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STRATEGIC PRODUCT PRE-ANNOUNCEMENTS IN MARKETS WITH NETWORK EFFECTS*

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Abstract

Firms often announce new products well in advance of their actual market availability. The incentives for pre-announcements are conceived to be stronger in markets with network effects because they can be used to induce the delay of consumers' purchases and forestall the build-up of rival products' installed bases. However, such announcements often are not fulfilled, raising antitrust concerns. We analyze the effects of product pre-announcements in the presence of network effects when firms strategically make false announcements. We also discuss their implications for consumer welfare.

Keywords: network effects, technology adoption, product pre-announcements, reputation
JEL Classification Codes: L1, D8

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I. *Introduction*

'Vaporware' is defined as "a product that the vendor keeps promising is about to arrive any moment (real soon now) — but it goes so long past its shipment date that no one really believes it will ever really ship. Sometimes it never does."[1] There are several cases, which are alleged as 'vaporware.' For instance, Microsoft made preannouncements on upgrades on MS-DOS in early 1990 in a response to the release of a competitor's product DR-DOS (or Novell DOS), which included several new features. The preannouncement by Microsoft deflated the sales of DR-DOS, however, the new upgrade of MS-DOS was released more than six months late than the promised release date and did not contain several promised features. Even a competitor was alleged to use 'vaporware' strategy to respond to MS's release of a new product. For instance, Lotus made a preannouncement of a new release of '1-2-3' for Apple in a response to Microsoft, however, the new spreadsheet was released three years later. [2]

Some firms are alleged to use it to deflate rival firms' sales, and there have been debates on how to deal with it in competition law. The most well-known antitrust claim on vaporware is the Microsoft consent decree case. Rejecting the consent decree proposed to the court, the District Court Judge Sporkin noted "Microsoft could unfairly hold onto this position with aggressive preannouncement of new products in the face of the introduction of possibly superior competitive products."[3,4] The District Court Judge cited that Microsoft had engaged in preannouncements of products for the purpose of fending off competitors.

The concern for exclusionary effects of product pre-announcements is heightened in a market with network effects. To quote Hovenkamp et al. (2003):

> The competitive effect of vaporware – allegedly predatory pre-announcements of nonexistent products – depends heavily on *network effects*... For vaporware to be worthwhile as a strategy for maintaining monopoly power, the producer must therefore capture more from an early lie than it loses later in diminished credibility. Network effects may offer a credible explanation for such a strategy ... By announcing a product, a large company may therefore influence the outcome of a standards competition in an industry characterized by network effects. *Absent network effects, though, it is difficult to see why anyone would be concerned about vaporware as an antitrust issue.* It is unlikely that deception could really lead to market power in a non-network market (italics added).

This suggests that the prevailing thinking in the policy arena is that network effects are essential for product pre-announcements to be an antitrust concern. In markets with network effects, consumers have to consider whether a currently available technology would be a market standard in the future. By choosing a wrong technology, consumers not only get an inferior

[1] From Williams and Cummings(1993). It is recited from R. Prentice (1996).

[2] These cases are from R. Prentice (1996), which includes an excellent survey of vaporware cases.

[3] 159.F.R.D. 318 (D.D.C.1995), rev'd, 56F.3d 1448 (D.C. Cir 1995).

[4] Judge Stanley Sporkin rejected the consent decree proposed in the antitrust case United cases v. Microsoft based on that the consent decree did not address the vaporware strategies by Microsoft. However, Judge Sporkin's decision was reversed in the appeal court. Also, Microsoft did not admit its using of preannouncements for anticompetitive purposes. The department of Justice of United States did not claim MS's anticompetitive use of product annoucements. (R. Prentice 1996).

technology, but also become stranded by future consumers. This is especially important when another firm is developing a new, incompatible technology with the currently available one. In making their consumption decisions, consumers need to forecast which technology would be the market standard.

As a currently available technology builds a larger installed base of customers, it becomes increasingly difficult for another firm to successfully introduce a new technology. Thus, a firm has incentives to forestall the build-up of the rival's installed base by making a pre-announcement of its forthcoming product and hope that at least some buyers will delay their purchases. Hence a firm and consumers have incentives to exchange information on forthcoming products. Since a new technology is still under development, consumers have to rely on information provided by firms developing new technologies.

