \( X \). The bonus for success \( (W) \) induces effort, while the termination bonus \( (X) \) encourages the manager to terminate low-demand products. The format of the compensation scheme is not assumed but is supported in equilibrium. If the product is terminated, there is no variable outcome to serve as the basis of a variable compensation scheme. Therefore, the firm can only offer a fixed payment. If the product continues, the firm can in theory offer both the outcome-based bonus and a fixed payment that is independent of the product outcome. However, a fixed payment increases the wage bill without inducing efficient effort or investment, and so the firm will always prefer to reduce the fixed payment to zero.
We assume that the cost of effort (c) is sufficiently small that it is efficient for the manager to exert effort when demand is high: \( aY > Z + c \).\(^3\) We also assume that the outside opportunity of the manager is zero, so that his participation constraint is satisfied if his expected wages are equal to his effort costs (if any). This assumption is analytically convenient because it allows us to focus on incentive compatibility. However, it is not crucial to the analysis; we can establish similar results when the outside option is (strictly) positive or negative.\(^4\)

Finally, we assume the manager has limited liability to the firm so that the minimum wage of the manager is zero. This implicitly rules out degenerate contracts in which the firm effectively sells itself to the manager. The assumption of limited liability is common in the related literature.\(^5\) In our context, the assumption can be justified by recognizing that the manager always has the option of resigning. We will later investigate how relaxing this assumption affects the results.

Before analyzing the model, it is helpful to discuss two key assumptions: the observability of the manager’s effort, and the manager’s private information about demand. This discussion will focus both on justifying the assumptions and broadening their interpretation.

### 2.5 Observability of Effort and Demand

Several factors may limit a firm’s ability to observe a project manager’s effort. First, the firm may be able to observe whether the manager is exerting effort, but unable to distinguish between “high” and “very high” effort. Even when feasible, this may require a level of monitoring that is costly and interferes with the manager’s effectiveness. Second, the manager may be working at full capacity, but faces a multi-task problem, in which he has to allocate scarce effort between different activities (Holmström and Milgrom 1987). If the importance of the tasks is not fully observable to the senior managers, it creates an incentive for the project manager to misallocate effort, unless his incentives are aligned through a bonus. An alternative interpretation is that senior managers may be able to observe the level of effort, but not the quality of effort. For example, the manager may be working a lot of hours doing busy work (e.g. writing reports), but not spending time on difficult activities (e.g. managing employees). Third, in small firms the project manager maybe the CEO, with the investors or Board of Directors

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\(^3\) In later analysis we rely on analogous assumptions to ensure that the firm always earns positive expected profits in equilibrium.

\(^4\) If the manager retains the right to resign any time, the payment upon failure needs to be greater than or equal to the manager’s outside opportunity to be effective. In this case, a positive outside opportunity cannot help the firm eliminate the investment inefficiency problem.

\(^5\) For recent examples of papers that make the same assumption see: Bester and Krähmer (2008); Bergmann and Friedl (2008); and Shin (2008).
serving the supervisory role. Because the investors and Board are rarely co-located with the CEO, the CEO’s efforts may be particularly difficult to observe.6

Our second key assumption is that the firm has less information than the product manager about whether the product will succeed. This assumption is common in the related literature.7 The product manager will almost certainly have had more direct communications with key participants in the process, including: suppliers, distributors, customers, market research professionals, and other members of the product development team. It seems reasonable to expect that the depth and frequency of the manager’s interactions with the participants in the product development process place him in a unique position for understanding demand.

Notice that our assumption requires not just that the product manager has more information, but also that the firm cannot contract on whether the manager reveals this information truthfully (see also Demski and Sappington 1987; and Baiman and Sivaramakrishnan 1991). There are at least three reasons to believe that contractibility will be imperfect. First, while some of the information gained from these interactions can be communicated directly to senior managers (and contracted upon), other information will be more difficult to communicate. For example, while senior managers may be able to require that the product manager supplies the final report produced by a market research firm, they cannot contract on whether the manager correctly reports what he observes during the research process. Second, the manager presumably not only receives private information, but also has private information about how much information he receives. While the senior managers may know whether the product manager purchased market research, they may not know how many conversations he had with suppliers and customers, or the level of certainty that these conversations provide. Third, when demand information is observable to the firm managers may find other ways to respond. The examples at the start of this section suggest that they may distort the information, discredit it, or simply not collect it. We will consider all three possibilities in extensions to our model (Section 3.4).

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6 These explanations all describe why the firm may need to induce the manager to exert effort. It is also possible that the firm may reward success for other reasons. For example, it would be sufficient that the manager has private information about his effectiveness. In this situation, the reward for success may reflect the firm’s efforts to screen managers. Because competent managers are more likely to develop successful products, rewarding success can ensure that the position attracts only competent managers. In terms of our model, managerial effort could be relabeled “managerial competency,” and the cost of effort could be reinterpreted as the incremental payoff capable managers could have earned (over incapable managers) outside the firm. The rest of the model remains unchanged.

It is convenient to label the manager’s private information as knowledge of demand. However, the information could equivalently describe knowledge about suppliers or other factors that determine product success. Examples might include knowledge about the cost and availability of critical components. It is also plausible that both the firm and the manager share common knowledge about the likelihood of success that is not shared by outside bystanders. This common knowledge is not important to the model, and so we will assume it is already reflected in the probabilities in Table 2.

3. Initial Analysis

We begin by considering two benchmark models. Comparisons between the full model and these benchmark models will help illustrate the tension between rewarding success and inducing the manager to accurately report demand.

3.1 Benchmark Cases

*The “First-Best”*

If the firm and the manager were integrated as one entity, they do not need $W$ or $X$ to motivate effort and kill low-demand products. The joint entity will exert effort and only continue the product if demand is high. The expected joint profit equals $s(aY – Z) – c$, which is the maximum expected profit the firm and manager can achieve.

*Verifiable Effort*

When effort is observable and verifiable, so that the firm and manager can contract on the manager’s effort level, the firm can directly reimburse the manager for his effort costs. To persuade the manager to truthfully reveal whether demand is high, the firm must construct $W$ and $X$ such that $aW \geq X \geq bW$. It can do so by making $W$ infinitesimally small, and then offering $X = bW$, which is also infinitesimally small. In this way, the firm can kill low-demand products and again approach first-best profits.

These benchmark models confirm the importance of our assumptions. It is only when the firm cannot contract on the manager’s effort level that a tension emerges between implementing efficient investment and motivating effort.

We next illustrate this tension by returning to our assumption that effort is unobservable (we will later consider settings in which effort is observable but unverifiable). We begin analysis of the optimal success and termination bonuses ($W$ and $X$) by recognizing that the firm’s key decision is whether to ensure that the manager kills low-demand products. Killing low-demand products is costly because the firm must pay the manager a termination bonus. This means that the manager can always earn a bonus without exerting effort, and so the firm must pay an even
larger bonus in order to induce effort. An alternative is to allow low-demand products to continue. This avoids the need for a termination bonus and in turn reduces the bonus required to induce effort.

3.2 Killing Low-Demand Products

The optimal contract that ensures low-demand products are killed can be found by solving the following optimization problem, where the subscript “K” stands for “kill low-demand products”:

\[
\begin{align*}
\max \Pi_K &= s(aY - Z - aW) - (1 - s)X \\
\text{s.t.} \quad aW &\geq X \quad (\text{IC}_1: \text{continue high-demand products}) \\
X &\geq b_\varepsilon W \quad (\text{IC}_2: \text{kill low-demand products}) \\
&\quad s \ aW + (1 - s)X - c \geq s \max(bD \ W, X) + (1 - s)X \quad (\text{IC}_3: \text{exert effort})
\end{align*}
\]

The firm earns an expected net return of \(aY - Z\) from continuing a high-demand product, which occurs with probability \(s\). Meanwhile, the firm must pay the manager an expected salary of \(s \ aW + (1 - s)X\). The firm chooses a contract \((W, X)\) to maximize its expected net profit. In doing so, the firm must ensure that the manager chooses to work hard before observing the true state of demand \((\text{IC}_3)\), continues the product if he subsequently observes that demand is high \((\text{IC}_1)\), and terminates the product if demand is low \((\text{IC}_2)\).

Because there is a positive probability that even low-demand products will succeed \((b_\varepsilon > 0)\), the firm must offer a strictly positive termination bonus \((X > 0)\) to satisfy \(\text{IC}_2\) and ensure that low-demand products are killed. However, this makes it harder to satisfy the effort constraint \((\text{IC}_3)\). Notice also that if the manager is indifferent between terminating and continuing a low-demand product, he will strictly prefer to continue high-demand products, so that if \(\text{IC}_2\) is binding then \(\text{IC}_1\) is slack. We know that \(\text{IC}_2\) must be binding in equilibrium, otherwise the firm can always reduce \(X\) and improve profits. Therefore, in equilibrium the firm sets \(W\) and \(X\) so that only \(\text{IC}_2\) and \(\text{IC}_3\) are binding. Solving these binding constraints, we obtain the equilibrium contract and firm profit:

\[
\begin{align*}
W_k^* &= c / \{s \ [a - \max(bD, b_\varepsilon)]\} \\
X_k^* &= b_\varepsilon \ W_k^* \\
\Pi_k^* &= s(aY - Z) - [s \ a + (1-s) b_\varepsilon] \ W_k^*
\end{align*}
\]

The firm’s expected profit is strictly lower than the first-best profit because it must over-compensate the manager by paying him more than his cost of effort. The firm pays the manager an expected wage of \(c + ck\) where:

\[
k = \max \{ \ b_\varepsilon / (s a) , \ (b_\varepsilon (1-s) + sbD) / (s a - bD) \} > 0.
\]
The premium that the firm pays the manager (ck) is increasing in both \( b_D \) and \( b_E \). Any increase in the (small) probability that a low-demand product will succeed makes it more difficult to persuade the manager to kill the product. As a result, the firm has to pay a larger bonus upon termination (X). This weakens the manager’s incentive to work, and so the firm must also pay a larger success bonus (W) to encourage effort. We will return to this point when we discuss the role of biases in managerial beliefs. If these biases increase the perceived probability that low-demand products will succeed, it becomes more costly for the firm to ensure that they are terminated.

If the cost of terminating low-demand products is too high the firm may allow them to continue, even though the manager has information indicating that demand will be low. We investigate this possibility next.

### 3.3 Allowing Low-Demand Products to Continue

The most profitable contract under which a manager exerts effort and prefers continued investment in low-demand products can be found by solving the following optimization problem:

\[
\max \, \Pi_{NK} = s (a Y - Z) + (1 - s) (b_E Y - Z) - [s a + (1 - s) b_E] W \\
\text{s.t.} \quad a W \geq X \quad \text{(IC}_1: \text{continue high-demand products)} \\
b_E W \geq X \quad \text{(IC}_2: \text{continue low-demand products)} \\
[s a + (1 - s) b_E] W - c \geq s \max(b_D W, X) + (1 - s) X \quad \text{(IC}_3: \text{exert effort)}
\]

The firm pays an expected wage of \([s a + (1 - s) b_E] W\) and expects to earn \( a Y - Z \) from high-demand products and to lose \( Z - b_E Y \) from low-demand products. The manager’s contract induces effort, but now the manager will not terminate the product even if he observes demand is low (IC₂). In fact, no products will be terminated once the manager has exerted effort. Some low-demand products will be a success, albeit with a low probability \( b_E \). Therefore, the firm will observe success with probability \( s a + (1 - s) b_E \).

