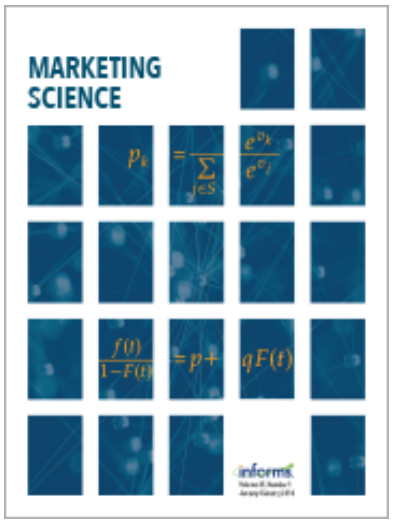


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# Vaporware, Suddenware, and Trueware: New Product Preannouncements Under Market Uncertainty

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A firm may want to preannounce its plans to develop a new product in order to stimulate future demand. But given that such communications can affect rivals' incentives to develop the same new product, a firm may decide to preannounce untruthfully in order to deter competitors. We examine an incumbent's preannouncement strategy when there is uncertainty regarding the commercial viability of a new product opportunity and a threat of rival entry. Each firm has a private assessment of the market potential for the new product. Two competitive incentives arise for the incumbent in terms of discouraging rival entry: it can use preemptive communication or it can remain silent and instill a pessimistic market potential outlook. We find that an incumbent prefers to follow a *vaporware strategy*—i.e., declares plans to pursue a new product opportunity even when it may have no development intentions—when its market forecasting capabilities are weak and the demand-side benefits from preannouncing are small. By contrast, when the incumbent has strong market forecasting capabilities and the demand-side benefits are small, the incumbent adopts a *suddenware strategy*—i.e., remains silent about its new product plans even when it actually plans to develop the new product. Finally, when its market forecasting capabilities are strong and the demand-side benefits are large, the incumbent prefers to engage in a *trueware strategy*—i.e., truthfully preannounces development plans. We show that an interplay between competition-related and demand-related considerations is what allows trueware to emerge as an equilibrium in the absence of any ex post cost to engaging in vaporware. In an extension, we let the incumbent's actual development plans leak out and allow the entrant to wait and learn those plans prior to setting a research and development level. We identify conditions for the entrant to postpone development despite the risk of being late to market, as well as conditions for the entrant to commence development immediately despite not knowing the incumbent's plans based on the observed preannouncement strategy.

*Key words*: new product preannouncements; market uncertainty; competitive signaling; new product development
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## 1. Introduction

In markets characterized by intense innovative activity, firms may benefit from preannouncing their new product plans. In particular, by communicating development plans, a firm can create early customer awareness for its product pipeline and encourage potential customers to delay their purchases until a new product becomes available (Mishra and Bhabra 2001, Lilly and Walters 1997).

The public nature of such preannouncements make them visible not only to customers and collaborators but also to competitors that are considering new product plans of their own. In particular, an incumbent's decision to preannounce plans to develop a new product can have strategic implications for rival entrants. First, a preannouncement can have a preemptive effect. Specifically, because the prospects of having to compete for rents with the same new product lower the expected returns on development effort, a preannouncement may discourage entry (Eliashberg and Robertson 1988, Rabino and Moore 1989). For example, in the late 1990s, network equipment maker Alteon WebSystems Inc. preannounced its new product well in advance of the launch to deter competitors from developing comparable gear (Mohr et al. 2005). Also in the early 1990s, Chrysler's president intimated that his company had a plan to develop a low-cost minivan in the "desk drawer" (Healey 1990); analysts considered this to be a preemptive communication aimed at deterring competitors (Nagel and Holden 2002).

Second, because the market potential is difficult to forecast ex ante for many innovative concepts, a preannouncement (or lack thereof) can affect projections

of a new product's profitability and market acceptance. Specifically, when a rival entrant hears an incumbent firm preannounce plans to pursue a certain new product opportunity, it might infer from such a communication that the firm thinks highly of the market potential for the new product. This, in turn, can increase the expected returns from following the same research and development (R&D) path and encourage entry (Eliashberg and Robertson 1988, Kohli 1999). For example, in the market for mass disk storage systems, a preannouncement by Storage Technology Corp. encouraged rival EMC to develop the same innovation (Mohr et al. 2005). By contrast, if a rival entrant does not hear any communication regarding the incumbent firm's desire to develop a certain new product, it might infer that the firm is pessimistic about the market potential. This can decrease the expected returns from following this R&D path, thereby discouraging entrant investment.

In this paper, we develop a model in which an incumbent firm needs to decide whether to pursue a new product opportunity *and* decide which preannouncement strategy to engage in. The incumbent faces an entrant that plans to pursue the same new product and that observes the preannouncement decision. At the start of the game, firms are uncertain if the commercial potential for the new product is high or low. This captures the notion that, prior to launch, for many innovations it is not obvious how robust demand will be. For example, in the late 1980s, there was considerable uncertainty as to whether the cellular telephony market would take off; in the early 1990s, car makers were debating consumers' willingness to switch to electric vehicles; and in the late 1990s, there were both optimistic and pessimistic sentiments about the adoption rate of personal transporters (e.g., the Segway).

The incumbent and entrant each receive a noisy private signal, which reflects each firm's own assessment of the market potential for the new product (based on, say, any market research it conducted). The incumbent pursues the new product opportunity when its signal is high and forgoes the new product opportunity when its signal is low. A *vaporware strategy* is when the incumbent, regardless of its actual development plans, always preannounces intentions to pursue the new product. A *trueware strategy* is when the incumbent preannounces plans to pursue the new product only when it really intends to do so but remains silent otherwise. And a *suddenware strategy* is when the incumbent, regardless of its actual development plans, remains silent (even when it really plans to pursue the new product). The entrant observes the incumbent's preannouncement decision and has to determine how much to invest in attempting to develop the new product.

We start with a basic setup in which we only consider the competitive implications of the incumbent's preannouncement decision. Our analysis reveals that the incumbent must consider two countervailing competitive forces, the desire to appear preemptive and the desire to generate market pessimism—forces that arise endogenously in our model. By declaring plans to pursue the new product opportunity, the incumbent causes the entrant to take into account the possibility that both firms will launch the new product and have to compete for demand. This declaration reduces the entrant's expected payoffs and its desire to invest in R&D, and thus it creates a preemptive force that drives the incumbent to want to untruthfully preannounce plans to pursue the new product (i.e., to engage in vaporware). On the other hand, by not communicating plans to pursue the new product, the incumbent can project a pessimistic outlook on the market potential. This can depress the entrant's own market assessment and discourage investment, thus creating a force that drives the incumbent to be silent about its intentions to develop the new product (i.e., to engage in suddenware). The ability to affect the entrant's beliefs about the market potential in this way is greater the more reliable the incumbent's signal is—because the entrant tends to rely more heavily on the inferences it draws about the incumbent's signal. Consequently, the desire to cast a negative market outlook drives the incumbent toward a suddenware strategy if its signal is sufficiently reliable. Otherwise, if its signal is relatively unreliable, the incumbent would rather act preemptively by engaging in vaporware. We note that whereas a preemptive competitive force has been recognized in the extant literature on preannouncements, the market pessimism competitive force has been virtually ignored and plays a crucial role in our results.

Later, we modify the basic model to examine how these two competitive forces may interact with demand-side considerations for issuing new product preannouncements. Specifically, we assume that a segment of consumers is in the market at the start of the game. These consumers are willing to wait for a new product only if they believe that the incumbent is planning to attempt development. They are rational and aware of the incumbent's incentives to engage in vaporware. If these customers decide to wait, they are indifferent as to whether they buy from the incumbent or from the entrant. We find that an incumbent whose signal is sufficiently reliable prefers to play the trueware strategy: if it receives a low signal, it remains silent in order to discourage the entrant from aggressive investment; if it receives a high signal, it communicates its plans to develop the new product in order to stimulate greater demand. Thus, the incumbent acts truthfully based on a combination

of competition-related and demand-related considerations. The former acts as a force to reveal the absence of plans to develop the new product, whereas the latter acts as a force to divulge plans to develop the new product. It is the interplay between these considerations that allows trueware to emerge in our model. This result differentiates our work from the extant literature whereby firms prefer truthful communication to vaporware only as a result of some high exogenous ex post cost (such as facing an antitrust law suit or risking the firm's reputation).[1]

Finally, we extend the basic model to incorporate the possibility that the incumbent's new product development (NPD) plans will leak out over time, and we allow the entrant to wait and learn these plans before investing in R&D. If the entrant chooses to wait, it faces the risk of being late to market and not making any profit. We show that when the incumbent's signal quality is in a midrange, the entrant's decision to wait depends on the signal it receives: a high signal favors waiting, whereas a low signal favors commencing development right away. This happens because the gains from waiting are asymmetric and, somewhat surprisingly, greater for the entrant with a high signal. This result is driven in large part by the market pessimism effect.