However, a firm has an incentive to overstate the quality of a product under development, and in practice, such exaggerated announcements are often not fulfilled. There are some concerns that vaporware could be anticompetitive entry barriers. Hovenkamp et al. (2003) noted "Thus, at a minimum a strong showing not only of market power but also of the contribution of the product preannouncements to barriers to entry would seem to be a prerequisite for an antitrust claim based on vaporware."

The proper analysis of antitrust effects of product pre-announcements thus requires a model that explicitly accounts for network effects. To address this issue, we set up a two-period model in which we analyze the effects of strategic product pre-announcements in markets with *network effects*. We consider a situation where a firm develops a new product, while a competitive product already exists. The firm developing the new product introduces it in period two. The firm makes pre-announcements in order to delay the purchase decision of consumers and to forestall the build-up of rival products' installed bases. To capture that firms often make announcements that not are fulfilled, we allow the firm to make false announcements, if it wants. However, after the firm introduces its new product in period two, consumers can observe the quality and check whether the first period announcement on the product quality is correct.

In this setting, we would ask whether a firm's pre-announcement would improve consumer welfare when network effects exist. We assume that firms are heterogeneous in their R&D capabilities, which in turn determine their chances of developing a high-quality new product. We show that the value of maintaining reputation of being honest increases with the firm's chance of developing a high-quality product in the future. The differences in the value of reputation across different types of firms provide the high-type firm with incentives to behave honestly even if being honest hurts its payoff in the short-run. We find that product pre-announcement always improves social welfare even though the firm might make false announcements.

In addition, we find that network effects facilitate the existence of an informative equilibrium. In an industry with network effects, building an installed base is important. If a rival firm builds a large installed base, it becomes difficult for another firm to penetrate the market. Thus, by making a product announcement, a firm tries to slow down a rival firm's building of an installed base. When consumers put more weights on the firm's announcement, the product announcement can delay a rival firm's building of an installed base, and the firm can penetrate the market more easily. Thus, product announcements play a more important strategic role in an industry with large network effects and a firm has more incentives to

maintain its reputation. As a result, it is more likely to have an informative equilibrium with larger network effects, which improves consumer welfare.

This paper builds on our previous work, Choi, Kristiansen, and Nahm (2010). In a model *without network effects,* Choi, et al (2010) builds an informative equilibrium, in which a firm's product announcement partially delivers information on a product's quality. This paper, extending the analysis of Choi, et al (2010) to a model with network effects, explores how the announcements affect consumers' adoption decisions and social welfare in markets with *network effects*.

Our paper is related to technology adoption with network effects. Farrell and Saloner (1986) construct a dynamic model of technology adoption in which the timing of the announcement of a new *incompatible* product can critically determine whether the new product succeeds in replacing the existing technology. In their model, consumer welfare can be lower with *network effects* when product pre-announcements is allowed. Due to the presence of network effects, even if the potential users who decide to wait are indeed well-informed and their welfare is increased as a result of product pre-announcement, their adoption of the new technology may adversely affect both the users in the installed base and later adopters who might have preferred the old technology to the new one. In contrast to our paper, they assume that the announcement is truthful. Thus, there is no issue of consumer inferences and reputation concerns in their paper.

Dranove and Gandal (2003) measures the effects of product pre-announcements in the market with network effects. More specifically, they chronologically document the development of the DVD market and observe that there was a dip in sales of the DVD players in the fall of 1997 when the Circuit City, the nation's leading electronics retailer at that time, prematurely announced DIVX, which was an alternative technology to DVD.[5] They test whether this dip in sales was statistically meaningful and check how the pre-announcement of DIVX affected the adoption of DVD technology. [6,7]

Choi (1994) studies consumers' irreversible technology adoption in the absence of any product announcements when these technologies are characterized by network effects. As in this paper, consumers in his model have an option to wait for the next generation technology with uncertain values. He shows that early consumers adopt irreversible technology too soon. However, product announcements are not allowed in the paper.

Our paper is also linked to the theoretical literature on strategic information transmission, which examines how an uninformed party elicits information from an informed party when the informed party can engage in "cheap talk."[8] Morris (2001) is closely related to our paper. Morris (2001) studies reputation effects that arise endogenously in a twice repeated cheap-talk game. In particular, he shows the possibility that reputational concerns may *distort* the advisor's incentives to tell the truth, leading to suppression rather than revelation of private information.[9]

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[5] Suspicions of "vaporware" arose soon after the announcement, with Circuit City being unable to demonstrate neither DIVX hardware nor software for several months. See Dranove and Gandal (2003) for details.