It should be clear that \( X \) will be 0 in equilibrium. Since the firm no longer tries to distinguish between high- and low-demand products, it gains nothing from offering a termination bonus, which only counters the incentive to work. Mathematically, \( X \) does not enter the firm’s objective function but enters the constraints, where \( X = 0 \) imposes the weakest constraint. The equilibrium value of \( W \) is derived by solving the binding effort constraint IC₃:

\[
W_{NK}^* = \frac{c}{[s (a - b_D) + (1 - s) b_E]} \\
X_{NK}^* = 0
\]
\[ \Pi_{NK}^* = s (a Y - Z) + (1-s) (b_E Y - Z) - [s a + (1-s) b_E] W_{NK}^* \]

By allowing low-demand products to continue, the firm incurs a net loss of \(Z - b_E Y\) with probability \((1-s)\). However, the firm no longer pays a termination bonus. Moreover, the elimination of the termination bonus makes it less expensive to motivate the manager to work, so that \(W_{NK}^* < W_K^*\).

Whether the firm wants to terminate low-demand products depends on which strategy yields higher equilibrium profits. The firm will prefer to kill low-demand products \((\Pi_K^* > \Pi_{NK}^*)\) iff:

\[
(2) \quad (1-s) (Z - b_E Y) > [s a + (1-s) b_E] (W_K^* - W_{NK}^*) \]

\[= [s a + (1-s) b_E] (c / \{s [a - \max(b_D, b_E)]\} - c / \{s (a-b_D) + (1-s) b_E\}) \]

This is a key condition in the paper, which we will return to in later discussion. It can be shown that Condition (2) is less likely to be satisfied with larger values of \(b_E\). A larger value of \(b_E\) alleviates the inefficiency loss from continuing to invest in products for which demand is low \((Z - b_E Y)\), increases the payroll cost to terminate low-demand products \((\text{higher } W_K^*)\), but reduces the bonus needed to induce effort when low-demand products are allowed \((\text{lower } W_{NK}^*)\). The following Proposition summarizes this result:

**Proposition 1**

If the firm cannot observe effort or demand, it may be optimal to continue investing in products even after the manager has learned that demand is low. Low-demand products are more likely to continue if effort alone is a more important determinant of product success \((\text{high } b_E)\).

**Proof:**

By construction.

The firm trades off efficient investment with payroll reduction. To ensure only high-demand products continue, the firm must grant the manager a bonus for terminating low-demand products. The firm may find it more profitable to eliminate the termination payment, which lowers the manager’s compensation but introduces the risk of inefficient investments in low-demand products.

Our analysis has focused on the manager’s incentives to suppress demand information. The motivating examples in Section 2 reveal that this is not the only type of response that we observe from managers. In particular, where the demand information is provided by an outside research provider it may not be possible for the manager to suppress it. Instead, the examples suggest that managers may respond by distorting the information, discrediting it, or simply not
collecting it. We consider these settings next, and illustrate how our findings can be extended to accommodate these responses.

3.4.1 Distorting Demand Information

We cited several examples of product managers distorting information to make demand look more favorable. These included inflating inputs to forecasting models, and visiting stores to manipulate test market findings. The information that is distorted is the information that the firm observes. Recall that our argument requires that the manager has private information about demand and this information is not distorted. This suggests two possibilities; either the distorted information is additional to what the manager receives (such as a market test that supplements information the manager has already acquired); or the manager acquires the information but can distort what the firm sees (such as changing the distribution and advertising assumptions in a forecasting model).

Either interpretation is consistent with the current model. The manager acquires private information that the firm does not see and the manager can distort the information that the firm does observe. This is equivalent in modeling terms to the manager deciding what to tell the firm about demand.

3.4.3 Discrediting Demand Information

Our interview subjects reported that it is common for product manager’s to discredit unfavorable research outcomes by arguing that the findings are unreliable. We can easily extend the model to accommodate this response. Assume that market research yields a demand signal. The manager and the firm observe the signal, but only the manager observes its accuracy. Specifically, informative market research accurately indicates whether demand is high or low. Uninformative market research also signals whether demand is high or low, but this signal is uninformative, providing no additional information beyond the prior probabilities.

Unless the manager is offered a sufficient termination bonus, he will prefer to discredit negative information by claiming that the negative signal is inaccurate. For the manager to honestly admit that negative information is accurate the firm must ensure that \( X \geq b_W \). This requires a positive termination bonus \( X \), which undermines the manager’s effort incentives and escalates the firm’s payroll costs. Alternatively, the firm can accept the manager’s claim that negative information is inaccurate. This option parallels the baseline model; not offering a termination bonus means that the firm may invest in all products (including low-demand products). The trade-off between these two options yields a condition analogous to Condition (2) describing parameter conditions under which the firm continues to invest in the product despite unfavorable demand information (that the manager knows is accurate).
3.4.2 Forgoing Demand Information

Recall that the product manager in the healthy snack example chose not to conduct a market test, apparently out of concern that an unfavorable result would threaten product launch. Forgoing information is very similar to discrediting information, and introduces the same trade-offs. Assume that after exerting effort the manager can conduct additional research before recommending further investment. The outcome of the research is the same as in the discrediting information example. The only difference is that in this case the manager privately anticipates the accuracy of the research before it is collected.

If the manager honestly reports that market research yields accurate demand information, then any negative research outcome will lead to product termination. Therefore, unless there is a sufficient termination bonus, the manager will argue that market research is inaccurate and should be skipped. This termination bonus again weakens the effort incentive and escalates the firm’s payroll costs. To avoid paying a termination bonus, the firm can accept the manager’s claim that the research is inaccurate. In this case, the firm does not condition its investment decisions on the outcome of the research, and instead invests in all products. If it does not use demand information then there is no need to incur the expense of collecting it, and so the firm will allow the manager to forgo the additional research even when the manager knows that it will be accurate.

We conclude that the tension between rewarding success and terminating low-demand products extends beyond suppressing or withholding information to include a broad range of managerial distortions. In the next section, we explore the robustness of this tension by investigating how the outcome changes when we relax a range of assumptions.

4. Robustness of the Main Result

4.1 Psychological Biases in Beliefs

Managers may have biased expectations about the probability the product will succeed. Our review of the literature identifies at least two sources of bias. First, Biyalogorsky, Boulding and Staelin (2006) find that a manager’s initial support for a product may positively bias his expectations about the probability of success. They label this phenomenon: “belief inertia distortion,” and predict that it may lead the manager to discount negative information and mistakenly believe it is profitable to continue. Second, the managerial decision making literature has documented a phenomenon called “managerial conceit,” that leads managers to

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8 Boulding, Kalra and Staelin (1999) observe the same distortion in consumers, whose perception of service quality is influenced by their prior beliefs.
believe that they can beat the odds through additional effort (March and Shapira 1987). Managerial conceit may also create overly optimistic expectations about product success.

Our model offers two findings that help interpret the role of these psychological biases. First, if the firm anticipates the bias, it can design incentive contracts that overcome the resulting distortions.\(^9\) This suggests that belief distortions and managerial conceit are not on their own sufficient to explain why firms allow continued investment in low-demand products. However, this does not imply that these biases play no role. To the contrary, belief distortions and managerial conceit both make it more costly to kill low-demand products. They may greatly amplify the tension that we study, making it more likely that the firm will continue to invest in low-demand products.

More formally, we can model belief inertia distortions by assuming that when the manager receives a negative signal about demand he believes that the probability of success is \(b'\), while the true probability is \(b\).\(^{10}\) To confirm that this distortion cannot on its own explain continued investments in low-demand products we begin by removing the tension that we study in this paper. In particular, assume that the firm can directly compensate the manager for verifiable effort. If the firm offers a success bonus of \(W^* = \epsilon\) and a termination bonus of \(X^* = b'W^*\) it can kill low-demand products and achieve approximately first-best profits (by setting \(\epsilon\) sufficiently low). In the case of managerial conceit, once the manager has exerted effort, we assume that he perceives the probability of success is \(a'\) when demand is high, and \(b\epsilon'\) when demand is low, where \(a' > a\), \(b\epsilon' > b\epsilon\), and \(a' > b\epsilon'\). If the firm can directly compensate the manager for effort, it will offer a success bonus of \(W^* = \epsilon\) and a termination bonus of \(X^* = b\epsilon'W^*\). This again allows the firm to kill low-demand products and restore first-best profits.

Although this analysis confirms that biases in managers’ expectations are not on their own sufficient to explain continued investment in low-demand products, this does not imply that these biases play no role. When we reintroduce the tension between rewarding success and killing low-demand products we see that these biases are important. If managers are overconfident about the probability of success then a larger termination bonus is required to ensure low-demand products are killed. This increases the required success bonus, resulting in a higher wage bill and lower profits (see the Appendix for a formal analysis). We conclude that

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\(^9\) Designing contracts to accommodate distortions in managers’ behavior has a parallel in the literature on performance evaluation. Hauser, Simester and Wernerfelt (1997) investigate side payments between marketing managers and their employees and show that side payments will almost always occur. However, if firms can anticipate the resulting inflation in the employee evaluations, they can write first-best contracts that adjust for these distortions.

\(^{10}\) The negative information is under weighted rather than ignored, and so we assume \(a > b'\).
biases in managers’ beliefs complement the results in this paper, by making it harder to resolve the tension between rewarding success and killing low-demand products.

4.2 Observability vs. Verifiability of Effort

We have assumed that the firm cannot observe the manager’s effort. An alternative possibility is that effort is observable but not verifiable, so that the firm cannot contract on it. For information to be verifiable, the interpretation of the signal by the two contracting parties and any third party who may be required to enforce the contract must be the same (Hart 1995). For example, while the firm may observe that the manager avoids difficult tasks, the manager may defend accusations of shirking with evidence that he has worked long hours.

If the manager’s effort is observable but not verifiable then the firm cannot condition the manager’s compensation on effort. However, it can change its investment decisions. In particular, if the firm observes low effort, it can terminate the product even when the manager claims that demand is high. In our model this change is reflected in the manager’s effort constraint (IC3). In particular, if the firm wants to kill low-demand products, the manager’s effort constraint becomes:

\[ s \ a W + (1 - s) X - c \geq X \]

This revised constraint recognizes that the manager can no longer avoid effort yet still recommend product continuation. The resulting optimal profit is: \( s (a Y - Z) - c - c b_e / s(a-b_e) \). Notice that the new profit is equal to the previous profit (\( \Pi_k^* \)) when \( b_0 \) is set to 0. Intuitively, if \( b_0 \) equals 0, the product always fails when the manager shirks. This is equivalent to the outcome when effort is observable but not verifiable, as the firm will always terminate the product if it observes the manager shirking.

If the firm wants to allow low-demand products to continue then the revised effort constraint (IC3) is:

\[ [s \ a + (1 - s) b_e] W - c \geq X \]

---

11 The distinction between verifiable and non-verifiable information has also been compared to the distinction between soft and hard information in the finance literature (see for example Peterson 2004).

12 In contrast, when effort is unobservable, the firm will always follow the manager’s recommendation of whether to continue a product. \((W_k^*, X_k^*)\) is the cheapest “separating” contract to elicit truthful reporting of demand. Knowing the manager is truth-telling, the firm has no incentive not to follow the manager’s recommendation. \((W_{pek}^*, X_{pek}^*)\) is the cheapest “pooling” contract whereby the manager always recommends continuation once he has invested effort. The firm can choose not to (always) follow the manager’s recommendation. However, doing so only makes effort more expensive to induce.
The corresponding optimal profit is: \( s(aY-Z) + (1-s)(b_{E}Y-Z) - c \). This is equal to the profit \( \Pi_{NK}^{*} \) when \( b_{D}=0 \).

It follows that the firm will kill low-demand products if and only if:

\[
(1-s)(Z-b_{E}Y) > cb_{E} / s(a-b_{E})
\]

As we would expect, this condition is equivalent to Condition (2) when \( b_{D} \) equals 0. For some parameter values, this modification strengthens Condition (2) and for other parameter values it weakens it. The net outcome is that the tension between rewarding success and inducing truthful reporting of demand survives, and so the firm may continue to invest in low-demand products even when effort is observable but not verifiable.

