Why are bad products so hard to kill?

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Overview

Motivation

Why do firms continue to invest in product development projects when they should know that demand will be low?

- Large bonus motivates the manager, but also make the manager more likely to continue low-demand products.
- To avoid investing in low-demand products, the firm must also reward decisions to kill products.
- However, rewarding managers for killing products effective undermines the reward 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 projects.

Model Setup

- A risk neutral firm (principal) hires a risk-neutral manager (agent) to develop a product.
- The product development process yields a return of $Y > 0$ upon success, and zero upon failure.
- Product success depends on:
  - The effort from the manager
  - The demand from the product
- Manager's effort level is **not** observed by the firm.
- Manager has **private** information about demand.
- Investment in continued product development is $Z > 0$.

Model Setup

Probability of Success

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

	Effort	**No Effort**
High demand	a	b_D
Low demand	b_E	0

Table: Probability of Product Success

Probability of High Demand

The firm and the manager share the same prior beliefs that demand is high with probability $0 < s < 1$ and low with probability $1 - s$.

Assumptions in the model

Condition (1)

It is efficient for firms to invest when products are in favorable state, and inefficient for firms to invest when products are not in favarable state.

$$b_i Y < Z < aY, i = \{D, E\}$$

Both the firm and the manager know the values of Y, Z, a, b_D, b_E.

Timing of the Game

1. Manager is hired.
2. **The manager chooses whether to exert effort.** The manager's cost of effort is $c > 0$. We assume that the cost of effort (c) is sufficiently small so that it is efficient for the manager to exert effort when demand is high: $aY > Z + c$.
3. **The manager observes whether demand is high or low.**
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 $W \geq 0$ upon success and 0 upon failure.

Benchmark Cases

The "First-Best"

If the firm and the manager are 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.

$$\prod_{FB} = s(aY - Z) - c$$

Verifiable Effort

When effot is observable and verifiable (by the firm), the firm can directly reimburse the manager for his effort costs. To pursuade the manager to truthfully reveal whether demand is high, the firm must construct W and X such that $aW \geq X \geq b_E W$. In this way, the firm can kill low-demand products and again approach first-best profits.

Late Demand Information

Maximisation and Constraints (Firm Killing Low-Demand Products)

$$\max \prod_k = s(aY - Z) - saW - (1-s)X$$

$$st.\ aW \geq X \ (IC_1 : \text{continue high-demand products})$$

$$\boldsymbol{X \geq b_E W} \ (IC_2 : \text{kill low-demand products})$$

$$saW + (1-s)X - c \geq s\max(b_D W, X) + (1-s)X \ (IC_3 : \text{exert effort})$$

- IC_3 and IC_2 must be binding, while IC_1 is slack.
- If IC_2 is not binding, the firm can always decrease X and increase profits.
- If IC_3 is not binding, the firm can always decrease W to increase profits.
- IC_1 is slack because by definition, $a > b_i$.

Late Demand Information

Maximisation (Firm Killing Low-Demand Products)

$$W_k^* = c/s[a - \max(b_D, b_E)]$$
$$X_k^* = b_E W_k^*$$
$$\prod_k^* = s(aY - Z) - [sa + (1-s)b_E]W_k^*$$

Max Profit Less Than First-best Outcome

$$\prod_k^* < \prod_{FB}$$

The firm's expected profit is strictly lower than the first-best profit because it must overcompensate the manager by paying him more than his cost of effort.

Late Demand Information

Maximisation and Constraints (Firm Allowing Low-Demand Products to Continue)

$$\begin{aligned}
\max \prod_{Nk} &= s(aY - Z) + (1-s)(b_E Y - Z) \\
&\quad - [sa + (1-s)b_E]W \\
st.\ aW &\geq X \ (IC_1 : \text{continue high-demand products}) \\
\boldsymbol{X} &\leq \boldsymbol{b_E W} \ (IC_2 : \text{continuelow-demand products}) \\
[sa + (1-s)b_E]W - c &\geq s\max(b_D W, X) + (1-s)X \ (IC_3 : \text{exert effort})
\end{aligned}$$

- X will be zero in equillibrium. Because the firm no longer distinguish between high and low demand products, the termination bonus only counters the incentive to work.