[6] However, we need to note that the impact was only temporary and that the DVD technology ultimately prevailed. Many early adopters believed that DIVX would be an inferior and "niche" product compared to the DVD technology.

[7] In contrast to the assumptions in our model, in this particular case these two technologies were not completely incompatible: there was one-way compatibility in that DIVX players would play all DVD discs in addition to special DIVX discs that could not be played by DVD players.See Dranove and Gandal (2003) for the discussion.

[8] See, for example, Crawford and Sobel (1982) and Sobel (1985).

In contrast, we investigate how reputational concerns help informative communication.'

Gerlach (2004) analyzes strategic interactions between an incumbent and an entrant, in which an incumbent adjusts its pricing policy based on an entrant's product announcement.[10]

We point out that all of papers above except Farrell and Saloner (1996) and Choi (1994) do not consider *network effects* in their models, which is the main feature of our model. Formal economic analysis of product pre-announcements that explicitly accounts for network effects and the possibility of false announcements is scarce. Our paper intends to fill this gap in the literature. By using a twice-repeated cheap talk game, we build a reputation model with network effects and show that product announcement could increase social welfare. Farrell and Saloner (1986) shows that that product pre-announcements could lower social welfare.[11] Their paper, however, considers only one product cycle and does not allow *intentionally false* announcements. We allow the possibility of strategic false announcements and consumers' potentially incorrect inference about the informational content of announcements. In addition, we consider a situation in which a firm can introduce a sequence of products over time and how reputational concerns discipline the firm's incentives to mislead consumers.

The remainder of the paper is organized in the following way. In section II, we set up the basic model of product pre-announcements with network effects. Section III solves the game when it is played only once. Section IV looks at the case in which the game is played twice and derives conditions for an equilibrium in which the firm's pre-announcement affects consumers' adoption behaviors. In section V, we analyze welfare implications of product pre-announcements. Section VI contains concluding remarks.

II. *The Model*

In this section, we construct a simple model of product pre-announcements in the presence of network effects.[12] There are two product cycles in this model. In each product cycle, there are two periods, $t=1, 2$. Let us describe one product cycle, which consists of two periods. There are also two potential consumers, 1 and 2, who arrive at the market sequentially at periods $t=1$ and 2, respectively.[13] A consumer has unit demand for a product in each product cycle.

In the first period ($t=1$), consumer 1 has two options. She can choose an existing product that is competitively supplied at the production cost, or she can wait until period 2. One firm in

[9] This paradoxical result takes place when the policymaker thinks that the advisor might be biased in favor of one decision, and the advisor, wanting his/her valuable advice to have an impact on future decisions, does not wish to be thought of as biased.

[10] The focus of Gerlach's paper is quite different from ours. In addition, his main focus is primarily on verifiable announcements. If false announcements were allowed, all firms would lie in equilibrium. In contrast, we show how reputational concerns may prevent firms from making false announcements.

[11] In their model, when a firm makes some announcements on a new product, some consumers are already locked to an existing product, and social welfare includes these consumers' welfare. Thus, product announcements could create excessive momentum to a new technology.

[12] The model of this article and the equilibrium characteristics closely follow Choi, et al (2005, 2010).

[13] We can easily reinterpret each consumer as a group of consumers. As long as they share the same preferences and we make a coordination assumption that they collectively choose their Pareto optimal outcome, the analysis will be the same.

the middle of developing a new product will introduce the new product in the second period ($t=2$). The new product is produced with a proprietary technology and can be produced only by the developing firm. Thus, if consumer 1 waits, she can make her optimal choice given the quality and price of the new product that will be available by that time.

The quality of the new product is revealed at period two, and the quality of the new product is either high or low. However, the firm that is developing a new product can realize the quality of the product in the first period. Realizing its product quality, the firm can make an announcement on the quality of the product in period one.

In period two ($t=2$), consumer 2 makes her choices between the old and the new products based on consumer 1's choice. We assume that the product in consideration exhibits network effects. The exiting product and the new product are incompatible. We denote by Δ the value each consumer attaches to the network effects conferred when consumer 1 and consumer 2 buys the same product. The purchasing decision by consumer 1 has dynamic implications on the choice by consumer 2 because of network effects. If the firm succeeds in delaying a consumer' purchases, it will not only have a larger potential purchaser in period two but also face a smaller installed base of old products.