It may initially seem surprising that the observability of effort does not always make it easier to kill low-demand products. The reasoning is as follows. When effort is observable it is cheaper for the firm to implement either outcome (killing low-demand products or allowing them to continue) as the manager’s effort constraint is more easily satisfied in both cases. The relative savings for the two outcomes depend on the model parameters, and so the impact on Condition (2) also depends upon the model parameters. We conclude that the observability of effort does not eliminate the tension between effort inducement and information elicitation. Unless effort is verifiable, the firm still has to offer a success bonus to motivate effort. Consequently, the firm still has to pay a termination bonus to elicit truthful reporting of demand, which weakens the manager’s incentives to work.

### 4.3 Monitoring

We can also consider the possibility that by investing in monitoring the firm can collect verifiable information about the manager’s effort level that allows it to directly contract on effort. Assume that at cost \( M > 0 \) the firm fully verifies the manager’s effort. We know from the “verifiable effort” benchmark we discussed at the start of Section 2 that the firm earns a profit of \( s(aY-Z) - c - M \) by monitoring. As long as \( M \) is not too high, the firm will prefer to always incur this monitoring cost and will never invest in low-demand products.

In some settings monitoring is more profitable if it occurs randomly (Townsend 1979; Border and Sobel 1987), so that the manager knows that with some probability his effort will be verified. However, random monitoring does not increase the firm’s profits in our model. Notice first that in order for random monitoring to be an equilibrium outcome the firm must be indifferent between monitoring and not monitoring. However, the manager will not randomly choose whether to work in equilibrium. If the manager is indifferent about working the firm can increase the success bonus by a small amount, guarantee effort, and improve its expected profits. This result has an important corollary; if monitoring enables the firm to observe but not
verify effort, the firm will never choose monitoring. Since the contract already guarantees effort, if the firm cannot vary manager compensation based on the monitoring outcome it has no incentive to incur the monitoring cost. It remains to check whether random monitoring is profitable when the firm can verify effort.

We denote by $B$ the wages that the manager earns when verification confirms he has worked, and consider two possibilities. First if these wages are less than the effort costs ($B < c$), then the firm must over-compensate the manager when monitoring does not occur, otherwise the manager will not work. Therefore, if the firm wants to kill low-demand products and monitoring does not occur, it must pay a success bonus higher than $W_k^*$ and earn less than $\Pi_k^*$. Because the profit from monitoring must be the same as the profit from not monitoring, stochastic monitoring cannot increase the firm’s profits compared to never-monitoring. On the other hand, if $B \geq c$, then the firm earns $s(aY-Z)-B-M$. This is no higher than the optimal profit of $s(aY-Z) – c – M$ under full-time monitoring (see above). We obtain similar results if the firm accepts investment in low-demand products or conditions its investment decisions on monitoring.

We conclude that monitoring can enable the firm to overcome the tension between rewarding success and killing low-demand products. However, if monitoring costs are high, it will be more profitable to allow continued investment in low-demand products. Moreover, the firm cannot improve the profitability of monitoring by implementing it on a random basis. To be credible the firm must be indifferent about whether to monitor, and this randomized monitoring cannot yield higher profits than both never-monitoring and always-monitoring.

### 4.4 Menus of Contracts

The firm could offer the manager a menu of contracts, and it is at least theoretically possible that the manager may be able to delay his choice of those contracts until after he has observed demand. However, we can show that this cannot improve the firm’s profits.

If the firm intends to kill low-demand products, then the menu of contracts will be designed to distinguish high-demand products (which are continued) and low-demand products (which are killed). The contract associated with high-demand products will offer a success bonus, while

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$^{13}$To see this, assume the firm monitors effort with probability $r$, where $0 < r < 1$. If the manager exerts effort, he earns an expected net payoff of $rB + (1-r) [saW + (1-s) X] - c$; if he shirks, he earns $(1-r) [s \max(b_0W, X) + (1-s) X]$. The effort constraint, after rearranging terms, is $saW + (1-s) X - c + (B-c)r/(1-r) \geq s \max(b_0W, X) + (1-s) X$. But this inequality is the same as the effort constraint in the baseline model except for the additional term $B-c)/r/(1-r)$. If $B < c$, the new effort constraint becomes harder to satisfy, and the equilibrium success bonus is higher than $W_k^*$. 

---
the contract associated with low-demand products will be simply a termination bonus. The resulting IC constraints reduce to the same constraints as those used to find \( \Pi_K^* \).

If the firm allows low-demand products to continue, a menu of contracts cannot improve profits either. Assume there is an equilibrium in which both high and low-demand products continue, but a contract choice induces the manager to reveal whether demand is high or low. This generates a contradiction, because the firm will then kill low-demand products. Notice also that if the firm could guarantee not to kill the product, the firm would not benefit from the information (and so profits could not increase).

Another way of understanding this result is that a menu of contracts is redundant because the manager’s recommendation already acts as a choice from a menu of contracts. We can consider \( W \) and \( X \) as different contracts in a menu, where the manager elects to receive the bonus for success when demand is high, and to receive the bonus for termination when demand is low.

4.5 Negative Wages

We have assumed that the manager’s minimum wage is non-negative. As a result, the firm can only induce effort by offering a reward for success. If negative wages are feasible the firm could also motivate effort by punishing the manager if he recommends investment but the product fails (while ensuring that the manager’s ex ante expected wage still exceed his effort costs). As we will see, negative wages may allow the firm to avoid investments in low-demand products.

Let \( L \) denote the limit on the manager’s liability to the firm (any punishment cannot exceed \( L \) in absolute value). The Appendix presents the full solution to how the product termination decision varies with \( L \). It identifies two thresholds:

\[
\underline{L}_k = c \left[ s b_0 + (1-s)b_e \right] / s(a-b_0)
\]

\[
\underline{L}_{NK} = \frac{c s b_D}{s(a-b_0) + (1-s)b_e}
\]

where \( \underline{L}_k > \underline{L}_{NK} \). We show that if \( L \) is sufficiently large \( (L \geq \underline{L}_k) \), so that the firm can severely punish the manager for failure, it only has to pay an expected wage equal to the cost of effort \( c \). The firm will always kill low-demand products.

In contrast, if the limits on liability are less than \( \underline{L}_{NK} \), we return to the result in Proposition 1. The firm must pay an expected wage higher than \( c \), whether it intends to kill low-demand products or not. The savings from continuing low-demand products are identical to our baseline model, and so the firm kills low-demand products iff Condition (2) holds. This result
clarifies that Proposition 1 does not rely on wages being nonnegative. Instead it requires a limit on how large any negative wage can be.

Finally, if the limits on liability are at an intermediate level ($L_{NK} \leq L < L_S$), the firm may continue to allow investments in low-demand products, but this occurs less frequently (Condition 2 holds for a wider range of parameter values). Intuitively, by punishing failure the firm can pay a smaller reward for success. This weakens the manager’s incentives to recommend continued investment in low-demand products and eventually obviates the need for a termination bonus.

The assumption of limited liability is not only common in the related literature, but has also been used recently in the popular press to explain why bankers can receive large bonuses in profitable years, but are merely fired, and do not have to re-pay bonuses in unprofitable years. Our findings suggest that tying bonuses to the success of investments may not be sufficient to prevent bankers, or loan officers, from overlooking unfavorable risk information. If limited liability insulates them from the downside risk, they will tend to underweight the risk of failure as long as there remains a positive probability that the investment will succeed.

### 4.6 Continuous Effort and Demand

To aid clarity we have presented a model with discrete effort and demand levels. However, the underlying tension between motivating effort and truthful reporting of demand is a general phenomenon that survives when we allow effort and demand to be continuous. In particular, assume that the manager chooses effort from a continuous strategy space, where the lowest level of effort is $e$. The cost of the effort is given by the function $c(e)$. After choosing effort the manager privately observes the demand parameter ($d$), which represents a draw from a continuous distribution. The outcome of the product development process also represents a draw from a continuous distribution, where the expected outcome increases with effort and the demand parameter. To ensure that effort cannot be inferred from the outcome, we assume that the support of the outcome distribution is fixed.

We label the first-best effort as $e^*$ and label the threshold demand level at which it is efficient to continue investing in the product as $d^*$. We focus on the non-degenerate case where $e^* > e$. We can show that the firm will only earn the first-best profits if it can verify and contract on effort. We formally prove this result as our second proposition:
**Proposition 2**

If effort and demand are continuous and the firm can verify and contract on effort, then it can achieve first-best profits. If effort is not observable to the firm, then the firm cannot implement efficient product termination without over-compensating the manager.

**Proof:**

We begin by proving that first-best profits cannot be achieved when effort and demand are unobservable to the firm. When the observed demand is $d^*$ the manager must be indifferent about continuing or terminating the product, otherwise for slightly lower or slightly higher demand realizations the manager will not make the efficient recommendation. Because the outcome distribution has fixed support we know that after observing $d^*$ the manager earns a positive expected wage if the product continues. Therefore the termination bonus must be strictly positive otherwise the manager will not be indifferent about continuing. Because the manager can earn a positive termination bonus by choosing the lowest level of effort $e$, he must earn more than $c(e^*) - c(e)$ if he chooses $e^*$.

In contrast, if the firm can verify and contract on effort it can mandate that the manager choose $e^*$ and pay him $c(e^*)$ when he does so. In addition, because the expected outcome increases with demand, the firm can use an infinitesimal performance-based bonus and termination bonus to ensure that the manager only wants to continue the product when demand exceeds $d^*$. Q.E.D.

The tension that prevents the firm from achieving first-best profits in the discrete model also arises in this continuous model. When the firm cannot observe demand it must pay a bonus to convince the manager to terminate low-demand products. However, this bonus undermines the incentives to work, and so the firm must increase the manager’s expected wage when working. This tension disappears if the firm can verify and contract on effort.

The design of sales force contracts shares similar characteristics to this problem. Firms can only achieve first-best profits if they can verify effort. However, in the sales force case the output is a function of effort and unobserved error. In our product development setting the output is a function of effort and unobserved demand. Therefore, for the sales force the problem is moral hazard, while in our product development setting the problem is further complicated by an interaction between moral hazard and adverse selection.

In the analysis so far we assume that the manager chooses whether to work before observing demand. In the next section we investigate how the timing of the manager’s effort decision
affects the outcome. We will show that the results depend not just on the timing itself, but also on how much the firm knows about this timing.

5. Early Information about Demand

5.1 Product Termination with Early Information about Demand

In practice, managers may not always have to exert effort before learning about demand. To investigate how this possibility affects the outcome, we reverse Steps 2 and 3 in the sequence of actions:

1. A manager is hired to lead development of the new product. The firm and manager both know that demand for this new product will be high with probability s.
2. Demand is observed by the manager.
3. The manager chooses whether to exert effort.
4. The manager recommends whether to kill the product.
5. If the firm kills the product the manager receives X; otherwise the product continues and the firm invests Z.
6. The continued product either succeeds or fails. The manager receives W upon success and 0 upon failure.