The rest of this paper is organized as follows. In §2, we relate our contribution to the extant literature. We set up the basic model in §3 and solve it in §4. In §5, we incorporate demand considerations and allow the entrant to wait and learn the incumbent's signal. We conclude in §6.

## 2. Literature Review

Most relevant to our paper is research that examines firms' strategic incentives to preannounce. Existing analytic work has mainly focused on vaporware behavior. Notably, Bayus et al. (2001) show that a dominant firm may engage in vaporware to signal it has low development costs and thereby deter entry, if the ex post penalty cost for lying is low enough. Other scholars have investigated vaporware behavior when new product preannouncements could also affect consumers. Choi et al. (2005) analyze a context in which the firm interacts with consumers over two periods and preannounces the quality of its upcoming new product in each period. Consumers are willing to postpone their purchase only if the new product is expected to be of high quality. Choi et al. show that in the last period, because there are no more reputation concerns, the firm will engage in vaporware, and in the first period, only a partially truthful equilibrium exists in which the type with a weaker R&D capability makes an untruthful preannouncement when its new product is of low quality. Similarly, Gerlach (2004) analyzes preannouncements that are intended to increase consumers' desire to wait and finds that firms never preannounce truthfully in the absence of an ex post cost of engaging in vaporware.

Haan (2003) investigates firms' incentives to conceal their new product plans through actions that have signaling potential. In his paper, the incumbent firm may or may not have an innovation that will be launched in the second period of the game; whether the firm is endowed with the innovation is exogenous. This information is not known to a potential entrant or to consumers. If the incumbent has the innovation, the entrant does not want to enter, and consumers are less willing to pay in the current period for the incumbent's existing product. The incumbent does not have an option to preannounce but rather signals the availability of the new product through its quantity choice in the first period. Haan (2003) shows that the incumbent has no incentive to truthfully reveal its type, and hence, only a pooling equilibrium exists in which the incumbent acts like it always has the new product. The paper calls this outcome "vaporware." Because the game modeled in Haan (2003) is not a cheap talk game but rather a signaling game, "engaging in vaporware" through adjusting quantity is naturally costly.

Our results differ from the above literature streams in a number of important ways. We also examine the competitive implications of new product preannouncements. However, in our model, firms' private information is about a common value—specifically, the market potential for a new product. Thus, both the incumbent and the entrant are uncertain about their rival's signal (as opposed to being uncertain only about a private value that one firm possesses, as is the case in Bayus et al. 2001 and Haan 2003). Learning this signal can reduce market uncertainty. Consequently, a primary distinguishing feature of our work is that in addition to the preemption incentive, our model endogenously gives rise to *another competitive force*: the desire to instill market pessimism in a rival's beliefs. Specifically, through an appropriate preannouncement strategy, the incumbent can cause the entrant to revise downward its profit projections for the new product. This market pessimism force has been neglected in the literature. In existing models the incumbent is the only player with private

[1] The assumption of no ex post costs is justified in many cases, because it is often difficult to verify if a firm was untruthful in its product roadmap announcements. This is particularly true in markets such as software, where the R&D failure rate is high. For example, according to a survey of 8,000 U.S.-based software projects, over 30% were cancelled before completion (Hoch et al. 2000). Moreover, for an antitrust lawsuit to have merit, evidence needs to be mounted that the firm's behavior has left consumers worse off, which can be a difficult task.

information, which is about the "competence" of its new product development (whether it even has the new product or what its R&D capability is). The presence of the market pessimism force allows us to show that in a one-shot preannouncement game, and in the absence of any ex post cost to engaging in vaporware, a unique equilibrium can exist in which the incumbent truthfully preannounces its development plans. In effect, the incumbent may have a strong incentive to fully reveal that it received a low signal as a way to discourage entry by instilling pessimism about future rewards. Moreover, by taking into consideration the market pessimism force, we are able to characterize another type of equilibrium preannouncement strategy (besides vaporware) in which the incumbent firm is silent about its new product plans—"suddenware," as we refer to it. To our knowledge, the only other paper that mentions suddenware as a possibility is Haan (2003). However, a suddenware equilibrium cannot exist in his model because there is no market pessimism incentive (and the action taken by the incumbent in the first period is meant to deter entry through a market preemption effect).

Finally, because we assume no ex post cost to untruthful communication, the incumbent's preannouncement is basically cheap talk. Cheap talk is a nonbinding and nonverifiable communication (Farrell 1987). However, if the intentions of the sender and receiver are sufficiently aligned, there can exist equilibria in which cheap talk conveys information (Crawford and Sobel 1982, Farrell and Rabin 1996). Farrell and Gibbons (1989) find that the addition of a second receiver to the game can lead to credible communication, despite a lack of incentive alignment between the sender and the first receiver. In our model, because of the existence of customers as a second audience and the market pessimism competitive force, a truthful cheap talk equilibrium (trueware) can uniquely exist, even with full incentive misalignment between the incumbent and the entrant. The strategic incentive to instill market pessimism in addition to market preemption also separates our work from the literature on deterring entry through predatory or limit pricing (Balachander and Srinivasan 1994, Milgrom and Roberts 1982) and the literature on signal jamming (Fudenberg and Tirole 1986).[2]

## 3. Model Setup

In the current period, an incumbent firm is in the market and has a product based on the existing technology. The incumbent currently earns profits of $\pi_0$ and faces a new product opportunity that can potentially allow it to earn higher profits. If the incumbent forgoes this opportunity, it can pursue an outside option and earn profits of $\pi^{\varnothing}$. There are both technological and market-related uncertainties associated with the new product opportunity—for example, whether R&D effort aimed at developing the new product will succeed (i.e., will result in a working product that performs the purported new functions) and whether customers will adopt it once it is introduced. We denote by $p$ and $f$ the incumbent's decision to "pursue" or "forgo" the new product opportunity, respectively. The incumbent faces the threat of a rival entrant that is also contemplating the new product opportunity. Subscript $k = \{I, E\}$ will be used to denote the incumbent and entrant, respectively.

The game unfolds in the following way. At $t = 0$, nature determines whether the market potential for the new product is high or low, and each firm receives a noisy private signal for the market potential; this constitutes each firm's own assessment of the new product's commercial prospects. After the firms receive their signals, at $t = 1$, the incumbent makes the following decisions: (i) whether to pursue the new product opportunity and, if so, how much to invest in R&D; and (ii) whether to preannounce that it is pursuing the new product opportunity or to remain silent. We will denote the incumbent's actions at $t = 1$ as $(d_I, a)$ such that $d_I$ is the incumbent's actual development decision and $a$, $a \in \{p, s\}$, is its preannouncement decision, where $p$ denotes communicating plans to pursue development and $s$ denotes being silent about future plans. If the incumbent's preannouncement decision matches its actual development plans, i.e., $a = p$ for $d_I = p$ and $a = s$ for $d_I = f$, we call this strategy "trueware." If the incumbent preannounces plans to pursue the new product regardless of its actual development intentions, i.e., $a = p$ $\forall\, d_I$, we will call this strategy "vaporware." If the incumbent remains silent about its development plans regardless of its actual intentions, i.e., $a = s$ $\forall\, d_I$, we call this strategy "suddenware." The incumbent's preannouncement decision is observable to the entrant while the actual development decision and the R&D investment level are not. At $t = 2$, the entrant decides how much to invest in R&D.[3] At $t = 3$, the R&D uncertainty is resolved for both firms, consumers enter the market and make their purchase decisions given the available products, and payoffs are determined. See Figure 1 for the game's timeline.