We assume that there are two types of the firm, θ_1 and θ_2, where $\theta_1<\theta_2$. The firm's type determines the probability of developing a high-quality product, that is, θ_i denotes type i's probability of developing a high-quality product. Thus, a firm of type θ_2 has a higher probability of introducing a high-quality product than a firm of type θ_1 does. The firm's type is private information: only the firm knows its own type, while consumers know that the chance of the firm's being of type θ_2 is q.

The firm's announcement does not have any direct cost on itself besides its reputational concerns. Thus, it is a cheap-talk game. Since there is no alignment of interests between the firm and the consumer, the product pre-announcements cannot be informative in a model of one product cycle. Thus, we allow the game to be played twice in a model of two product cycles.

The firm's type is fixed between the two product-cycles. The product pre-announcements can have informational content even though they are a cheap talk as the firm aims to build its reputation. In a scenario in which the firm and consumers interact twice, Choi et al. (2010) developed a reputation model of vaporware and derived conditions under which product pre-announcements can be informative. As in Choi et al. (2010), we would build an informative Perfect Bayesian equilibrium (PBE) in which consumers would update their belief on the product quality based on the product quality announcement, and all players' strategies are optimal.

For simplicity, we assume that the production costs for both old and new products are zero. Therefore, the old, existing product is competitively supplied at a price of zero. The stand-alone value of the currently available product in period one is given by w per period. When consumer 1 delays her purchase, and waits until period 2, she foregoes the current consumption benefit that can be considered her waiting costs.[14] If the quality of the new product is low, the amount of *additional* stand-alone value the new product provides over the existing product is given by $\nu_L(>0)$, that is, its stand-alone value is $w+\nu_L$. If the quality

[14] As mentioned earlier, we can easily extend the analysis to a group of consumers in each cohort as long as consumers are homogeneous in their waiting costs (w) and, therefore, make the same decision as to purchase/wait in the first period.

realization is high, we assume that the amount of *additional* stand-alone value consumers derive from the new product is random and denoted by $\tilde{\nu}_H$. $\tilde{\nu}_H$ can take $\bar{\nu}_H$ with probability α and $\underline{\nu}_H$ with probability $(1-\alpha)$, where $\bar{\nu}_H > \underline{\nu}_H (> \Delta)$. The actual value of $\tilde{\nu}_H$ is *private* information revealed to consumers only in the second period and is unknown to them in the first period. This assumption reflects the fact that when new features are promised for new software, it would be difficult to know in advance how much additional value such features would provide for a consumer. The assumption also implies that the firm sets its price for the new product knowing only the distribution of the values. Without the assumption, as will be shown shortly, the firm introducing a high-quality product can extract all consumer surplus from consumers, and consumers do not have any incentive to wait for the new product.

III. *Analysis of the Benchmark: There Is Only One Product Cycle.*

We start analyzing the Benchmark case in which the game is played *only once*. As usual, we solve the game by backward induction. In period 2, there are four subgames we can consider, depending on the period 1 consumer's decision and the quality realization of the new product. They are denoted by (D, L), (ND, L), (D, H) and (ND, L), where the first element indicates consumer 1's decision (Delay or No Delay of her purchase) and the second element represents the firm's product quality (Low or High). For instance, (D, L) denotes the subgame in which consumer 1 does not buy any product in period one to wait for the new product, and the quality realization of the new product is Low. We analyze the market outcome in each subgame. We then show that product pre-announcements cannot impart any information even if they are allowed. The reason is that the firm of any type has nothing to lose from falsely claiming that the quality of its good is high when the game is played only once.

1. Subgame (D, L)

Consider a subgame in which consumer 1 delayed her purchase (D), and the quality realization of the new product in the second period is low (L). Since consumer 1 does not buy the old product, as a result, the old and new products compete on the same level since the old product does not have any installed base. The new product then will be sold to both consumers at the price of $p = \nu_L$, which is the quality advantage of the new product over the old one, when the new product is of low quality.[15] In this subgame, the firm's introducing the low quality new product earns a profit, which is given by $\pi_D^L = 2\nu_L$, and consumers 1 and 2 buy the same product, the new product.