Notice that receiving “early demand information” does not imply that the firm knows whether the product will succeed. Instead the manager learns whether demand is high or low before choosing effort. In either case success remains uncertain, and subject to the conditional probabilities in Table 2.\(^{14}\) When demand is high, the firm clearly prefers that the manager exerts effort. If demand is low, the firm would prefer to kill the product irrespective of the manager’s effort. The key question is: by inducing effort when demand is high does the firm also create an incentive for the manager to preserve low-demand products? The answer is no. We formally state this as our third proposition:

**Proposition 3:** If the manager chooses effort after observing demand, the firm only invests in high-demand products.

**Proof:**
See Appendix.

\(^{14}\) The model accommodates situations in which the demand signal is precise and situations in which it is noisy.
Intuitively, if the manager is indifferent between shirking and working on a high-demand product, he will always prefer shirking to working on a low-demand product. As a result, the firm can always ensure that low-demand products die because the manager prefers to terminate them without wasting effort on them. The optimal contract that achieves this outcome can be found by solving the following problem:\(^{15}\)

$$\max \Pi_H = s (aY - Z) - s aW - (1 - s) X$$

s.t. 
$$aW - c \geq b_D W$$ \hspace{1cm} (IC\(_1\): exert effort when demand is high)
$$aW - c \geq X$$ \hspace{1cm} (IC\(_2\): continue high-demand products)
$$X \geq \max (b_W W - c, 0)$$ \hspace{1cm} (IC\(_3\): kill low-demand products; save effort)

The firm maximizes its expected returns from high-demand products net of expected wages. The new IC constraints reflect the manager’s knowledge of demand before choosing effort. If demand is high, the manager prefers working and earning an expected payment of \(aW\) over shirking, which earns the manager either \(b_D W\) or the termination bonus \(X\). If demand is low, the manager prefers receiving the termination bonus over wasting effort. In the proof to Proposition 3 we establish that the optimal contract is:

$$W_H^* = \frac{c}{(a - b_D)}$$
$$X_H^* = \max[c (b_D + b_E - a) / (a - b_D), 0]$$
$$\Pi_H^* = s (aY - Z) - c \left[s a + (1 - s) \max (b_D + b_E - a, 0)\right] / (a - b_D)$$

Proposition 3 highlights an important boundary condition for our explanation of why low-demand products are hard to kill. If demand uncertainty is only resolved after effort is sunk, there is a chance that the effort will be wasted. However, with early demand information, the firm can ensure the manager only invests effort when demand is high. This increases the firm’s profits because it no longer has to compensate the manager for wasted effort.\(^{16}\) This outcome

\(^{15}\)The firm may also offer a menu of contracts to the manager, and it is theoretically possible that the manager may be able to delay his choice of those contracts until after he has observed demand (and possibly until after he has selected effort). However, for the same reasons discussed in Section 3, it can be shown that a menu of contracts cannot yield higher profits for the firm. If the firm implements efficient product termination, then \(W\) is the only instrument relevant for high-demand products, while \(X\) is the only instrument relevant for bad products. The manager’s recommendation of whether to continue can be considered a selection from a menu of these two contracts. If the firm invests in both high and low-demand products, then knowing demand does not benefit the firm.

\(^{16}\)This result assumes that managers correctly interpret the information that they receive. As we discussed, managers’ prior beliefs may bias how they perceive new data. Managers that overlook negative demand information are more likely to work hard and recommend continued investment in low-demand products (see Section 4.1).
is consistent with recommendations that product development take a “phased-in” approach, where each phase generates useful information for subsequent decisions.

While early demand information allows the firm to avoid continued investments in low-demand products, motivating the manager to work when demand is high is still costly. High-demand means that that the product may succeed even if the manager does not work ($b_D>0$). As a result, the manager may be tempted to shirk and recommend continued investment. By paying a premium for success the firm can ensure the manager works (to increase his chance of receiving this premium). The size of this premium depends upon the degree to which effort increases the probability that a high-demand product will succeed (the difference between $a$ and $b_0$). The smaller this difference the larger the required premium. As long as the potential returns ($Y$) are large enough, it is worthwhile for the firm to pay this premium and induce high effort.

Although the firm must always pay the manager a premium to ensure low-demand products are killed, this premium is smaller if the manager has access to early demand information. Recall from Section 3 that the contract to kill low-demand products when there is no early information about demand is $\{W_k^*, X_k^*\}$. The contract required to kill low-demand products if early demand information is available has a smaller success bonus ($W_h^* < W_k^*$) and a smaller termination bonus ($X_h^* < X_k^*$). As a result, the manager will prefer that the firm believes that early demand information is unavailable. The following analysis focuses on this issue and explores whether uncertainty about the timing of demand information affects the firm’s product investment decisions.

5.2 Uncertain Timing of Demand Information

We have previously assumed that the firm knows when the manager receives his demand signal. In practice, this may not always be the case. The firm may be uncertain not just about whether demand is high or low, it may also be uncertain about whether the manager has early information about demand. We modify our model by assuming that only the manager knows whether early demand information is available before he chooses whether to work. The firm’s prior beliefs are that early demand information is available with probability $q$, where $0 < q < 1$.

Recall that if managers learn demand after choosing effort then Condition (2) determines whether firms invest in low-demand products. If managers learn demand before choosing effort Proposition 3 establishes that firms never invest in low-demand products. Jointly this implies that if Condition (2) holds and the timing of demand information is known, then investment in low-demand products will never be optimal. For this reason we will focus the remaining analysis in this section on parameter values for which Condition (2) holds. This allows us to question whether mere uncertainty about the availability of early demand
information increases the range of parameter values for which firms allow low-demand products to continue.

We will demonstrate that the firm must choose from four options. The first option is to kill low-demand products, with the manager working unless he knows demand is low. In Lemma 1 we establish that if the firm wants to implement this outcome, but is uncertain whether the manager has early information about demand, then it will use \((W_k^*, X_k^*)\). This is the same contract that we identified in Section 3 as optimal when the firm wants to kill low-demand products and the manager chooses effort before observing demand.

The second option is more conservative. The firm only implements effort when the manager knows in advance that demand is high. This allows the firm to pay smaller bonuses, because it does not have to compensate the manager for wastefully exerting effort when demand is subsequently revealed to be low. On the other hand, the firm never proceeds without early demand information, and so some potentially high-demand products are killed.

We rule out a third option. Under this option the firm confronts its uncertainty using a menu of contracts that induces the manager to truthfully report whether he has early information about demand. We establish in Lemma 2 that menus of contracts cannot improve the firm’s profits.

Finally, the fourth option is to allow continued investment in low-demand products. We explore whether this can yield higher profits, even though the firm would never allow investments in low-demand products if it knew the timing of the demand information (given our assumption about Condition 2).

**Option 1: Killing Low-Demand Products**

In Lemma 1 we identify the optimal “single” contract that implements the outcome under which low-demand products are killed and the manager works unless demand is known to be low.

**Lemma 1:**

If the firm is uncertain whether early demand information is available, then \((W_k^*, X_k^*)\) is the optimal contract that ensures low-demand products are killed and the manager works unless demand is known to be low.

**Proof:**

We first show that \((W_k^*, X_k^*)\) both kills low-demand products, and implements effort unless the manager knows demand is low. We then show that \((W_k^*, X_k^*)\) is the cheapest contract to achieve this goal.
When early demand information is unavailable, the contract \((W_k^*, X_k^*)\) induces the manager to work and to terminate low-demand products (see Section 3). When early demand information is available, \((W_k^*, X_k^*)\) satisfies the new IC constraints with slack:

\[
\begin{align*}
    aW_k^* - c &> b_D W_k^* \quad \text{(IC1: exert effort when demand is high)} \\
    aW_k^* - c &> X_k^* \quad \text{(IC2: continue high-demand products)} \\
    X_k^* &> b_E W_k^* - c \quad \text{(IC3: kill low-demand products; save effort)}
\end{align*}
\]

The firm maximizes the same profit function \(\Pi = s (aY - Z) - s aW - (1-s) X\). Because \((W_k^*, X_k^*)\) is the unique optimal solution to this objective function when there are fewer constraints, it must also be the unique optimal solution when there are additional slack constraints. Q.E.D.

It should also be clear that never implementing effort is dominated by \((W_k^*, X_k^*)\). However, we do have to consider the possibility that the firm will only induce effort when demand is known to be high.\(^{17}\) We consider this possibility next.

**Option 2: A More Conservative Approach**

The contract \((W_k^*, X_k^*)\) overcompensates the manager when early demand information is available. This is because effort is cheaper to induce if the manager can avoid wasting effort on low-demand products. Therefore, it is possible that the firm could improve profits by forgoing effort and killing all products when early demand information is unavailable. The optimal contract that implements this solution (which we denote by “C” for conservative) is determined from:

\[
\max \Pi_C = q \left[ s (aY - Z) - s aW - (1-s) X \right] + (1-q) (-X)
\]

s.t. If early demand information is available:

\[
\begin{align*}
    aW - c &\geq \max(b_D W, X) \quad \text{(IC1: work on and continue high-demand products)} \\
    X &\geq \max(b_E W - c, 0) \quad \text{(IC2: kill low-demand products; save effort)}
\end{align*}
\]

If early demand information is unavailable:

\[
\begin{align*}
    X &\geq s \max(aW, X) + (1-s) \max(b_E W, X) - c \quad \text{(IC3: save effort)} \\
    X &\geq b_D W \quad \text{(IC4: kill the product)}
\end{align*}
\]

\(^{17}\) It can be shown that there is no single contract that only induces effort if early demand information is unavailable.
Under this conservative approach, the firm’s expected profit depends on the timing of demand information. If demand information is available before the manager chooses effort, the firm wants the manager to work only when demand is high. If early demand information is unavailable, the firm prefers the manager to terminate the project altogether to avoid wasting effort on low-demand products.

The IC$_1$ constraint, which requires that aW – c ≥ X, must be binding in equilibrium otherwise the firm can decrease W and improve profits. It follows that IC$_2$ and IC$_3$ hold with slack, and that the final constraint is binding (X = b$_D$W). Consequently, the equilibrium contract and profit can be derived as:

\[ W^*_C = \frac{c}{a - b_D} < W^*_K \]
\[ X^*_C = \frac{c b_D}{a - b_D} \]
\[ \Pi^*_C = q s (aY - Z - c) - c b_D / (a - b_D) \]

We can compare the profitability of this contract (W$_C^*$, X$_C^*$) with (W$_K^*$, X$_K^*$). The outcome depends on the parameters and so neither contract is dominant. However, we know that the most profitable contract of the form (W, X) is one of these two contracts.

There is also another possibility. The firm may want to use a menu of contracts to induce the manager to honestly report whether early demand information is available. For example, the firm could offer a menu of contracts, where the manager prefers to choose one contract when early demand information is available and the other when it is unavailable. We consider this possibility next.

**Option 3: Menus of Contracts**

In Lemma 2 we establish that menus of contracts cannot achieve higher profits than (W$_K^*$, X$_K^*$) and (W$_C^*$, X$_C^*$).

**Lemma 2:**
When the firm is uncertain whether early demand information is available, a menu of contracts is no more profitable than the optimal single contract.

**Proof:**
See Appendix.

The intuition for this result is that inducing the manager to reveal whether early information is available requires a transfer of surplus to the manager. This transfer of surplus depends upon the foregone rents that the manager enjoys from early information. As a result, the cost of
inducing the manager to select the appropriate contract is no less than the rents that the manager enjoys when the firm uses a single contract.

We conclude that the most the firm can earn if it only invests in high-demand products is either $\Pi_k^*$ (which induces effort when demand is high or uncertain) or $\Pi_c^*$ (which only induces effort when demand is high). The contract in Option 1 over-compensates the manager when he has early information about demand. The more conservative contract $(W_c^*, X_c^*)$ reduces the firm’s payroll costs by only inducing effort when demand is known to be high, though it also potentially leads to the termination of high-demand products when early demand is unavailable. Both contracts offer a positive bonus $(X_k^* + X_c^*)$ to ensure termination of low-demand products. These termination bonuses allow the manager to enjoy a surplus when shirking, leading to the now familiar outcome that the firm must pay higher success bonuses to induce effort. In the final step in our analysis we demonstrate that it may be possible for the firm to earn more than either $\Pi_k^*$ or $\Pi_c^*$ by allowing low-demand products to continue.

**Option 4: Allowing Low-Demand Products to Continue**

Rather than fully characterizing the optimal contract that allows investments in low-demand products, we instead provide an example of a contract that allows low-demand products to continue and yields higher profits than the three previous options. Because the firm would not allow low-demand products to continue when it knows the timing of demand information (under our assumption that Condition 2 holds), the existence of such a contract is sufficient to show that mere uncertainty about the timing of the demand information can increase the likelihood that the firm invests in low-demand products.