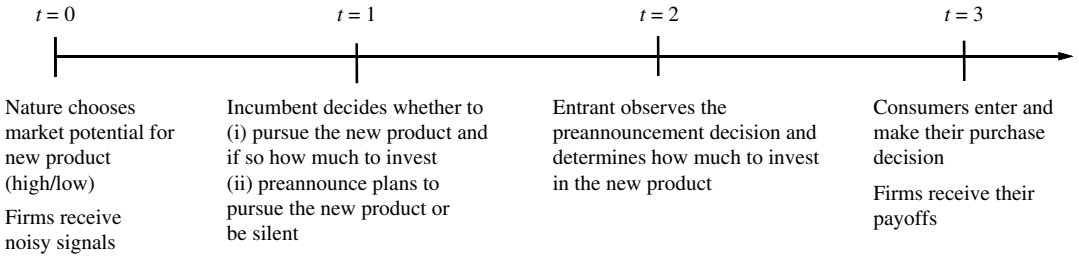
### 3.1. Technology Uncertainty

We use the following simple structure: a firm either succeeds or fails to develop the new product, and

[2] In signal jamming models, there is no information asymmetry between firms as in our model. Rather, both firms are uncertain about the entrant's fixed operating costs; in equilibrium, the entrant is not deterred by the incumbent's actions.

[3] We assume no fixed entry cost. Including such a cost would not qualitatively affect our results. Specifically, in those cases where in our model the entrant chooses to invest very little, it would not invest at all if there were a fixed entry cost.

**Figure 1 The Timeline of the Game**




the level of R&D intensity it selects is the probability that its development efforts will succeed. Let $\phi_E$ and $\phi_I$ be the entrant's and the incumbent's choice of R&D level, respectively. These levels satisfy $\phi_k \in [0, 1]$, and because each firm attempts to develop the new product on its own, the R&D success probabilities are assumed to be independent. The greater a firm's wish to secure R&D success, the higher the expenditure it must incur. We assume that these development costs are quadratic and convex.[4] Given the R&D-level selections, the development costs are thus $(1/2)c_E(\phi_E)^2$ and $(1/2)c_I(\phi_I)^2$ for the entrant and incumbent, respectively, and are incurred before the outcome of R&D efforts is known.

### 3.2. Market Uncertainty

We assume that with probability $x$ $(0 < x < 1)$ the commercial rewards from the new product are high ("high state") and with probability $1 - x$ the commercial rewards are low ("low state"). When the low state materializes, the new product is not commercially viable, and we normalize the returns from it to 0. On the other hand, when the high state materializes, we assume that the new product obsoletes the incumbent's current product technology.[5]

Each firm's noisy private signal about the state is denoted by $s_k \in \{high, low\}$. For a rival to be able to draw inferences from a firm's actions, the following simple signal structure is sufficient. When a firm receives a low signal ($s_k = low$), it is still possible that the market potential is high; i.e., $0 < \text{Prob}_k(\text{market potential} = high \mid s_k = low) < x$. But when a firm receives a high signal, it is certain that the market potential is high; i.e., $\text{Prob}_k(\text{market potential} = high \mid s_k = high) = 1$.[6]

We designate the probability of receiving a high signal, conditional on the true value of the market potential being high, as the signal's quality (or reliability). We will denote the entrant's and incumbent's signal qualities as $\sigma_E$ and $\sigma_I$, respectively $(\sigma_E, \sigma_I \in (0, 1))$. Hence we can write

$$\text{Prob}(s_k = high \mid \text{market potential} = high) = \sigma_k. \quad (1)$$

Note that a firm remains uncertain about the market potential when it gets a low signal, and the degree of uncertainty is a function of its signal quality as follows:

$$\text{Prob}(\text{market potential} = high \mid s_k = low) = \frac{x(1-\sigma_k)}{1-x\sigma_k}. \quad (2)$$

As reflected in (1) and (2), the better a firm's signal quality, the more likely its assessment corresponds to the true state of nature. Signal qualities are intended to capture how good firms are at assessing the market potential for new products, and they depend on firm characteristics such as market research capabilities, information processing competence, and/or management experience and objectivity in using market data. We do not impose any restriction on the relative magnitudes of the entrant's and incumbent's signal qualities.[7] Given that signal qualities in our model reflect core firm capabilities, we assume that they are common knowledge.[8]

Firms form beliefs about the market potential for new products. They do so by combining their private signal with inferences they draw about their rival's

[4] This assumption reflects diminishing returns to development effort, e.g., the facts that larger R&D teams face more coordination issues and that finding additional suitable personnel becomes increasingly difficult.

[5] This structure is consistent with how managers classify the possible effects of a new technology (Chandy et al. 2003). In the technical appendix (available at http://dx.doi.org/10.1287/mksc.1120.0762), we analyze the case in which the incumbent can invest in increasing the probability that the state will be high (the value of $x$) and show that our results qualitatively hold.

[6] This assumption can be relaxed so that a firm remains uncertain even when it receives a high signal without affecting our findings (see the technical appendix). Note that firms' signals are independent conditional on the true state of nature.

[7] Several papers in marketing contend that the ability to "sense the market" as part of predevelopment activities can be heterogeneous across firms and have strategic consequences (e.g., Day 1994, 2007; Narasimhan et al. 2006). Moreover, managers are typically aware of who in their industry is strong or weak at assessing demand for new products (Frambach et al. 2003).

[8] The common knowledge assumption on firm signal accuracies is standard in the literature on the strategic use of information (e.g., Sarvary and Parker 1997, Raju and Roy 2000, Makadok and Barney 2001). In the technical appendix, we relax the common knowledge assumption and also solve an extension in which firms can improve their signal reliabilities.

signal. Naturally, we expect the incumbent's beliefs to affect its decision to pursue or forgo the new product opportunity. Because the incumbent sets its strategy at $t = 1$, based only on its own signal, we capture this by assuming that the incumbent will find it beneficial to pursue the new product when $s_I = high$ and forgo it when $s_I = low$.[9]

### 3.3. Profit Structure

If the market potential for the new product is indeed high and only one firm manages to develop it, that firm enjoys monopoly profits ($\pi_m$) by being able to offer the most advanced product on the market. If both firms develop the new product, then they compete for demand, and each earns duopoly profits ($\pi_d$, with $\pi_m > \pi_d$). If the incumbent forgoes the new product opportunity and invests in the outside option, then it receives profits of $\pi^{\varnothing}$ if the entrant succeeds at development and profits of $\pi^{\varnothing} + \pi_0$ otherwise (because of the additional sales of its current product that is still viable in this case at $t = 3$). We assume $\pi_m > \pi^{\varnothing}$ to ensure that the incumbent finds the new product opportunity attractive if it believes the market potential for it is high. Table 1 summarizes the profits to each firm at $t = 3$ when the market potential for the new product is high.

When the true market potential is low, the incumbent receives $\pi_0$ if it pursued the new product opportunity and $\pi^{\varnothing} + \pi_0$ if it decided to forgo development and instead undertake the outside option. The entrant in this case receives payoffs of 0.

Before examining the incumbent's NPD and preannouncement decisions, we will characterize firms' expected payoffs when they set their R&D levels. Let $EV_k$ denote firm $k$'s expected payoffs and let $\mu_k$ denote its belief that the market potential is high when selecting its R&D level. If the incumbent chooses to pursue the new product ($d_I = p$), its expected payoffs are

$$EV_I = \mu_I(\phi_I\tilde{\phi}_E\pi_d + \phi_I(1-\tilde{\phi}_E)\pi_m + (1-\phi_I)(1-\tilde{\phi}_E)\pi_0) + (1-\mu_I)\pi_0 - \tfrac{1}{2}c_I(\phi_I)^2. \quad (3)$$

If the incumbent chooses to forgo the new product ($d_I = f$), its expected payoffs are

$$EV_I = (1-\mu_I\tilde{\phi}_E)\pi_0 + \pi^{\varnothing}. \quad (4)$$

From the signal structure definition, $\mu_I = 1$ when $s_I = high$ and $\mu_I = x(1-\sigma_I)/(1-x\sigma_I)$ when $s_I = low$.

For the entrant, $\mu_E$ will depend on $s_E$ (the entrant's private signal) and on any inference the entrant makes about $s_I$ from the incumbent's preannouncement behavior. The entrant's expected payoffs are

$$EV_E = \mu_E(\tilde{\phi}_I\phi_E\pi_d + (1-\tilde{\phi}_I)\phi_E\pi_m) - \tfrac{1}{2}c_E(\phi_E)^2. \quad (5)$$

Note that $\tilde{\phi}_{k'}$ is the R&D level firm $k$ expects its rival to choose based on all the information it has.