Late Demand Information

Maximisation (Firm Allowing Low-Demand Products to Continue)

$$W^*_{NK} = c/[s(a - b_D) + (1 - s)b_E] < \boldsymbol{W^*_K}$$
$$X^*_{NK} = 0$$
$$\prod^*_{NK} = s(aY - Z) + (1 - s)(b_E Y - Z) - [sa + (1 - s)b_E W^*_{NK}]$$

Condition 2: Kill or Not Kill?

The firm will prefer to kill low-demand products iff :

$$\overset{*}{\prod_{NK}} < \overset{*}{\prod_{K}}$$

The firm may allow continued investment in a product, even though the manager knows the demand is low.

Late Demand Information

Proposition 1

If the firm cannot observe effort or demand, it may be optimal to continue investing in products ever after the manager has learned that demand is low.

Proposition 2

Similar conclusions when the effort and demand are continuous.

Early Demand Information

- Earlier, we covered the case when the manager choose effort before observing demand.
- In practice, **managers might observe demand before choosing effort**.
- When this is true, the firm will prefer that the manager exerts effort when demand is high and kills the product when demand is low.

Early Demand Information

When firm encourages effort if and only if demand is high, the firm solves the following optimization problem:

$$\max \prod_{H} = s(aY - Z) - saW - (1 - s)X$$

$$st.\ aW - c \geq b_D W\ (IC_1 : \text{exert effort when demand is high}).$$

$$aW - c \geq X\ (IC_2 :\ \text{continue high-demand products})$$

$$\mathbf{max}(\boldsymbol{b_E W - c}, \mathbf{0}) \leq \boldsymbol{X}(IC_3 : \text{kill low-demand products}).$$

IC_1 and IC_3 must be binding while IC_2 is slack in equillibrium.

Early Demand Information

When firm encourages effort if and only if demand is high:

In equillibrium:

$$W_H^* = c/(a - b_D)$$
$$X_H^* = max[c(b_D + b_E - a)/(a - b_D), 0]$$
$$\prod_H^* = s(aY - Z) - c[sa + (1 - s)\max(b_D + b_E - a, 0)]/(a - b_D)$$

Early Demand Information

When firm encourages effort regardless of demand is high or low:

$$\max \prod_{L} = s(aY - Z) + (1-s)(b_E Y - Z) - saW - (1-s)b_E W$$

$$st.\ aW - c \geq b_D W \ (IC_1 : \text{exert effort when demand is high}).$$

$$aW - c \geq X \ (IC_2 : \text{ continue high-demand products})$$

$$b_E W - c \geq 0 \ (IC_3 : \text{ exert effort when demand is low})$$

$$\boldsymbol{b_E W - c \geq X} \ (IC_4 : \text{ Continue low demand products})$$

Early Demand Information

When firm encourages effort regardless of demand is high or low:

In equillibrium:

$$
\begin{aligned}
W_L^* &= c/min(b_E, a - b_D) > \boldsymbol{W_H^*} \\
X_L^* &= 0 \\
\prod_L^* &= s(aY - Z) + (1 - s)(b_E Y - Z) \\
&\quad - c[sa + (1 - s)b_E]/min(b_E, a - b_D)
\end{aligned}
$$

Proposition 3

$$\prod_H^* > \prod_L^*$$

If the manager choose effort after observing demand, the firm will only invest in high-demand products.

Uncertainty About When the Manager Receives Demand Information

- When the firm knows that manager has access to early demand information:
  - The firm doesn't invest in low-demand products.
  - The manager's compensation is lower.
- The manager has an incentive to lie to the firm.
- Therefore, let's assume that the firm is uncertain about whether the manager learns demand before choosing effort.