It suffices to find one contract that allows low-demand products to continue but generates a higher expected profit than both $\Pi_k^*$ and $\Pi_c^*$ for certain values of $q$. An obvious candidate is the optimal contract that kills low-demand products when the manager has early access to demand information: $(W_h^*, X_h^*)$. If early demand information is available, the firm earns $\Pi_h^*$. If early demand information is unavailable, the firm earns an expected profit of $\Pi_u$ and, importantly, may allow low-demand products to continue. When the firm is uncertain about the availability of early demand information, offering $(W_h^*, X_h^*)$ yields expected profits of:

$$\Pi_e = q \Pi_h^* + (1-q) \Pi_u.$$  

It should be clear that when $q$ is close to one, so that early demand information is generally available, then the firm earns a profit close to $\Pi_h^*$, while still occasionally investing in low-demand products in the rare occasions that early demand information is unavailable. Because $\Pi_h^*$ exceeds the profits under $(W_k^*, X_k^*)$ and $(W_c^*, X_c^*)$, investing in some low-demand products is more profitable than always terminating them. We formally state this result as Proposition 4:
**Proposition 4:**
Uncertainty about whether early demand information is available may make it more profitable to allow continued investment in low-demand products.

**Proof:**
See the Appendix.

5.3 Summary
Given our assumptions about Condition (2), if the firm knows whether the manager has access to early demand information it will never invest in low-demand products. Propositions 1 and 3 establish that this is true irrespective of whether there is early demand information. It is only when the firm is uncertain about the manager’s information that allowing low-demand products to continue can be optimal. Why do things change when the firm is uncertain about the manager’s access to demand information?

Killing low-demand products is relatively inexpensive when the manager receives early demand information. However, if the demand information arrives after effort is chosen, killing low-demand products becomes more expensive. This presents the firm with a trade-off: it can pay a lower salary in the hope that the manager receives demand information early. In doing so it risks that it may invest in low-demand products if the information is late. The more likely that demand information will be early (when $q$ is high), the more profitable this option becomes.

We conclude that the tension between motivating effort and implementing efficient product termination does not just depend upon whether the firm can observe demand. It also depends upon whether the firm knows how informed its manager is when choosing effort. Uncertainty about demand and uncertainty about how much the manager knows both make it more expensive to kill low-demand products than to continue them. Eventually these costs are sufficiently high that it is in the firm’s interests to continue investing even though the manager may know demand is low.

In this section we assumed that the timing of the manager’s demand signal is exogenously determined. In practice, the manager may be able to affect this timing through influence over the product development team’s priorities. We investigate this possibility in the next section.
6. The Incentives to Acquire Demand Information Early

If it takes no additional cost or effort to collect demand information earlier, then the manager will always do so, as he can avoid wasting effort on products that will be killed. However, if additional effort is required, the manager must trade-off the cost of this additional effort with the advantage of knowing when not to work. The timing of the manager’s demand information also affects the firm’s profits. As we discussed in the previous section, the firm would always prefer that the manager receives demand information early. If it knows that early demand information is available it can lower the manager’s compensation. This in turn influences the manager’s willingness to reveal whether he has acquired the information early.

In this section we investigate these issues, and demonstrate how they affect the firm’s product investment decisions. To ensure that the findings depend solely on the timing of the information, we will assume that the content of the information is not affected by when it is received.

6.1 The Manager’s Incentives to Acquire Information Early

We begin by showing that if there is no cost to getting demand information early, then the manager will always want to do so. Formally, given any contract \((W, X)\), the maximum payoff the manager can earn by choosing effort after observing the demand signal is:

\[
UA = s \max(aW - c, bW, X) + (1-s) \max(bW-c, X)
\]

On the other hand, the maximum payoff the manager can earn if effort is chosen before receiving the demand signal is:

\[
UN = \max [saW + (1-s)\max(bW-c, X)–c, s \max(bW, X)+(1-s)X]
\]

Notice that \(UA \geq UN\) by construction. Other things being equal, the manager is always (weakly) better off if he can choose effort after learning about demand. We conclude that if there is no cost to getting the information early, then the problem is equivalent to when the manager always receives demand information before choosing effort (Section 5). In these settings the firm only invests in high-demand products (Proposition 3).

In the remainder of this section we will assume that the manager incurs a cost to collect demand information early. The magnitude of \(UA – UN\) will depend upon his wage contract; which therefore also determines the manager’s incentive to acquire information early. Intuitively, the manager will have no incentive to acquire information if the contract allows the firm to extract all of the information rents. Therefore, whether information acquisition emerges in equilibrium is ultimately the firm’s decision.
In analyzing the firm’s decision we will consider two cases. In the first case the firm can contract on the manager’s information acquisition activities. This requires that information acquisition is verifiable; for example, the firm can verify whether it paid for market research. In the second case we assume that information acquisition is unverifiable; for example, the firm cannot verify how much time the manager spent talking to potential customers.

6.2 Contracting on the Option of Acquiring Information Early

We begin by deriving the optimal contract under which the manager acquires information early, and then derive the optimal contract in which he forgoes this option. We compare the resulting profits and establish the conditions under which the firm prefers early information acquisition. Finally, we explore how the option of acquiring information early affects the firm’s decision to kill low-demand products.

If the firm can contract on whether the manager acquires demand information early then it is straightforward to prevent information acquisition. The cheapest way to do so is to offer a payment of zero if the manager acquires information, and the now familiar \((W_K^*, X_K^*)\) or \((W_{NK}^*, X_{NK}^*)\) otherwise. The profit that results is the higher of \(\Pi_K^*\) and \(\Pi_{NK}^*\), as determined by Condition (2).

The cheapest way to implement information acquisition is to offer a payment of zero if the manager does not acquire information, and a contract \((T, W_{H}^*, X_{H}^*)\) otherwise, where \(T \geq 0\) represents the bonus for acquiring information, and \((W_{H}^*, X_{H}^*)\) is the optimal contract when the firm knows for certain that early demand information is available (Section 5). The bonus \(T\) ensures that the manager is compensated for his information acquisition costs, while \((W_{H}^*, X_{H}^*)\) ensures that the firm makes efficient use of the acquired information.

We will denote the cost incurred by the manager to acquire early demand information by \(A > 0\). Let \(P\) denote the manager’s expected payment from acquiring information and accepting the contract \((T, W_{H}^*, X_{H}^*)\). The manager will acquire information iff \(P - A - sc \geq 0\), where the effort cost term is \(sc\) because the manager only exerts effort when demand is high. The firm earns a profit of \(s(aY - Z) - P\) if early demand information is available. This profit exceeds the highest profit from not acquiring information iff \(P < s(aY - Z) - \max(\Pi_K^*, \Pi_{NK}^*)\). Therefore, information is acquired early in equilibrium iff:

\[
A < s(aY - Z - c) - \max(\Pi_K^*, \Pi_{NK}^*)
\]

This condition also allows us to characterize how the option of acquiring information early affects the likelihood that low-demand products will be killed. In the absence of early demand information, the firm cancels low-demand products when \(\Pi_K^* > \Pi_{NK}^*\) (Condition 2). If we evaluate Condition (3) when Condition (2) is just binding \((\Pi_K^* = \Pi_{NK}^*)\), we can determine
whether the option of collecting early demand information makes it more or less likely to kill low-demand products. Substituting $\Pi_k^* = \Pi_{NK}^*$ into Condition (3), we see that the firm no longer allows low-demand products to continue if:

$$A < s(aY - Z - c) - \Pi_k^*$$

The right-hand side of this expression is strictly positive. Therefore, the option of acquiring early demand information increases the range of parameters under which the firm will kill low-demand products.

We next consider how the results change when the firm cannot contract on whether the manager collects early demand information (see also Guo 2009). This is an important distinction as the firm must use the success and termination bonuses to induce the manager to implement the firm’s preferred outcome.

6.3 No Contracting on the Option of Acquiring Information Early

Here we compare how the profits in Section 3 (when there is no option of collecting information early) change when this option becomes available. We will show that killing low-demand products becomes more profitable and investing in low-demand products becomes less profitable. The implication is that the option of acquiring information early increases the probability that low-demand products will be killed, even when the firm cannot contract on whether the manager exercises this option.

Notice first that in equilibrium, if information is acquired early then the manager will only work when demand is high. It is costly to get the information early and the only advantage is that the manager can avoid wasting effort on low-demand products.\(^{18}\) Therefore, to induce the manager to acquire information early the firm solves the following problem:

$$\max \Pi_A = s(aY - Z) - s aW - (1-s) X$$

s.t.

$$aW - c \geq \max (b_0 W, X)$$ \hspace{1cm} (IC\_1: \ work \ and \ continue \ high-demand \ products)$$

$$X \geq \max (b E W - c, 0)$$ \hspace{1cm} (IC\_2: \ not \ work \ and \ kill \ low-demand \ products)$$

$$-A + s(aW-c) + (1-s)X \geq 0$$ \hspace{1cm} (IC\_3: \ acquire \ demand \ information)$$

$$\max [s aW + (1-s) \max (b_0 W, X) - c, s \max (b_0 W, X) + (1-s)X]$$

The optimal contract $(W_A^*, X_A^*)$ compensates the manager for the additional cost of acquiring the information early. We denote the optimal expected profit as $\Pi_A^*$, and in the Appendix show that if the cost of acquiring information is lower than $(1-s)c$, then the early information

\(^{18}\) We verify this claim in the Appendix.
option increases profits from killing low-demand products: $\Pi_A^* > \Pi_k^*$. Intuitively, the value of acquiring information early is $(1-s)c$, which reflects the cost of effort ($c$), and the probability it will be wasted $(1-s)$. If $A < (1-s)c$ then the benefit of avoiding wasted effort on low-demand products exceeds the cost of compensating the manager for acquiring the information earlier.

In contrast, it is no more profitable to continue investing in low-demand products. Recall that if information is acquired early then low-demand products will be killed. Therefore, the firm will only continue investing in low-demand products if the manager does not acquire information early. This is equivalent to the problem in Section 3 of continuing investments in low-demand products but with an additional constraint: persuade the manager not to acquire information early. The addition of this constraint implies that the resulting profits can be no higher than $\Pi_{nk}^*$. We conclude that if $A < (1-s)c$ then the option of acquiring information early makes it more likely that low-demand products will be killed.

We also have to consider settings in which $A \geq (1-s)c$, so that the value of early information is less than its cost. The firm will not want the manager to acquire information early, but to ensure the manager does not do so, the firm may have to adjust its contracts. We investigate this possibility by evaluating how the manager responds if the firm offers the contracts from Section 3 designed to either kill low-demand products ($W_k^*, X_k^*$) or continue them ($W_{nk}^*, X_{nk}^*$).

We can verify that under the contract $(W_k^*, X_k^*)$ the manager has no incentive to seek early demand information when $A \geq (1-s)c$. Intuitively, the generous success bonus $W_k^*$ is sufficient to induce effort regardless of demand. Therefore, if $A \geq (1-s)c$ and the firm wants to kill low-demand products, the option of acquiring early demand information is irrelevant as neither the firm nor the manager will want to exercise the option. In contrast, the $(W_{nk}^*, X_{nk}^*)$ contract may prompt the manager to acquire information early (see the Appendix). To prevent this, the firm can increase the success bonus $W_{nk}^*$. Inducing the manager to work hard regardless of demand ensures that the manager has no incentive to acquire information early. However, a higher success bonus makes it less profitable for the firm to allow low-demand products to continue. The net outcome is that the early information option again relaxes Condition (2), increasing the range of parameter conditions under which the firm will prefer to kill low-demand products.

We conclude that the option of acquiring information before exerting effort makes it more likely that low-demand products will be killed, even when the firm cannot contract on whether the manager exercises this option.
6.4 Summary

As we would expect, the impact of allowing the manager to acquire demand information depends upon the information acquisition cost. We can summarize the outcome using three cost levels.

First, if there is no cost to acquiring information early, then the manager will always acquire it, and the model reverts to the setting in Section 5, where the manager always has demand information before selecting his effort level. In this case, the firm never allows investments in low-demand products (Proposition 3).

Second, if it is very costly to acquire demand information early, then the manager will never acquire it. In this case, the manager only receives demand information after choosing his effort level, and the model reverts to the setting in Section 3.