**Table 1 Payoffs (Incumbent, Entrant) When Market Potential for the New Product Is *High***

| Incumbent's new product decision (pursue/forgo) and R&D outcomes (success/failure) | Payoffs |
|---|---|
| Incumbent pursues and both firms succeed | $(\pi_d, \pi_d)$ |
| Incumbent pursues and only incumbent succeeds | $(\pi_m, 0)$ |
| Incumbent pursues and only entrant succeeds | $(0, \pi_m)$ |
| Incumbent pursues and both firms fail | $(\pi_0, 0)$ |
| Incumbent forgoes and entrant succeeds | $(\pi^{\varnothing}, \pi_m)$ |
| Incumbent forgoes and entrant fails | $(\pi^{\varnothing} + \pi_0, 0)$ |

## 4. The Incumbent's Preannouncement Strategy: Competitive Considerations

When the incumbent preannounces that it plans to pursue development of the new product, the entrant may become concerned about the magnitude of profits it can earn. Specifically, if the incumbent also introduces the new product, the entrant will have to share the market and receive duopoly profits of $\pi_d$ (versus monopoly rewards of $\pi_m$ if it is the sole innovator). This concern over sharing the market lowers the entrant's desire to incur costly R&D and, in turn, creates an incentive for the incumbent to untruthfully preannounce plans to pursue the new product even when it does not intend to do so (i.e., to engage in vaporware). We call this the incumbent's *market preemption* incentive.

Yet the preannouncement decision at $t = 1$ may have another effect: the entrant may draw an inference from it about the incumbent's private signal and may use this information to update its belief about the market potential. In particular, when the incumbent preannounces plans to pursue the new product, the entrant may infer that the incumbent's signal is high. This causes the entrant with a low signal to revise its belief about the market potential upward, which, in turn, increases the R&D level the entrant is expected to select. By contrast, when the incumbent is silent about its plans, the entrant may infer that the incumbent's signal is low. This causes the entrant with a low signal to revise its belief about the new product's commercial potential further downward and hence select a lower R&D level, thus putting pressure on the incumbent to not preannounce plans to pursue the new product. We call this the incumbent's incentive to generate *market pessimism* through silence. In sum, the two competitive forces—market preemption and market pessimism—work in opposite directions in

[9] It is trivial that if the model were such that the incumbent always pursues or forgoes the new product regardless of its signal, then preannouncements would serve no strategic role in affecting entrant decisions, which is the focus of this paper.

terms of their influence on the incumbent's preannouncement decision.

We now characterize the pure-strategy perfect Bayesian equilibria of the game (Fudenberg and Tirole 1991) presented in §3. Recalling our convention for the incumbent's strategy $(d_I, a)$, where the first argument is the development decision and the second argument is the preannouncement decision, the possible pure-strategy equilibria are as follows.

1. *Vaporware*: Preannounce plans to pursue the new product regardless of actual development plans. This is a pooling equilibrium in which the incumbent's strategy is $(p, p)$ when $s_I = high$ and $(f, p)$ when $s_I = low$. In this equilibrium, the entrant's posterior beliefs regarding the incumbent's signal are $\text{Prob}(s_I = high \mid s_E = high,\ a = p) = \sigma_I$ and $\text{Prob}(s_I = high \mid s_E = low,\ a = p) = ((x(1-\sigma_E))/(1-x\sigma_E))\sigma_I$. The entrant's off-the-equilibrium-path belief is $\text{Prob}(s_I = low \mid a = s) = 1$.

2. *Trueware*: Preannounce plans to pursue the new product only when development is intended and remain silent otherwise. This is a separating equilibrium in which the incumbent's strategy is $(p, p)$ when $s_I = high$ and $(f, s)$ when $s_I = low$. In this equilibrium, the entrant's posterior beliefs are $\text{Prob}(s_I = high \mid a = p) = 1$ and $\text{Prob}(s_I = low \mid a = s) = 1$.

3. *Suddenware*: Keep silent regardless of actual development plans. This is a pooling equilibrium in which the incumbent's strategy is $(p, s)$ when $s_I = high$ and $(f, s)$ when $s_I = low$. In this equilibrium, the entrant's posterior beliefs are $\text{Prob}(s_I = high \mid s_E = high, a = s) = \sigma_I$ and $\text{Prob}(s_I = high \mid s_E = low,\ a = s) = (x(1-\sigma_E)/(1-x\sigma_E))\sigma_I$. The entrant's off-the-equilibrium-path belief is $\text{Prob}(s_I = high \mid a = p) = 1$.[10]

Note that in all possible equilibria, the incumbent's development decision is based on its signal ($d_I = pursue$ when $s_I = high$ and $d_I = forgo$ when $s_I = low$), but the preannouncement decision need not match the development decision.

Proposition 1. *There exist $\sigma_I^v$ and $\sigma_I^s$ $(\sigma_I^v < \sigma_I^s)$ such that the incumbent engages in vaporware for $\sigma_I < \sigma_I^v$ and in suddenware for $\sigma_I^s < \sigma_I$. A trueware equilibrium cannot exist.*

Proposition 1 tells us several interesting things. First, despite the existence of a preemptive incentive to untruthfully declare plans to pursue the new product, and despite the absence of an ex post cost to making untruthful statements, the incumbent may refrain from vaporware behavior. Specifically, when it has a sufficiently reliable signal (i.e., $\sigma_I^s < \sigma_I$), the incumbent prefers to remain silent and adopt the suddenware strategy instead of playing vaporware. Second, Proposition 1 reveals that when only competitive considerations are in play, there cannot exist a truthful equilibrium.

To understand the intuition, assume that the incumbent is expected to follow the vaporware strategy in equilibrium. If the incumbent deviates to silence, then the entrant immediately infers that $s_I = low$. On the one hand, the entrant realizes that if it succeeds in development, it will be a monopolist, which, all else equal, encourages it to aggressively pursue the new product. On the other hand, the incumbent's deviation will cause the entrant with a low signal to revise its initial belief about the new product's market potential downward such that $\text{Prob}(\text{market potential} = high \mid s_E = low; s_I = low) < \text{Prob}(\text{market potential} = high \mid s_E = low)$. The more reliable the incumbent's signal is, the more weight the entrant attaches to the fact that $s_I = low$, and hence the more pessimistic the entrant becomes about the new product's market potential. All else equal, this discourages the entrant with a low signal from pursuing the new product (i.e., the entrant's R&D level decreases when the incumbent deviates to silence). When the incumbent's signal is highly reliable, *the market pessimism effect dominates the market preemption effect*, and the incumbent deviates from vaporware.

Now assume that the incumbent is expected to play an equilibrium strategy of being silent regardless of its actual development plans (i.e., suddenware). If the incumbent deviates and preannounces plans to pursue the new product, then the entrant infers that $s_I = high$. On the one hand, the entrant realizes that if both firms succeed in development, it will share the market with the incumbent, which, all else equal, discourages it from aggressively pursuing the new product. On the other hand, the incumbent's deviation will cause the entrant with a low signal to revise its initial belief about the market potential upward such that $\text{Prob}(\text{market potential} = high \mid s_E = low; s_I = high) = 1 > \text{Prob}(\text{market potential} = high \mid s_E = low)$. The more optimistic the entrant is about the market potential, the more motivated it is to invest in R&D. But when the incumbent's signal is unreliable $(\sigma_I < \sigma_I^v)$, the likelihood that it received a high signal when the true market potential is high is diminished (per (1)); hence *the market preemption effect dominates the market pessimism effect*, and the incumbent prefers to deviate from suddenware. As the above-mentioned intuition highlights, even though both vaporware and suddenware are pooling equilibria, the competitive force that drives each of them to be selected is quite different and depends on the incumbent's signal reliability.[11]

[10] Because the incumbent pursues the new product opportunity only when its signal is high, it seems highly reasonable to choose $\text{Prob}(s_I = low \mid a = s) = 1$ and $\text{Prob}(s_I = high \mid a = p) = 1$ as the entrant's off-the-equilibrium-path beliefs for the vaporware equilibrium and the suddenware equilibrium, respectively.

[11] For $\sigma_I^v < \sigma_I < \sigma_I^s$, either multiple equilibria (vaporware and suddenware) or mixed-strategy equilibria exist. This occurs because

The truthful (separating) equilibrium cannot exist in the basic setup because when the market preemption effect dominates, the incumbent with $s_I = low$ would prefer to deviate and untruthfully preannounce plans to pursue the new product to make the entrant think that $s_I = high$. Conversely, when the market pessimism effect dominates, the incumbent with $s_I = high$ would prefer to deviate from trueware to silence to make the entrant think that $s_I = low$.