Uncertainty About When the Manager Receives Demand Information

- The firm's prior beliefs are that early demand information is available with probability q, where $0 < q < 1$.
- Assume that condition 2 holds ($\prod_K^* > \prod_{NK}^*$).
- If the timing of demand information is known, then investment in low-demand products will never be optimal.
  - If manager learn demand **after** choosing effort, firm will not invest in low-demand products (condition 2).
  - If manager learn demand **before** choose effort, firm will not invest in low-demand products (proposition 3).
- Examine whether mere uncertainty about the availablilty of early demand information increases the range of parameter values for which firms invest in low-demand products.

Uncertainty About When the Manager Receives Demand Informationd

Killing Low Demand Products

- Option 1: Killing Low-Demand Products: (W_k^*, X_k^*) is the optimal contract that ensures that low-demand products are killed and the manager works unless demand is known to be low.
- Option 2: Killing all products when demand information is unavailable: (W_C^*, X_C^*)
- Option 3: Menu of Contracts: (Conbination of 1 and 2): Not more profitable than option 1 and 2.
- Option 4: Suppose firm offer contract: (W_H^*, X_H^*):
  - $\prod_U$: Expected profit when early information is unavailable.
  - $\prod_H^*$: Optimal profit when early information is available.
  - continued on next page ...

Uncertainty About When the Manager Receives Demand Information

Option 4: Allowing Low-Demand Products to Continue

$$\prod_U = s(aY - Z) + (1-s)(b_E Y - Z)$$
$$- [sa + (1-s)b_E]W_H^* \text{ (if effort constraint satisfied: } b_D + b_E \geq a)$$
$$\text{or}$$
$$= s(b_D Y - Z) - sb_D W_H^* \text{ (if } b_D + b_E \leq)a$$
$$\prod_E = q\prod_H^* + (1-q)\prod_U$$

When q is close to 1, so that early demand information is generally available, the firms earns a profit close to $\prod_H^*$. It's easy to see that $\prod_H^* > \prod_C^*$ and $\prod_H^* > \prod_K^*$.

Uncertainty About When the Manager Receives Demand Information

Proposition 4

Uncertainty about whether early demand information is available may make it more profitable to allow continued investment in low-demand products.

The Incentives to Acquire Demand Information Early

No cost to collect information

The manager will always prefer to acquire information early, so that they can avoid wasting effort on products that will be killed.

Suppose the cost to acquire informaiton is $A > 0$, and the manager's expected payment from acquiring information is P.

Condition 3

- **The information is acquired early in equillibrium iff the information acquisition cost A is small enough:** $A < s(aY - Z - c) - \max(\prod_K^*, \prod_{NK}^*)$.
  - The manager will acquire information iff $P - A - sc \geq 0$.
  - The firm earns a profit of $s(aY - Z) - P$ if early information is available. This profit exceeds the highest profit from not acquiring information iff $P < s(aY - Z) - \max(\prod_K^*, \prod_{NK}^*)$.

The Incentives to Acquire Demand Information Early

Kill the Product?

- In the absence of early demand information, the firm cancels low-demand products when $\prod_K^* > \prod_{NK}^*$(condition 2).
- If we evaluate condition 3 when condition 2 is just binidng $(\prod_K^* = \prod_{NK}^*)$, **we see that firm no longer allows low-demand products to continue if** $A < s(aY - Z - c) - \prod_K^*$.
- Therefore, the option of acquiring early demand information increases the range of parameters under which the firm will kill low-demand products.

The Incentives to Acquire Demand Information Early

Proposition 5

The manager's option of acquring 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.

Summary

- When the firm knows that the manager exert effort before observing demand information, the firm might choose to invest in low-demand products.
- When the firm knows that the manager exert effort after observing demand information, the firm only invests in high-demand products.
- When there the firm is uncertin when the manager receives demand information, the firm might invest in low-demand products.
  - However, the lower the cost for manager to obtain information, the less likely the firm is going to invest in low-demand project.

Comments

- This article assumes that the private information about demand that firms receive is correct.
- What if the information of high demand that the managers received during market testing is misleading?
- [Anderson et al. 2015] provides an alternative explanation that the early adopters of a product might under-represent the customers in the majority market. In fact, the early adopters' preferences might be very different from that of other customers.

References

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