Finally, if the cost of acquiring demand information early falls within an intermediate range, the decision to acquire information early depends upon how doing so affects the firm’s profits. The firm ensures that the manager acquire early information only when the firm wants him to. If the firm can observe and contract on the action of acquiring early demand information, then the option of acquiring information early increases the range of parameters under which the firm kills low-demand products. On the other hand, if the firm cannot contract on information acquisition, it must use the success and termination bonuses to guide the manager’s actions. The manager’s ability to acquire costly demand information weakly lowers the firm’s profit from allowing low-demand products to continue, but increases the firm’s profit from killing low-demand products. Consequently, the firm is more likely to kill low-demand products than when early demand information is unavailable, and this likelihood weakly decreases with A.

We summarize these findings in two Propositions. The proofs are in the Appendix.

Proposition 5
The manager’s option of acquiring demand information early reduces the likelihood that the firm will invest in low-demand products. The lower the cost of acquiring information early, the more likely that low-demand products will be killed.

Proposition 6
The manager is more likely to acquire demand information early when it can contract on whether the manager exercises this option.
7. Discussion and Conclusions

This paper offers an explanation for why firms continue to invest in products even after the product manager has received information indicating that the product is unlikely to succeed. Our explanation focuses on the tension between rewarding success and inducing the manager to truthfully report when demand is low. To ensure that the manager abandons low-demand products, the firm must reward the manager for product termination. However, this termination bonus undermines the rewards for success. We first demonstrate this tension by focusing on the manager’s incentives to withhold negative demand information. We then show that a similar tension arises with other forms of manager responses, including distorting information, discrediting information, and not collecting information. We also explore the robustness of this result by incorporating biases in manager’s beliefs, observability (versus verifiability) of the manager’s effort; monitoring; menus of contracts; and negative wages.

We further extend the model by investigating how the findings differ according to the timing of the manager’s demand information. If the manager learns about demand before choosing effort then the firm can design a contract that kills low-demand products. It is only when demand is revealed to the manager after choosing effort that the inefficiency in product investment arises. This result highlights the benefits of using a sequence of small market tests rather than a single-phased launch. We also consider the possibility that the firm is uncertain about the timing of demand information. This mere uncertainty can increase the likelihood that low-demand products continue. The firm must choose between paying a generous contract to always implement efficient product termination, forgoing some high-demand product opportunities, and allowing low-demand products to continue. When it is likely that the manager has access to early demand information, then the risk of investing in low-demand products is diminished, making the last option more profitable.

The timing of the demand information is unlikely to be entirely exogenous. In many cases the product manager will be able to affect this timing through his influence on the product development team’s priorities. If there is no cost to acquiring demand information early then the manager will always do so, and the firm will never make inefficient investments in low-demand products. In contrast, if acquiring information early is costly, then the firm may continue to invest in low-demand products. However, we show that even when there is a cost, the option of acquiring early demand information makes it more likely that the firm will kill low-demand products (compared to when demand information is never available early). The lower the cost is, the more likely that low-demand products are killed. This is true even if the firm cannot contract on the manager’s information acquisition activities.

We can extend the intuition to other marketing decisions. Examples may include the failure to experiment when setting prices or designing product lines. Market experiments may enhance
these decisions, but they add cost and introduce delay. By offering incentives to experiment when uncertainty is high, the firm may also encourage unnecessary experiments when uncertainty is low. Similar intuition may explain under-investment in channel relationships. Lavishing sports tickets or expensive meals on channel partners may be an effective way to build channel relationships, but they may also act as a substitute for employee effort. If investments and effort both contribute to market success, then by rewarding success the firm creates incentives for abuse.

Opportunities for future research include investigation of other mechanisms for resolving this tension. For example, Guedj and Scharfstein (2004) evaluate clinical trial strategies of biopharmaceutical firms and compare “mature” firms with a large number of drugs under development to those of “early stage” firms with fewer drugs in development. Their findings suggest that firms with a larger portfolio of products under development make more efficient decisions, and are quicker to abandon less promising products. The uncertainty in their setting is on the supply side; whether the drugs will be effective. However, we might expect the same result to extend to managing demand uncertainty, suggesting that firms with more products under development will be better at killing low-demand products. While this mechanism may improve firm decisions, we caution that it may be less useful for aligning individual manager’s incentives. The depth of involvement required from a product development manager project means that it is generally not feasible for individual managers to maintain a portfolio of product development projects. Future research could also explore the agency problem faced by the manager in motivating his team.
References


Appendix

A.1 Negative Wages

We want to derive the equilibrium contract when the firm is allowed to pay the manager negative wages (i.e. to penalize the manager). Suppose the firm pays the manager $X$ upon termination, $W$ upon success, and $F$ upon failure. We remove the sign restrictions on $X$, $W$ and $F$, as long as each is greater than or equal to $-L$, where $L \geq 0$. In addition, the firm must ensure that the manager earns a non-negative expected wage net of any effort costs. The optimal contract varies depending on whether the firm wants to kill low-demand products.

A.1.1 To Kill Low-demand Products

To kill low-demand products, the firm solves the revised optimization problem:

$$
\max \Pi_k = s\,(aY - Z) - s\,[F + a(W-F)] - (1-s)\,X
$$

s.t. $F + a(W-F) \geq X$ (IC$_1$: continue high-demand products)

$X \geq F + b_\varepsilon(W-F)$ (IC$_2$: kill low-demand products)

$s\,[F+a(W-F)] + (1-s)\,X - c \geq s\max\{[F+b_0(W-F)], X\} + (1-s)\,max(F, X)$ (IC$_3$: exert effort)

$s\,[F + a(W-F)] + (1-s)\,X - c \geq 0$ (IC$_4$: non-negative expected wage)

$X, W, F \geq -L$ (IC$_5$: limited liability)

IC$_1$ and IC$_2$ together imply that $W \geq F$. Naturally, to align the manager’s incentives with that of the firm, the reward for success should not be lower than the payment upon failure. It follows that $W \geq X \geq F$, otherwise IC$_1$ and IC$_2$ will not hold. Therefore, the only relevant limited liability constraint is that $F \geq -L$.

Note that the lowest expected wage the firm must pay is $c$ (by IC$_4$). Indeed, if IC$_4$ is binding, the firm can achieve first-best profits. We first investigate the conditions for this outcome to arise. When IC$_4$ binds, IC$_3$ becomes $0 \geq s\max\{[F + b_0(W-F)], X\} + (1-s)\,X$, which means that $X \leq 0$. This result and IC$_4$ in turn require that $F + a(W-F) > 0$, making IC$_1$ redundant. In sum, the relevant constraints reduce to

$$
X \geq F + b_\varepsilon(W-F)
$$

(IC$_2$: kill low-demand products)

$$
0 \geq s\,[F + b_0(W-F)] + (1-s)\,X
$$

(IC$_3$: exert effort)

$$
0 \geq (1-s)\,X - c = 0
$$

(IC$_4$: non-negative expected wage)

$$
F \geq -L
$$

(IC$_5$: limited liability)

Substituting the binding constraints IC$_4$ into IC$_2$ and IC$_3$, we get $F \leq -c\,[sb_0 + (1-s)b_\varepsilon] / (s(a-b_0))$. Therefore, the necessary and sufficient condition for the firm to achieve first-best profits is
\[ L \geq L_K = c \left[ \frac{sb_D + (1-s)b_E}{s(a-b_D)} \right] \]

When \( L < L_K \), IC5 binds in equilibrium, and the firm charges a punishment for failure equal to the manager’s maximal liability. The firm offers an expected wage larger than the manager’s cost of effort. Meanwhile, since IC4 holds with slack, IC2 must bind in equilibrium, otherwise the firm can lower \( X \) and improve profits. The firm’s expected payment thus equals \( P_k = F + [sa+(1-s)b_E] (W-F) \). Finally, the effort constraint must be binding. Therefore

\[ P_k = -L + P_k^* > c \quad \text{if} \quad L < L_K \]

where \( P_k^* = c \left[ \frac{sa+(1-s)b_E}{s(a-b_D)} \right] \) is the firm’s expected payment for killing low-demand products under the non-negative minimum wage assumption (Section 3).

A.1.2 To Continue Low-demand Products

To continue low-demand products, the firm’s optimization problem becomes

\[
\begin{align*}
\max \Pi_{NK} &= s(aY-Z) + (1-s)(b_EY-Z) - F - [sa+(1-s)b_E](W-F) \\
\text{s.t.} \quad F + a(W-F) &\geq X \quad \text{(IC}_1\text{: continue high-demand products)} \\
F + b_E(W-F) &\geq X \quad \text{(IC}_2\text{: continue low-demand products)} \\
F+[sa+(1-s)b_E] (W-F)–c &\geq s \max[F+b_D(W-F), X]+(1-s) \max(F, X) \quad \text{(IC}_3\text{: exert effort)} \\
F+[sa+(1-s)b_E] (W-F)–c &\geq 0 \quad \text{(IC}_4\text{: non-negative expected wage)} \\
X, W, F &\geq -L \quad \text{(IC}_5\text{: limited liability)}
\end{align*}
\]

Note that \( X \) only appears on the right-hand side of constraints IC1 through IC4. Therefore, the firm would want to offer the lowest \( X \) possible, in which case \( X = -L \). The remaining IC constraints reduce to

\[
\begin{align*}
F+[sa+(1-s)b_E] (W-F)–c &\geq s [F+b_D(W-F)] +(1-s) F \quad \text{(IC}_3\text{: exert effort)} \\
F+[sa+(1-s)b_E] (W-F)–c &\geq 0 \quad \text{(IC}_4\text{: non-negative expected wage)} \\
W, F &\geq -L \quad \text{(IC}_5\text{: limited liability)}
\end{align*}
\]

Similar to the case in which the firm kills low-demand products, we can derive the expected wage as

\[
\begin{align*}
P_{NK} &= c, \quad \text{if} \quad L \geq L_{NK} = c \left[ \frac{sb_D}{s(a-b_D)} + (1-s)b_E \right] \\
P_{NK} &= -L + P_{NK}^* > c \quad \text{if} \quad L < L_{NK}
\end{align*}
\]
where \( P_{NK}^* = c [sa+(1-s)b_e] / [s(a-b_D) + (1-s)b_e] \) is the firm’s expected payment for continuing low-demand products under the non-negative minimum wage assumption (Section 3).

It can be shown that \( L_k > L_{NK} \). Therefore, if \( L \geq L_k \), then \( P_k = P_{NK} = c \), and the firm prefers to kill low-demand products since there is no wage savings from continuing low-demand products. If \( L < L_{NK} \), then \( P_k > c \), \( P_{NK} > c \), but \( P_k - P_{NK} = P_k^* - P_{NK}^* \). Therefore, the firm kills low-demand products if and only if Condition (2) holds. If \( L_{NK} \leq L < L_k \), then \( P_k > c \), and \( P_{NK} = c \). However, it can be shown that \( P_k - P_{NK} < P_k^* - P_{NK}^* \). Therefore, the firm kills low-demand products more often than Condition (2) indicates.

A.2 Psychological Biases in Beliefs

A.2.1 Belief Inertia Distortion May Contribute to the Continuation of Low-Demand Products

Bialogorsky, Boulding and Staelin (2006) find that belief distortions may arise even if the manager has not exerted effort. In our model, decision inertia distortion means that by simply thinking that the product is viable in the first place (which is plausible given that the manager has agreed to take charge of product development), the manager will subsequently discount the information that demand is low. He will perceive a low-demand product’s chance of success as \( b_e' \) where \( b_e < b_e' < a \), and a dead product’s chance of success as \( d \) where \( 0 < d < b_e' \).