Our analysis has thus uncovered a new explanation for why incumbents might not want to engage in vaporware. When a new product opportunity is associated with market uncertainty, an incumbent with strong market assessment capabilities can benefit from casting a negative light on the commercial prospects of the new product as this can affect rival beliefs about the profit potential. Our explanation, therefore, relies on a competitive force that is distinct from that of preemption, rather than on exogenous penalties to making untruthful NPD claims. In the next section, we show how the incentive to instill market pessimism, a strategic force that has been neglected by the extant literature, can lead to truthful behavior when demand-side considerations are present.

## 5. The Incumbent's Preannouncement Strategy: Competitive *and Customer* Considerations

So far, we have considered the competitive effects of new product preannouncements. However, a firm's preannouncement behavior may also affect customer decision making. Specifically, when a firm declares plans to develop a new product, customers who are currently in the market may decide to delay their purchases until the new version becomes available. The impact that preannouncements can have on demand generation has been extensively documented in the literature (see, for example, Eliashberg and Robertson 1988, Lilly and Walters 1997, Guiltinan 1999, Gerlach 2004). In this section, we incorporate such demand-side incentives for issuing preannouncements into our setup and investigate the confluence of competitive and customer considerations on the incumbent's equilibrium strategy.

Recall from §3 that in the basic setup, a pool of consumers enter the market at $t = 3$ and make their purchase decision based on the available products. Obviously, these customers are not affected by preannouncements (that were made well before their entry). To allow preannouncements to affect customers' decision making, we extend our setup as follows. Let the size of the segment of consumers who enter at $t = 3$ be normalized to 1, and let there be another group of consumers of size $\beta$ who are in the market to buy a product at $t = 1$. These consumers, whom we will refer to as the $\beta$-*segment*, would be willing to wait till $t = 3$ for the new product only if they believe the incumbent is definitely planning to attempt development. Otherwise, they would prefer not to wait and will buy an outside option.[12] The $\beta$-segment consumers are rational and hence aware of the incumbent's incentives to engage in vaporware. If these consumers do decide to wait till $t = 3$ and the new product is available, they are indifferent between buying from the incumbent or the entrant. Therefore, when the true market potential is high and the $\beta$-segment consumers postponed their purchase: if both firms successfully develop the new product, each receives duopoly profits of $(1+\beta)\pi_d$; if only one firm successfully develops the new product, then it receives monopoly profits of $(1+\beta)\pi_m$. If the $\beta$-segment consumers do not postpone, the payoffs reduce to the ones in the basic model setup of §3 (i.e., $\pi_d$ in the event of a duopoly and $\pi_m$ in the event of a monopoly), as only the segment that enters at $t = 3$ is relevant.

When the true market potential is low, as in the basic setup, the incumbent receives $\pi_0$ if it pursued the new product opportunity and $\pi^{\varnothing} + \pi_0$ if it decided to forgo development and instead undertake the outside option. The entrant in this case receives payoffs of 0. When the $\beta$-segment of consumers do not delay their purchase, the expected payoff expressions are the same as in (3)–(5). The expected payoff expressions for when the $\beta$-segment consumers delay their purchase to $t = 3$ are provided in the appendix.[13] Next, we will characterize the pure-strategy perfect Bayesian equilibria of the extended game presented above.

Proposition 2. *There exist* $\beta^s$ *and* $\beta^t$ $(\beta^s < \beta^t)$ *such that the incumbent engages in vaporware for* $\sigma_I < \sigma_I^v$ *and*

in this region neither market force sufficiently dominates the other. Hence, the incumbent does not want to deviate from either equilibrium or prefers to deviate from both. See the technical appendix for details.

[12] The assumption that consumers would base their decision to wait primarily on what they believe the incumbent is doing—and not place much emphasis on an entrant's plans—is quite realistic. The entrant is new to the market and has not yet established a credible position. Hence consumers may have doubts about its abilities and intentions. This is true even when the entrant is well regarded in a different market. For example, not many consumers or analysts gave much weight to Facebook's decision to enter the smartphone market. Indeed, in less than a year, Facebook declared it would not pursue further development in this category (Ricknas 2012).

[13] The $\beta$-segment's posterior and off-the-equilibrium-path beliefs about the incumbent's private signal are only relevant when the market potential is high and are the same as those of the entrant (see §4). The aspect of players having the same posteriors and off-the-equilibrium-path beliefs is standard treatment in games such as ours (Fudenberg and Tirole 1991).

*$\beta < \beta^t$, suddenware for $\sigma_I^s < \sigma_I$ and $\beta < \beta^s$, and trueware for $\sigma_I^s < \sigma_I$ and $\beta^t < \beta$.*

As we might expect, when the demand-side benefits are not too small ($\beta^t < \beta$), the incumbent with a high signal prefers to inform the segment willing to wait for the new product about its development plans so that this segment will indeed postpone purchasing. Although doing so risks generating market optimism for the entrant, the incumbent is willing to take that risk in order to benefit from the demand-side gains of preannouncing. We further know from Proposition 1 that if the incumbent's signal is reliable enough ($\sigma_I^s < \sigma_I$) and it receives a low signal, then it prefers to instill market pessimism by remaining silent (instead of engaging in vaporware) so that the entrant is discouraged from aggressive investment. Therefore, when $\beta^t < \beta$ and $\sigma_I^s < \sigma_I$, the trueware equilibrium exists. Another way to think about the emergence of the trueware equilibrium is that the *competition-related consideration of instilling market pessimism* discourages the incumbent from engaging in vaporware when its signal is low, whereas the *demand-related consideration* of motivating the $\beta$-segment consumers to postpone their purchase discourages it from being silent about its development plans when its signal is high. These two considerations in conjunction are what drive the incumbent toward truthful preannouncement behavior. Furthermore, the truthful separating equilibrium is unique for $\beta^t < \beta$ and $\sigma_I^s < \sigma_I$. This happens because for $\beta^t < \beta$ and $\sigma_I^s < \sigma_I$, the incumbent with a high signal would deviate both from the suddenware and the vaporware equilibria for any off-the-equilibrium-path belief.

Obviously, when the demand-side benefits are small ($\beta < \beta^t$), the incumbent essentially disregards the impact of its preannouncement decision on the $\beta$-segment, and its strategy mirrors that of the basic setup analyzed in §4 (per Proposition 1). In other words, for small $\beta$ values, the trade-off between the two competitive forces governs the incumbent's preannouncement strategy.[14]

Our analysis in this section has thus shown that when one integrates the demand-side effects with the competitive effects of new product preannouncements, trueware can exist as a unique equilibrium strategy. We emphasize that the demand-side benefits play a very different role in obtaining this outcome than do ex post costs to untruthful preannouncements. Notably, if there were no uncertainty about a common value, as is the case in our model with respect to the market potential, there would be no incentive for the incumbent to want to truthfully reveal that it received a low signal, which in our case is the incentive to generate market pessimism. Without this competitive incentive, an incumbent with a low signal would strictly prefer to engage in vaporware (regardless of the value of $\beta$). Also note that ex post punishment costs in previous work discourage the incumbent from engaging in vaporware behavior. In our model, however, the demand-side benefits discourage the incumbent from engaging in suddenware behavior. Said differently, the demand-side benefits do not dissuade the incumbent from untruthfully declaring plans to pursue the new product (per vaporware); on the contrary, they encourage the incumbent to "speak up" and not be silent about its plans to pursue the new product when it indeed intends to develop it.

An example consistent with such trueware behavior was provided during field interviews we conducted with DePuy Orthopaedics (which designs and manufactures orthopaedic devices for trauma and surgical use). The marketing director indicated that DePuy undertakes substantial efforts to research and analyze customer needs before making new product decisions (corresponding to having reliable market assessments). This fact is well known in the industry, and consequently, competitors and venture capital firms closely monitor DePuy's NPD plans. Because of the need to prepare the medical community well in advance of launch, DePuy typically preannounces intentions to develop novel products and technologies. However, with respect to opportunities that DePuy decides to forgo but that could potentially pose competitive threats if developed, the company tries to make sure the competition is aware of its decisions to pass up on certain opportunities. In effect, DePuy's behavior is in line with market pessimism being a driving force to engaging in trueware.