Belief inertia distortion hurts the firm in two ways: a higher termination bonus is demanded to kill low-demand products, which in turn makes effort more expensive to motivate. Let the subscript “D” represent distortion. To terminate all low-demand products, the firm solves the following optimization problem:

\[
\max \: \Pi_{k,D} = s (aY - Z) - s a W - (1 - s) X
\]

s.t.  
\[
a W \geq X \quad (IC_1: \text{continue high-demand products})
\]
\[
X \geq b_e' W \quad (IC_2: \text{kill low-demand products})
\]
\[
s a W + (1 - s) X - c \geq s \max(b_D W, X) + (1 - s) \max(dW, X) \quad (IC_3: \text{exert effort})^{19}
\]

The equilibrium contract is:

\[
W_{K,D}^* = c / \{s [a - \max(b_D, b_e')]\} \geq W_k^*
\]
\[
X_{K,D}^* = b_e' W_{K,D}^* > X_k^*
\]

Naturally, to encourage the manager to abandon low-demand products, the firm must compensate him for what he perceives to be the forgone return from continuation, which is

---

^{19} The effort constraints assume the manager is “boundedly rational yet sophisticated” and anticipates the termination bonus to accommodate his biased beliefs (see O’Donoghue and Rabin 2001).
higher than its actual value. The firm can avoid over-compensating the manager by allowing low-demand products to continue. The firm’s optimization problem is:

\[
\max \Pi_{NK-D} = s (aY - Z) + (1 - s) (bE Y - Z) - [s a + (1 - s)bE] W
\]

s.t. \(a W \geq X\) \hspace{1cm} (IC1: continue high-demand products)

\(bE' W \geq X\) \hspace{1cm} (IC2: continue low-demand products)

\([s a + (1-s) bE'] W - c \geq s \max(bDW, X) + (1-s) \max(dW, X)\) \hspace{1cm} (IC3: exert effort)

The equilibrium contract is:

\[
W_{NK-D}^* = c / [s (a-bD) + (1-s) (bE' - d)]
\]

\(X_{NK-D}^* = 0\)

The bonus for success may be higher or lower than that without belief inertia distortion \((W_{NK}^*)\), depending on the relative size of \(bE'\) and \(d\).

Belief inertia distortion exacerbates the inefficient continuation of low-demand products when \(\Pi_{K-D}^* - \Pi_K^* < \Pi_{NK-D}^* - \Pi_{NK}^*\), that is, when \([s a + (1-s) bE] W_K^* - [s a + (1-s) bE'] W_{K-D}^* < [s a + (1-s) bE] (W_{NK}^* - W_{NK-D}^*)\). It can be shown that this condition holds for some parameter values.

### A.2.2 Managerial Conceit May Contribute to the Continuation of Low-Demand Products

Let the subscript “MC” represent managerial conceit. To terminate low-demand products, the firm solves the following optimization problem:

\[
\max \Pi_{K-MC} = s (aY - Z) - s a W - (1 - s) X
\]

s.t. \(a' W \geq X\) \hspace{1cm} (IC1: continue high-demand products)

\(X \geq bE' W\) \hspace{1cm} (IC2: kill low-demand products)

\(s a' W + (1 - s) X - c \geq s \max(bDW, X) + (1-s) \max(dW, X)\) \hspace{1cm} (IC3: exert effort)

The effort constraint reflects the manager’s belief that the products he has chosen to work on have a better chance of success than what the objective probabilities would suggest. The equilibrium contract can is:

\[
W_{K-MC}^* = c / [s (a' - \max(bD, bE'))]
\]

\(X_{K-MC}^* = bE' W_{K-MC}^*\)

The bonus for success \(W_{K-MC}^*\) may be higher or lower than \(W_{NK}^*\), depending on the relative size of \(a', bD,\) and \(bE'.\) As a result, the total expected wages can be higher or lower than without managerial conceit.

Alternatively, the firm may choose to continue low-demand products and solve the following problem:
\[
\max \Pi_{NK-MC} = s (a Y - Z) + (1 - s) (b_E Y - Z) - [s a + (1 - s) b_E] W
\]
\[
s.t. \quad a' W \geq X \quad \text{(IC1: continue high-demand products)}
\]
\[
b_{E'} W \geq X \quad \text{(IC2: continue low-demand products)}
\]
\[
[s a' + (1-s) b_{E'}] W - c \geq s \max(b_D W, X) + (1-s) X \quad \text{(IC3: exert effort)}
\]

The equilibrium contract is similarly derived as:
\[
W_{NK-MC}^* = c / [s (a' - b_D) + (1-s) b_{E'}]
\]
\[
X_{NK-MC}^* = 0
\]

Note that \(W_{NK-MC}^* < W_{NK}^*\). Managerial conceit makes it more attractive to continue low-demand products by lowering the payroll cost to induce effort without increasing the manager's information rent.

Overall, managerial conceit acerbates the inefficient continuation of low-demand products when \(\Pi_{K-MC}^* - \Pi_K^* < \Pi_{NK-MC}^* - \Pi_{NK}^*\), that is, when \([s a + (1-s) b_E] W_K^* - [s a + (1-s) b_{E'}] W_{K-MC}^* < [s a + (1-s) b_E] (W_{NK}^* - W_{NK-MC}^*)\). It can be shown that this condition holds for some parameter values.

**A.3 Proof of Proposition 3**

We begin with the case where the firm encourages effort if and only if demand is high. The firm solves the following optimization problem:
\[
\max \Pi_h = s (a Y - Z) - s a W - (1 - s) X
\]
\[
s.t. \quad a W - c \geq b_D W \quad \text{(IC1: exert effort when demand is high)}
\]
\[
a W - c \geq X \quad \text{(IC2: continue high-demand products)}
\]
\[
X \geq \max (b_E W - c, 0) \quad \text{(IC3: kill low-demand products; prevent wasteful effort)}
\]

The constraint IC3 must be binding in equilibrium, otherwise the firm can reduce X and improve profits. It follows that IC2 is redundant: if X = 0, IC1 implies IC2; if X = b_E W - c, IC2 automatically holds as well. Given that IC2 is redundant, IC1 must be binding in equilibrium too, otherwise the firm can always reduce W and improve profits. It follows that
\[
W_H^* = c / (a - b_D)
\]
\[
X_H^* = \max[c ( b_D + b_E - a ) / (a - b_D), 0]
\]
\[
\Pi_H^* = s (a Y - Z) - c \max(b_D + b_E - a, 0) / (a - b_D)
\]

It remains to check whether the firm has any incentive to also induce effort when demand is low. Suppose the firm does support such an equilibrium, its optimization problem becomes:
\[
\max \Pi_l = s (a Y - Z) + (1 - s)(b_E Y - Z) - s a W - (1 - s) b_{E} W
\]
s.t. \( aW - c \geq b_0W \) \hspace{1cm} (IC_1: \text{exert effort when demand is high})
\( aW - c \geq X \) \hspace{1cm} (IC_2: \text{continue high-demand products})
\( b_\varepsilon W - c \geq 0 \) \hspace{1cm} (IC_3: \text{exert effort when demand is low})
\( b_\varepsilon W - c \geq X \) \hspace{1cm} (IC_4: \text{continue low-demand products})

where the subscript “L” stands for “work even when demand is low.” The equilibrium is

\[
\begin{align*}
W_L^* &= c / \min(b_\varepsilon, a - b_0) \\
X_L^* &= 0 \\
\Pi_L^* &= s (aY - Z) + (1-\varepsilon)(b_\varepsilon Y - Z) - c [s a + (1-s) b_\varepsilon] / \min(b_\varepsilon, a - b_0)
\end{align*}
\]

Note that \( W_H^* \leq W_L^* \) and that \( X_H^* \) equals either 0 or \( b_\varepsilon W_H^* - c < b_\varepsilon W_L^* \leq b_\varepsilon W_L^* \). That is, in the “L” equilibrium, the firm pays the manager a higher expected compensation, but only to make less efficient investments (\( b_\varepsilon Y \leq Z \)). Therefore, the firm has no incentive to support this wasteful “L” equilibrium.

The above result can be shown in a simpler way. When demand is high, the firm will want to encourage effort. The cheapest way to do so is to offer a bonus such that \( aW^* - c = b_0W^* \). Any \( X > b_0W^* \) only increases the bonus needed to sustain effort. Fortunately, for the cheapest possible bonus \( W^* \), the manager’s expected payoff from working on a low-demand product is \( b_\varepsilon W^* - c = c (b_D + b_\varepsilon - a)/(a-b_D) < c b_D/(a-b_D) = b_0W^* \). As a result, the firm can always terminate low-demand products without discouraging effort by offering \( b_\varepsilon W^* - c \leq X < b_0W^* \). If the firm terminates low-demand products, it pays the manager \( X \) when demand is low; if the firm continues low-demand products, it pays the manager a higher compensation of at least \( b_\varepsilon W^* > X \), but only to waste investment over low-demand markets. Therefore, the firm should be both willing and able to terminate all low-demand products.

A.4 Proof of Lemma 2

To terminate low-demand products and motivate effort, the firm needs to retain the contractual instruments \( W \) and \( X \). In addition, the firm can offer a lump-sum payment \( T_j \geq 0 \) if the manager reports that the state of early demand information availability is \( j \), where \( j \) equals either “A” (available) or “N” (unavailable). Altogether, the menu of contracts includes \( (W_A, X_A, T_A) \) and \( (W_N, X_N, T_N) \). Let \( U_i(W, X, T) \) be the manager’s expected payment minus expected effort cost if he accepts \( W, X, T \) while the true state is \( i \), where \( i \) equals either A or N. For the manager to tell the truth, the menu of contracts must satisfy the following IC constraints:

\[
\begin{align*}
U_A(W_A, X_A, T_A) &\geq U_A(W_N, X_N, T_N) \\
U_N(W_N, X_N, T_N) &\geq U_N(W_A, X_A, T_A)
\end{align*}
\]
where:
\[ U_s(W_N, X_N, T_N) = s \max(a W_N - c, b_D W_N, X_N) + (1-s) \max(b_e W_N - c, X_N) + T_N \]
\[ U_i(W_A, X_A, T_A) = \max(s a W_A + (1-s) b_D W_A, X_A) - c, s \max(b_D W_A, X_A) + (1-s) X_A + T_A \]

Given the assumption about Condition (2), the firm will always kill low-demand products once it finds out whether the manager has early demand information. If by using the menu of contracts, the firm wants the manager to work when demand is either known to be high or uncertain, then its expected profit is:
\[ \Pi_M = s (a Y - Z) - q [s a W_A + (1-s) X_A + T_A] - (1 - q) [s a W_N + (1-s) X_N + T_N] \]

Note however that \( U_s(W_A, X_A, T_A) = s a W_A + (1-s) X_A - sc + T_A \) in this case, and that \( U_A(W_N, X_N, T_N) \geq s a W_N + (1-s) X_N - sc + T_N \) by definition. Therefore, the IC constraint \( U_A(W_N, X_N, T_N) \geq U_A(W_N, X_N, T_N) \) means that \( s a W_A + (1-s) X_A + T_A \geq s a W_N + (1-s) X_N + T_N \). It follows that
\[ \Pi_M \leq s (a Y - Z) - [s a W_N + (1-s) X_N + T_N] \leq s (a Y - Z) - [s a W_N + (1-s) X_N] \]

The right-hand side of this expression is the profit from using a single contract \( (W_N, X_N) \) to induce effort without early demand information and to kill low-demand products. However, the optimal single contract to achieve this outcome is \((W_h^*, X_h^*)\). Therefore, \( \Pi_M \) cannot exceed \( \Pi_h^* \).

It can be similarly shown that the firm cannot improve profits by offering a menu of contracts that induce effort only when demand is known to be high. This menu of contracts is always weakly dominated by \((W_c^*, X_c^*)\). Neither can the firm improve profits by using a menu of contracts that induce effort only when demand is uncertain. Lastly, the firm has no incentive to offer a contract menu that always discourages effort.

**A.5 Proof of Proposition 4**

Suppose the firm offers \((W_h^*, X_h^*)\). If early demand information is unavailable, it can be shown that \( a W_h^* > X_h^* \), so that the manager would still recommend high-demand products for continuation once effort is sunk. However, \( X_h^* < b_e W_h^* \), which means that the manager would prefer to continue a low-demand product. In addition, \( X_h^* < b_D W_h^* \), hence if no effort is exerted, the manager would prefer to continue a high-demand product than to terminate it. Altogether, the effort constraint becomes \( s a W_h^* + (1-s) b_e W_h^* - c \geq s b_D W_h^* + (1-s) X_h^* \), which is satisfied if and only if \( b_D + b_e \geq a \). Therefore, by offering \((W_h^*, X_h^*)\) while early demand information is unavailable, the firm earns an expected profit of
\[ \Pi_U = s (a Y - Z) + (1-s)(b_e Y - Z) - [s a + (1-s) b_e] W_h^* \quad \text{if } b_D + b_e \geq a \]

and
\[ \Pi_U = s(b_D Y - Z) - s b_D W_H^* \quad \text{if } b_D + b_E < a \]

A.6 Proofs of Propositions 5 and 6

The proofs of Propositions 5 and 6 proceed through the following steps. We first prove that by inducing information acquisition the firm will not continue low-demand products. This result simplifies our subsequent search for optimal contracts that induce information acquisition. We then derive the optimal contracts that prevent information acquisition. Last, we prove that information acquisition is more likely to emerge in equilibrium when it is contractible.

A.6.1 If The Firm Induces Information Acquisition It Will Kill Low-Demand Products

Suppose the manager acquires early demand information in equilibrium. First note that the firm cannot both induce effort regardless of demand and kill low-demand products; knowing that low-demand products will be killed would have discouraged the manager from exerting costly effort on low-demand products in the first place. Therefore, it remains to check whether the firm would want to induce effort regardless of demand and retain low-demand products. The answer is no and the reason is as follows. By acquiring information, exerting effort regardless of demand, and retaining low-demand products, the manager earns a net payoff of \(-A + [s a + (1 - s) b_E] W - c\). However, if the manager deviates by skipping information acquisition, he still at least earns \([s a + (1 - s) b_E] W - c\) by exerting effort regardless of demand. Therefore, for any \(A > 0\) the firm cannot prevent the manager from skipping information acquisition. Intuitively, wasting effort on low-demand products defeats the purpose of acquiring demand information.\(^{20}\)

Since the manager will not work on low-demand products, these products are dead and will be terminated for certain. Therefore, if the firm induces information acquisition, it will only continue high-demand products.

A.6.2 The Optimal Contract to Induce Information Acquisition

We have shown that to induce information acquisition the firm wants the manager to only work on high-demand products and recommend these products for continuation. The optimal contract to achieve this goal solves the optimization problem presented in Section 6.3.

We investigate the cases of \(X < b_E W\) and \(X \geq b_E W\) respectively.

\textbf{Case 1: }\(X < b_E W\)

When \(X < b_E W\), the IC\(_3\) constraint of the firm’s optimization problem becomes

\(^{20}\) It can be similarly verified that, by inducing information acquisition, the firm has no incentive to induce effort only upon low demand or to always discourage effort.
\[-A + s (aW−c) + (1 − s) X ≥ s aW + (1 − s) b_\varepsilon W−c\]
\[-A + s (aW−c) + (1 − s) X ≥ s \max(b_0 W, X)+(1 − s)X\]

which can be rearranged as
\[X ≥ \frac{A}{1 − s} + b_\varepsilon W−c\]
\[aW−c ≥ \max(b_0 W, X) + A/s\]

Note that the necessary condition for \(X ≥ \frac{A}{1 − s} + b_\varepsilon W−c\) to hold when \(X < b_\varepsilon W\) is that \(A < (1 − s)c\). All the constraints for the optimization problem can be simplified into two constraints:
\[X ≥ \max\{\frac{A}{1 − s} + b_\varepsilon W−c, 0\}\]
\[aW−c ≥ \max(b_0 W, X) + A/s\]

These two constraints must bind in equilibrium, otherwise the firm would be able to decrease \(X\) and/or \(W\) to improve profits. Therefore, the optimal \(W\) must satisfy the following equation:
\[aW−c = \max\{b_0 W, \frac{A}{1−s}+b_\varepsilon W−c\} + A/s\]

If \(b_0 W ≥ \frac{A}{1−s}+b_\varepsilon W−c\), the optimal \(W\) solves \(aW−c = b_0 W + A/s\), which leads to
\[W_1^* = \frac{(A+s)c}{s(a−b_\varepsilon)}\]

For \(b_0 W_1^* ≥ \frac{A}{1−s}+b_\varepsilon W_1^∗−c\) to hold, we need either \(D ≤ 0\), or \(D > 0\) and \(A ≤ (1 − s)c\) \(t\), where \(D = s(a−b_\varepsilon) − b_0 + b_\varepsilon\), and \(t = s(a−b_\varepsilon) / D\).

If \(b_0 W < \frac{A}{1−s}+b_\varepsilon W−c\), the optimal \(W\) solves \(aW−c = \frac{A}{1−s}+b_\varepsilon W−c + A/s\), which leads to
\[W_2^* = \frac{A}{s(1−s)(a−b_\varepsilon)}\]

For \(b_0 W_2^* < \frac{A}{1−s}+b_\varepsilon W_2^∗−c\) to hold, we need \(D > 0\) and \(A > (1 − s)c\) \(t\).

Recall that the necessary condition for Case 1 to be relevant is \(A < (1 − s)c\). Also, when \(D > 0\), \(t ≤ 1\) if and only if \(b_0 ≤ b_\varepsilon\). Collecting terms, the optimal success bonus in Case 1 can be summarized as:
\[W^* = W_1^*\quad\text{if } b_0 > b_\varepsilon\text{ and } A < (1−s)c\text{, or } b_0 ≤ b_\varepsilon\text{ and } A ≤ (1−s)c\ t\]
\[W^* = W_2^*\quad\text{if } b_0 ≤ b_\varepsilon\text{ and } (1−s)c\ t < A < (1−s)c\]

The optimal termination bonus is:
\[X^* = \max\{\frac{A}{1−s} + b_\varepsilon W^∗−c, 0\}\]

**Case 2:** \(X ≥ b_\varepsilon W\)

When \(X ≥ b_\varepsilon W\), the IC\(_3\) constraint of the optimization problem can be simplified as
\[A ≤ (1 − s) c\]
\[ aW - c \geq \max(b_D W, X) + A/s \]

Note that \( aW - c \geq \max(b_D W, X) + A/s \) implies that IC\(_1\) must hold, and that \( X \geq b_E W \) guarantees that IC\(_2\) must hold as well. Therefore, the optimal \( W \) in Case 2 is solved by

\[ W^* = (c + A/s) / (a - \max(b_D, b_E)) \]

\[ X^* = b_E W^* \]

It can be easily verified that Case 2 yields higher \( W^* \) and \( X^* \) than Case 1, while both cases are subject to the same condition of \( A < (1 - s)c \). Therefore, the solution to the optimization problem \((W_A^*, X_A^*)\) comes from Case 1 and is formally stated as:

\[
W_A^* = (A + sc) / (s(a - b_D)) \quad \text{if } b_D > b_E \text{ and } A < (1 - s)c
\]

\[
W_A^* = A / s(1-s)(a - b_E) \quad \text{if } b_D \leq b_E \text{ and } (1 - s)c \leq t < A < (1 - s)c
\]

\[ X_A^* = \max[A/(1 - s) + b_E W_A^*-c, 0] \]

where \( t = s(a - b_E) / [s(a - b_E) - b_D + b_E] \). It is then straightforward to verify that

\[ W_H^* < W_A^* < W_K^* \]

Meanwhile, \( X_A^* < b_E W_A^* < b_E W_K^* = X_K^* \). Also, \( X_H^* = \max(b_E W_H^*-c, 0) \leq \max(b_E W_A^*-c, 0) \leq \max[A/(1 - s) + b_E W_A^*-c, 0] = X_A^* \). That is,

\[ X_H^* \leq X_A^* < X_K^* \]

By inducing information acquisition, the firm earns an equilibrium profit higher than \( \Pi_K^* \) because it kills low-demand products by paying lower wages than \((W_K^*, X_K^*)\). This equilibrium profit decreases with \( A \) since the wages increase with \( A \).

**A.6.3 The Optimal Contract to Prevent Information Acquisition**

We first explore the optimal contract to prevent information acquisition and kill low-demand products. It can be shown that given the contract \((W_K^*, X_K^*)\) the manager has no incentive to deviate and seek demand information iff \( A \geq (1-s)c \). Meanwhile, unless \( A < (1-s)c \), information acquisition cannot emerge in equilibrium. Therefore, when \( A \geq (1-s)c \), the optimal contract to kill low-demand products is \((W_K^*, X_K^*)\), which prevents information acquisition and brings the firm a profit of \( \Pi_K^* \). When \( A < (1-s)c \), if the firm wants to prevent information acquisition and kill low-demand products, it earns no more than \( \Pi_K^* \) because the manager’s information acquisition constraint is binding. Recall that the firm earns a higher profit than \( \Pi_K^* \) from inducing information acquisition. Therefore, when \( A < (1-s)c \), if the firm wants to kill low-demand products, it will prefer to induce information acquisition.
It remains to derive the optimal contract to prevent information acquisition and continue low-demand products. The optimization problem is the same as the original “NK” problem except for the additional IC constraint which prevents the manager from seeking demand information:

\[
\max \Pi = s(aY - Z) + (1 - s)(bE Y - Z) - [s a + (1 - s)bE] W \\
\text{s.t.} \quad a W \geq X \quad \text{IC}_1 \\
\quad bE W \geq X \quad \text{IC}_2 \\
\quad [s a + (1 - s)bE] W - c \geq s \max(bD W, X) + (1 - s) X \quad \text{IC}_3 \\
\quad [s a + (1 - s)bE] W - c \geq -A + s \max(aW-c, bD W, X) + (1 - s) \max(bE W - c, X) \quad \text{IC}_4
\]

Note that X must be zero in equilibrium, otherwise the firm can lower X and improve profits. It follows that IC₁ and IC₂ hold with slack, and that IC₃ and IC₄ can be rewritten as:

\[
\begin{align*}
[s a + (1 - s)bE] W - c &\geq sbD W \\
[s a + (1 - s)bE] W - c &\geq -A + s(aW-c) + (1 - s)(bE W - c) \\
[s a + (1 - s)bE] W - c &\geq -A + s(bD W - c) \\
[s a + (1 - s)bE] W - c &\geq -A + sbD W + (1 - s)(bE W - c) \\
[s a + (1 - s)bE] W - c &\geq -A + sbD W
\end{align*}
\]

The second and the fifth constraints are obviously redundant. The optimal success bonus is

\[W^* = \max(W_{NK^*}, [(1-s)c - A] / (1-s)bE, (sc-A) / (a-bD))\]

Therefore, \(W^* \geq W_{NK^*}\), and \(W^*\) weakly decreases with \(A\). It follows that by preventing information acquisition and continuing low-demand products, the firm earns an equilibrium profit no better than \(\Pi_{NK^*}\). This equilibrium profit weakly increases with \(A\).

**A.6.4 Information Acquisition Is More Likely to Emerge When It Is Contractible (Proposition 6)**

When it is contractible, information acquisition will emerge in equilibrium iff Condition (3) holds. Note that \(s(aY - Z) - \max(\Pi_k^*, \Pi_{NK^*}) = \min(P_k^*, (1-s)(Z-bE Y) + P_{NK^*})\), where \(P_k^*\) and \(P_{NK^*}\) are the manager’s expected payment from contracts \((W_k^*, X_k^*)\) and \((W_{NK^*}, X_{NK^*})\) respectively. We have shown in Section 3 that both \(P_k^*\) and \(P_{NK^*}\) are greater than \(c\). Therefore, the right hand side of Condition (3) is greater than \((1-s)c\), which is the cost of effort wasted on low-demand products. In contrast, when information acquisition is not contractible, it can only emerge in equilibrium if \(A < (1-s)c\), which is more stringent than Condition (3).