### 5.1. The Entrant Can Wait and Learn the Incumbent's NPD Decision

Up until now, the entrant only observed the incumbent's preannouncement decision prior to selecting its own R&D level. The incumbent's actual new product plans remained private; hence the entrant could ascertain those plans only if the incumbent adopted the trueware strategy. In reality, however, new product road maps may leak out before the completion of R&D efforts (see, for example, Mansfield 1985), and rivals can potentially benefit from this information leakage process. In our context, if the entrant waits to learn the incumbent's actual NPD plans before committing to an R&D level, it can make a more informed decision and avoid being "fooled" by the incumbent's preannouncement. However, by waiting, the

[14] For $\beta^t < \beta$ and $\sigma_I^v < \sigma_I < \sigma_I^s$, either the trueware equilibrium exists alone or both trueware and vaporware equilibria coexist. In this region, the incumbent with a high signal would always want to deviate from suddenware and would never want to deviate from trueware. The full characterization of each of the three pure-strategy equilibria is provided in the appendix.

entrant loses valuable time to initiate development and runs the risk of being late to market—thereby providing the incumbent an opportunity to gain a first-mover advantage. Assuming that the entrant has the option of either embarking on development immediately after observing the incumbent's preannouncement decision or waiting to learn its actual development plans, one wonders under what conditions the entrant would prefer to wait and whether the incumbent would ever engage in trueware given that its actual plans will be revealed at some point.

To investigate these issues, we analyze a modified version of the model setup in §5 that has the following timeline: After each firm receives its private signal, the entrant observes the incumbent's preannouncement decision at $t = 1$. Subsequently, at $t = 2$, the entrant has two options: (a) it can immediately set its R&D level and attempt development of the new product for launch at $t = 3$, or (b) it can wait till $t = 2'$, learn the incumbent's actual NPD decision, and only then set an R&D level with the hopes of launching the product at $t = 4$. If the entrant follows option (a), the model setup is identical to the one solved earlier. If the entrant follows option (b) and the incumbent successfully develops the new product at $t = 3$, then all consumers buy the new product from the incumbent (provided the state is high), and the incumbent enjoys the first-mover advantage. Therefore, when the entrant chooses to wait, it receives monopoly profits at $t = 4$ if the state is high and if the incumbent does not develop the new product, but it receives zero profits otherwise.

The entrant obviously only needs to consider waiting till $t = 2'$ if the incumbent is not playing trueware. The following lemma outlines the conditions for the entrant to wait versus invest in R&D as soon as possible.

Lemma 1. *There exist $\hat{\sigma}_{I1}$ and $\hat{\sigma}_{I2}$ such that if the incumbent engages in vaporware or suddenware,*

(a) *for $\hat{\sigma}_{I1} < \sigma_I$, the entrant never waits till $t = 2'$ to set its R&D level;*

(b) *for $\hat{\sigma}_{I2} < \sigma_I < \hat{\sigma}_{I1}$, only if $s_E =$ high will the entrant wait till $t = 2'$ to set its R&D level; and*

(c) *for $\sigma_I < \hat{\sigma}_{I2}$, the entrant waits till $t = 2'$ to set its R&D level.*

There are potential gains and losses for the entrant if it decides to wait. First assume that the entrant waits and learns that the incumbent has forgone the new product opportunity. From this, the entrant infers that the incumbent received a low signal. For an entrant that received a high signal, this is excellent news because if it successfully develops the new product it will be a monopolist, and there is justification to select a high R&D level (greater than what it would have chosen without learning this information). But for an entrant that received a low signal, there are two conflicting effects. On the one hand, knowing that it will be a monopolist if it successfully develops the new product makes the opportunity more attractive to the entrant. On the other hand, learning that the incumbent's signal is also low causes the entrant to update its belief about the market potential further downward. Next assume that the entrant waits and learns that the incumbent is developing the new product; i.e., the incumbent received a high signal. For an entrant with a high signal, this dampens expected rewards because it can now earn monopoly profits only if the incumbent's R&D efforts fail; the entrant sets a lower R&D level than it would without this information. For an entrant with a low signal, this news is again a mixed bag: learning that the market potential is high is encouraging, but having to contend with an incumbent that has already initiated aggressive development is discouraging. As a result, for an entrant with a low signal, there is potentially less to gain from waiting till $t = 2'$ than there would be for an entrant with a high signal.

If the incumbent's signal is quite reliable ($\hat{\sigma}_{I1} < \sigma_I$), it is likely that it will receive a high signal when the true market potential is high, and it will pursue the new product aggressively. Under this scenario, the entrant's risk of waiting till $t = 2'$ and being preempted by the incumbent at $t = 3$ overshadows the benefits of being able to adjust its R&D level to the information it can learn. This leads the entrant to prefer not to wait when $\hat{\sigma}_{I1} < \sigma_I$ regardless of its own signal. If the incumbent's signal quality is in a midrange ($\hat{\sigma}_{I2} < \sigma_I < \hat{\sigma}_{I1}$), the ex ante chances that it received a high signal when the true market potential is high are only moderate. For an entrant with a high signal, the potential gains of waiting outweigh the moderate risk; for the entrant with a low signal, this is not the case. Thus, the entrant waits till $t = 2'$ only if its signal is high. Finally, when $\sigma_I < \hat{\sigma}_{I2}$, the incumbent's signal is quite noisy, and the entrant recognizes that the probability of the incumbent receiving a high signal when the state is high is virtually random. Hence, if the entrant waits till $t = 2'$, its risk of being preempted is not high. Yet the upside of possibly learning that the incumbent is forgoing the new product opportunity is nonnegligible because of the prospects of being a monopolist at $t = 4$. The upside considerations dominate and prompt the entrant to wait regardless of its signal.

How does this analysis of the entrant's waiting behavior impact the incumbent's preannouncement strategy? Because delaying the entrant can yield a first-mover advantage, this would seem to motivate the incumbent to engage in untruthful behavior. Indeed, one might wonder whether the incumbent would ever want to play the trueware strategy.

PROPOSITION 3. *There exist* $\sigma_I^*$ $(\hat{\sigma}_{I2} < \sigma_I^* < \hat{\sigma}_{I1})$ *and* $\hat{\beta}^s$ *such that, in equilibrium,*

(a) *for* $\sigma_I^* < \sigma_I$ *and* $\max\{\beta^t, \hat{\beta}^s\} < \beta$, *the incumbent strictly prefers to engage in trueware* (*the trueware equilibrium is unique*), *and the entrant sets its R&D level at* $t = 2$;

(b) *for* $\hat{\sigma}_{I2} < \sigma_I < \sigma_I^*$ *and* $\beta < \beta^t$, *the incumbent will not engage in trueware, and the entrant sets its R&D level at* $t = 2$ *when* $s_E =$ *low but waits till* $t = 2'$ *when* $s_E =$ *high*; *and*

(c) *for* $\sigma_I < \hat{\sigma}_{I2}$ *and* $\beta < \beta^t$, *the incumbent will not engage in trueware, and the entrant waits till* $t = 2'$ *to set its R&D level.*

Proposition 3 reveals that there exist conditions for trueware to be the unique equilibrium, even though the incumbent has the option of prompting the entrant to wait by preannouncing untruthfully. Specifically, in the region $\sigma_I^* < \sigma_I < \hat{\sigma}_{I1}$ (a subset of the region $\hat{\sigma}_{I2} < \sigma_I < \hat{\sigma}_{I1}$), we know from Lemma 1 that the incumbent can induce an entrant with a high signal to wait by engaging in suddenware or vaporware. Instead, the incumbent prefers to engage in trueware. The intuition is related to our findings in Proposition 2: an incumbent with a low signal wants to instill market pessimism for the entrant by being silent, and an incumbent with a high signal wishes to enjoy the demand-side benefits by informing consumers about its plans. The gains from this course of action outweigh those from attempting to establish a first-mover advantage by delaying entrant R&D efforts. The requirement for this to occur is that the demand-side benefits are substantial and the incumbent's signal quality is high enough (so that the entrant with a low signal will update its beliefs sufficiently when it learns that the incumbent's signal is low). The fact that trueware can exist, despite the added competitive incentive to be untruthful to delay the entrant, attests to the significance of the market pessimism effect.

When its signal is not very reliable, the incumbent refrains from trueware. Here, the set of competition-related effects—market preemption or market pessimism *and* the ability to delay the entrant's R&D efforts—combine to produce either the vaporware equilibrium or suddenware equilibrium.[15]

## 6. Conclusion

Setting new product development strategy involves deciding not only which opportunities to pursue and how much to invest in R&D but also what to communicate to the outside world about the selected course of action. In this paper, we studied an incumbent's new product preannouncement behavior allowing for both competition- and customer-related factors to play roles. In particular, an incumbent may seek to affect customer behavior in order to stimulate future demand, but at the same time, it would like to discourage a rival entrant from pursuing the new product opportunity. Our findings show that balancing these two considerations can lead the incumbent to follow one of three possible preannouncement strategies: vaporware, suddenware, or trueware. We now reflect on a number of noteworthy findings that emanate from our analysis.

First, although vaporware seems like an attractive strategy to discourage entry by allowing the incumbent to, in effect, tell the entrant to "stay away" because of its own plans to dominate the market for the new product, we have uncovered an additional strategy the incumbent can employ to deter entry. It can tell rivals to stay away by imparting that the market for the new product is not worth pursuing. The option to strategically engender such market pessimism can be so attractive that it results in the incumbent preannouncing truthfully. Specifically, when the incumbent gets a high signal and plans to develop the new product, then preannouncing these plans makes sense for two reasons: it bolsters demand and it serves a preemptive purpose. But when the incumbent gets a low signal and plans to forgo development, then being silent can deter entry by suggesting that there will not be a market for the new product. To reiterate, although it is common in the preannouncement literature to assume that competitive concerns will lead to untruthful behavior, we have shown that competitive concerns may actually result in truthful behavior.

The second aspect of our results worth highlighting is related to the conditions by which the various preannouncement strategies hold. Our model captures the market uncertainty that firms face in conjunction with NPD planning. Firms that want to effectively evaluate innovation options prior to development must form profitability projections for them. These forecasts are inherently noisy, and their accuracy takes on a strategic consequence: the entrant treats the incumbent's preannouncement behavior differently depending on whether it perceives the incumbent's signal to be reliable or not. When the incumbent's signal is of good quality, the door is open to discourage (or avoid encouraging) the entrant by being silent—and suddenware is the preferred strategy if the ability to impact customers in advance is limited. Otherwise, trueware is preferred. When, on the other hand, the incumbent's signal is not very reliable, the entrant tends to rely on its own signal to assess the market potential. Because the incumbent's ability to instill market pessimism is modest, vaporware becomes an attractive option.

[15] Under the conditions specified in (b) and (c) of Proposition 3, the trueware equilibrium cannot exist. See the technical appendix for a formal characterization of the vaporware and suddenware equilibria in these regions.

Finally, we have shown that the desire to engage in the different preannouncement strategies can be affected by whether information about NPD plans leaks out over time. In such instances, an entrant may prefer to postpone development in order to learn what the incumbent is really up to. We find that the incumbent has an increased incentive to engage in vaporware or suddenware to cause the entrant to delay R&D effort but that the entrant will "bite" on this and wait only if the incumbent's signal is unreliable. Otherwise, the entrant worries more about being late and ceding the market to the incumbent than about being misinformed about its rival's actions. From the entrant's standpoint, we also find that the informational value gained by waiting can be greater when it receives a high signal rather than a low one.

We believe our findings have implications for managers involved in setting new product strategies. The results can help incumbents decide under what conditions to engage in vaporware behavior versus other situations where issuing no preannouncement may be the right course to follow. For entrants, the findings provide a sense for when it is possible to draw a valid inference from an incumbent's preannouncement (as it reflects the true development decision) versus other situations where the incumbent is being untruthful and hence no inference can be drawn regarding its market potential assessment.

Our findings can also help shed light on preannouncement decisions observed in the marketplace. For example, Microsoft's declaration in the early 1980s that it would develop a graphical user interface operating system was considered by many industry analysts as vaporware behavior intended to discourage competing software publishers from pursuing similar technology (Prentice 1996). And Boeing's strategy in the late 1990s to pursue the development of a midsized plane made of lightweight composite plastic (later dubbed the Dreamliner), but to not make these plans known initially, was seen as motivated by a desire to avoid alerting rival Airbus to this opportunity (*Economist* 2002). In understanding such competitive behavior, our work calls for examining the degree of market uncertainty faced by the firms, how reliable their demand projections were, and whether potential customers would be affected by preannouncements.[16]

## Electronic Companion

An electronic companion to this paper is available as part of the online version at http://dx.doi.org/10.1287/mksc.1120.0762.

[16] In both these examples, there is some evidence that incumbent signal reliability played a role consistent with our model predictions: in Microsoft's case, there was low reliability (Prentice 1996); in Boeing's case, high reliability (Boeing 2001).

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## Appendix. Notation Relevant for Comparing Expected Payoffs and R&D Levels

Let $EV^{\text{strat}}_{k|\text{sig}}$ denote the expected payoffs of firm $k \in \{I, E\}$ when it received a signal $sig \in \{L, H\}$ and the incumbent is following equilibrium preannouncement strategy $strat \in \{v, s, t\}$, where $v$ stands for vaporware, $s$ stands for suddenware, and $t$ stands for trueware. Similarly, let $\phi^{t*}_{E|_H}$ denote the entrant's R&D success probability in the trueware equilibrium when the incumbent's signal is high, let $\phi^{v*}_{E|_H}$ denote the entrant's R&D success probability in the vaporware equilibrium when the entrant's signal is high, and let $\phi^{s*}_{E|_H}$ denote the entrant's R&D success probability in the suddenware equilibrium when the entrant's signal is high. We will denote the expected payoffs and R&D levels of a deviation with a prime.

Proof of Proposition 1. To keep our proof simple, we solve for the case in which $c_I$ is low enough such that the incumbent with $s_I = high$ prefers to set an R&D level equal to 1. Please refer to the technical appendix to see that for a given $(\pi_m, \pi_d, \pi_0, c_E, c_I)$, there exist $x$ and $\pi^{\varnothing}$ values such that the incumbent pursues the new product opportunity and sets an R&D level equal to 1 when $s_I = high$ and forgoes it when $s_I = low$ $\forall(\sigma_E, \sigma_I)$). In the technical appendix, we also show that the results stated in Proposition 1 hold for any $c_I$ value.

First note that from payoff expressions (3)–(5), $\partial EV_I/\partial\tilde{\phi}_E < 0$. In vaporware equilibrium, $\tilde{\phi}^{v*}_E = \mu_E(\pi_m - \sigma_I(\pi_m - \pi_d))/c_E$, where $\mu_E = \sigma_E + x(1-\sigma_E)^2/(1-x\sigma_E)$ and $\mu_I = x(1-\sigma_I)/(1-x\sigma_I)$. If the incumbent deviates to $a = s$, then $\tilde{\phi}^{v\prime}_E = \mu_E^{\text{updated}}(\pi_m/c_E)$, where

$$\mu_E^{\text{updated}} = \sigma_E + \frac{x(1-\sigma_E)^2(1-\sigma_I)}{1-x+x(1-\sigma_E)(1-\sigma_I)}.$$

Since $\tilde{\phi}^{v*}_E(\sigma_I \geq \sigma_{I1}) \geq \tilde{\phi}^{v\prime}_E(\sigma_I \geq \sigma_{I1})$, where

$$\sigma_{I1} = \frac{\pi_m(\mu_E(1-x\sigma_E)^2 - x(1-x)(1-\sigma_E)^2) - \pi_d\mu_E(1-x\sigma_E)^2}{\mu_E(1-x\sigma_E)x(1-\sigma_E)(\pi_m-\pi_d)},$$

the incumbent deviates for $\sigma_I > \sigma_{I1}$. In suddenware equilibrium, $\tilde{\phi}^{s*}_E = \tilde{\phi}^{v*}_E$. If the incumbent deviates to $a = p$, then $\tilde{\phi}^{s\prime}_E = \pi_d/c_E$. Since $\tilde{\phi}^{s*}_E(\sigma_I \leq \sigma_{I2}) \geq \tilde{\phi}^{s\prime}_E(\sigma_I \leq \sigma_{I2})$, where $\sigma_{I2} = ((\mu_E\pi_m) - \pi_d)/(\mu_E(\pi_m - \pi_d))$, the incumbent deviates for $\sigma_I < \sigma_{I2}$. As a result, if $\sigma_I < \sigma_I^v \equiv \min\{\sigma_{I1}, \sigma_{I2}\}$, only the vaporware equilibrium exists, and if $\sigma_I > \sigma_I^s \equiv \max\{\sigma_{I1}, \sigma_{I2}\}$, only the suddenware equilibrium exists. In trueware equilibrium, $\phi^{t*}_{E|_H} = \pi_d/c_E$ and $\phi^{t*}_{E|_L} = \mu_E^{\text{updated}}(\pi_m/c_E)$. Thus, the incumbent with $s_I = high$ would deviate if $\pi_d/c_E > \mu_E^{\text{updated}}(\pi_m/c_E)$ and the incumbent with $s_I = low$ would deviate otherwise. □

Proof of Proposition 2. If the $\beta$-segment consumers postpone their purchase, the incumbent's expected payoff

(i.e., when $d_I = p$) is $EV_I = \mu_I(\phi_I\tilde{\phi}_E(1+\beta)\pi_d + \phi_I(1-\tilde{\phi}_E)\cdot(1+\beta)\pi_m + (1-\phi_I)(1-\tilde{\phi}_E)\pi_0) + (1-\mu_I)\pi_0 - (1/2)c_I(\phi_I)^2$, and the entrant's expected payoff is $EV_E = (1+\beta)\mu_E(\tilde{\phi}_I\phi_E\pi_d + (1-\tilde{\phi}_I)\phi_E\pi_m) - (1/2)c_E(\phi_E)^2$. Note that $\phi_E^* \le \mu_E(1+\beta)(\pi_m - \tilde{\phi}_I(\pi_m-\pi_d))/c_E$. Since $\mu_E \in (0,1]$, to guarantee that $\phi_E^* \in (0,1)$, for the rest of the analysis, for a given $\beta$ and $\pi_m$, we will solve for $c_E$ such that $c_E > (1+\beta)\pi_m$.

Note that when the $\beta$-segment consumers delay their purchase, the potential market size increases also for the entrant, which in turn encourages the entrant to set a higher R&D level. For that reason, and to prevent the market preemption force to disappear, we will conduct the analysis for $(1+\beta)\pi_d < \pi_m$; i.e., $\beta < (\pi_m - \pi_d)/\pi_d$.

As in the proof of Proposition 1, we will solve for the case in which $c_I$ is low enough such that the incumbent with $s_I = high$ prefers to set an R&D level equal to 1. Please refer to the technical appendix for the details. In the technical appendix, we also show that the results stated in Proposition 2 hold for any $c_I$ value.

*Trueware equilibrium*: When $a = p$, $EV_{I|_H}^{t*} = (1+\beta)(\pi_m - ((1+\beta)\pi_d/c_E)(\pi_m - \pi_d)) - c_I/2$ and when $a = s$, $EV_{I|_L}^{t*} = (1-\mu_I\mu_E^{\text{updated}}(\pi_m/c_E))\pi_0 + \pi^{\varnothing}$. If the incumbent with $s_I = high$ deviates to $a = s$, then $EV_{I|_H}^{t\prime} = (\pi_m - \mu_E^{\text{updated}}(\pi_m/c_E)\cdot(\pi_m - \pi_d)) - c_I/2$. If the incumbent with $s_I = low$ deviates to $a = p$, then $EV_{I|_L}^{t\prime} = (1-\mu_I((1+\beta)\pi_d)/c_E)\pi_0 + \pi^{\varnothing}$. The incumbent would not deviate from the trueware equilibrium if $(1+\beta)\pi_d/c_E > \mu_E^{\text{updated}}(\pi_m c_E)$ and $\mu_E^{\text{updated}}(\pi_m/c_E) > (1+\beta)^2\pi_d/c_E - \beta\pi_m/(\pi_m - \pi_d)$. Note that

$$\frac{\partial}{\partial\beta}\left(\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d}\right) < 0,$$

$$\left(\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d}\right)\Bigg|_{\beta=\pi_m-\pi_d/\pi_d} < 0,$$

$$\mu_E^{\text{updated}}(\sigma_I = 1)\frac{\pi_m}{c_E} = \sigma_E\frac{\pi_m}{c_E}, \quad \text{and}$$

$$\mu_E^{\text{updated}}(\sigma_I = 0)\frac{\pi_m}{c_E} = \mu_E\frac{\pi_m}{c_E}.$$

Given that $\mu_E(\pi_m/c_E) < (1+\beta)\pi_d/c_E$ for $\beta > (\mu_E\pi_m - \pi_d)/\pi_d$, where $(\mu_E\pi_m - \pi_d)/\pi_d < (\pi_m - \pi_d)/\pi_d$, for any $\sigma_I$ there exists a $\beta^t$ such that the trueware equilibrium can exist for $\beta > \beta^t$.

*Vaporware equilibrium*: In this equilibrium the $\beta$-segment consumers do not postpone their purchase neither in equilibrium nor off the equilibrium path; in equilibrium, they are not sure that the incumbent is pursuing the new product opportunity, and off the equilibrium path, they think that the incumbent's signal is low and is hence not pursuing the new product opportunity. Hence, as we know from Proposition 1, this equilibrium would exist only if $\sigma_I < \sigma_{I1}$.

*Suddenware equilibrium*: In this equilibrium, because the $\beta$-segment consumers are not sure that the incumbent is pursuing the new product opportunity, the consumers postpone their purchase only when the incumbent deviates to $a = p$. Therefore, when $s_I = high$, $EV_{I|_H}^{s*} = \pi_m - \tilde{\phi}_E^{s*}(\pi_m - \pi_d) - c_I/2$, and when $s_I = low$, $EV_{I|_L}^{s*} = (1-\mu_I\tilde{\phi}_E^{s*})\pi_0 + \pi^{\varnothing}$. If the incumbent with $s_I = low$ deviates to $a = p$, then $EV_{I|_L}^{s\prime} = (1-\mu_I\tilde{\phi}_E^{s\prime})\pi_0 + \pi^{\varnothing}$, where $\tilde{\phi}_E^{s\prime} = (1+\beta)\pi_d/c_E$. Thus, as we know from the proof of Proposition 1, the incumbent with $s_I = low$ would not deviate if $\sigma_I > \sigma_{I2}$. On the other hand, if the incumbent with $s_I = high$ deviates, then $EV_{I|_H}^{s\prime} = (1+\beta)(\pi_m - ((1+\beta)\pi_d/c_E)(\pi_m - \pi_d)) - c_I/2$. Therefore, the incumbent with $s_I = high$ would not deviate if $(1+\beta)^2\pi_d/c_E - \beta\pi_m/(\pi_m - \pi_d) > \tilde{\phi}_E^{s*}$. Because

$$\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d} < \frac{(1+\beta)\pi_d}{c_E},$$

$$\frac{\partial}{\partial\beta}\left(\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d}\right) < 0,$$

$$\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d}\Bigg|_{\beta=(\pi_m-\pi_d)/\pi_d} < 0, \quad \text{and}$$

$$\frac{(1+\beta)^2\pi_d}{c_E} - \frac{\beta\pi_m}{\pi_m-\pi_d}\Bigg|_{\beta=0} = \frac{\pi_d}{c_E}$$

for $\sigma_I > \sigma_{I2}$, there exists a $\beta^s$ such that $((1+\beta)^2\pi_d/c_E - \beta\pi_m/(\pi_m - \pi_d))|_{\beta=\beta^s} = \tilde{\phi}_E^{s*}$, and the suddenware equilibrium exists only for $\sigma_I > \sigma_{I2}$ and $\beta < \beta^s$.

As a result, for $\sigma_I < \sigma_I^v$ and $\beta < \beta^t$, only the vaporware equilibrium can exist. Note that since $\mu_E^{\text{updated}}(\pi_m/c_E) < \tilde{\phi}_E^{s*} < \pi d/c_E$ for $\sigma_I > \sigma_I^s$ and $\partial((1+\beta)^2\pi_d/c_E - \beta\pi_m/(\pi_m - \pi_d))/\partial\beta < 0$, $\beta^t > \beta^s$ for $\sigma_I > \sigma_I^s$. Thus, for $\sigma_I > \sigma_I^s$ and $\beta < \beta^s$, only the suddenware equilibrium can exist, and for $\sigma_I > \sigma_I^s$ and $\beta > \beta^t$, only the trueware equilibrium can exist. In the technical appendix, we prove that for $\sigma_I > \sigma_I^s$ and $\beta > \beta^t$, the trueware equilibrium exists uniquely and that the incumbent may prefer to engage in vaporware, trueware, or suddenware in equilibrium irrespective of whether the entrant's signal quality is higher than, lower than, or equal to the incumbent's signal quality (i.e., there exist parameter values $(\pi_m, \pi_d, \pi_0, x, c_E, c_I, \sigma_E, \beta)$ such that $\sigma_I^s < \sigma_E$ and such that $\sigma_I^v > \sigma_E$). □

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