2. Subgame (ND, L)

Let us look at the subgame in which consumer 1 has purchased the existing product in the first period (i.e., no delay, ND) and that the new product is of low quality. In this subgame, consumer 2 has two options. If she makes the same choice as consumer 1 by purchasing the

[15] Without any loss of generality, we make a tie-breaking assumption that consumers choose the new product when consumers are indifferent between the two products. Without the tie-breaking assumption, the new product will be sold at the price of $p = \nu_L - \varepsilon$, where ε is an arbitrary small positive number. The tie-breaking assumption is made to avoid this open set problem.

competitively supplied product, she receives the surplus of $w+\Delta$. In contrast, if she purchases the new product at the price of p, her surplus would be $w+\nu_L-p$. There are two cases to consider depending on the relative magnitudes of Δ and ν_L.[16] If $\Delta>\nu_L$, the quality increase is not sufficient for the supplier of the new product to overcome the installed-base effect, and consumer 2 buys the old product. However, if $\Delta<\nu_L$, the firm can charge $p=\nu_L-\Delta$ and sell the new product to consumer 2. In such a case, incompatibility will prevail and the network benefit of Δ is lost.

To limit the number of cases to consider, we assume that $\Delta>\nu_L$.[17]

(Assumption 1) $$\Delta>\nu_L$$

This assumption implies that when consumer 1 has already bought the currently available product, then consumer 2 would buy the same product to maintain compatibility if the new product is of low quality. The firm is unable to sell the new product, and its profit is given by $\pi^L_{ND}=0$.

We have solved subgame (*D, L*) and subgame (*ND, L*). Combining these two, we find that consumer 1 would not wait for the new product if she knows that the quality of the new product is low. The reason is as follows: If the quality of new product is known to be low for sure, consumer 1's payoff from purchasing the currently available product is given by $w+(w+\Delta)=2w+\Delta$ since consumer 2 will also purchase the same product to enjoy network benefits. In contrast, if she waits, she will get the utility of $(w+\nu_L+\Delta)$ from the new product, but has to pay the price of ν_L in the second period, which provides consumer 1 the (net) payoff of $(w+\Delta)$. Thus, consumer 1's optimal choice is to purchase the available product in period 1 if the quality of new product is known to be low for sure.

However, from the perspective of the firm with a low-quality product, its profit is zero ($\pi^L_{ND}=0$) if consumer 1 do not wait, whereas its profit becomes $\pi^L_D=2\nu_L$ if consumer 1 decides to delay her purchase. Thus, the firm's benefit of inducing the first period consumer to wait is given by $\pi^L_D-\pi^L_{ND}=2\nu_L$.

3. Subgame (ND, H)

Now consider the subgame where the new product is of high quality and consumer 1 has already made a purchase in the first period. Once again, consumer 2 has two options. If she purchases the competitively supplied product like consumer 1, she has surplus of $w+\Delta$ as before. In contrast, if she purchases the new product at the price of p, her surplus would be $w+\tilde{\nu}_H-p$.

Now let us analyze the firm's optimal price for the high quality new product. The firm has two candidates for the optimal price, $p=(\bar{\nu}_H-\Delta)$ or $(\underline{\nu}_H-\Delta)$. If the firm charges the higher price $p=(\bar{\nu}_H-\Delta)$ for the new product, consumer 2 will buy the product only in the event that the amount of *additional* standalone value she derives from the new product turns out to be $\bar{\nu}_H$. This event takes place with probability α. Thus, the expected payoff from charging $p=(\bar{\nu}_H-\Delta)$

[16] In the absence network effects with $\Delta=0$, consumer 1's choice would have no bearing on consumer 2's choice.

[17] The other case can be easily analyzed without affecting the main results.

is given by $\alpha(\bar{\nu}_H - \Delta)$. In contrast, if the firm charges $(\underline{\nu}_H - \Delta)$ for the new product, consumer 2 buys the product for sure, which yields a profit of $(\underline{\nu}_H - \Delta)$. We make the following assumption, which implies that the optimal price for the firm is $(\underline{\nu}_H - \Delta)$:

(Assumption 2) $$\alpha < \frac{\underline{\nu}_H - \Delta}{\bar{\nu}_H - \Delta} \tag{1}$$

Assumption 2 implies that the firm's profit in this subgame is given by $\pi_{ND}^H = (\underline{\nu}_H - \Delta)$. If consumer 1 makes her purchase in the first period and the new product turns out to be of high quality, she will be stranded by consumer 2 who will choose the new product. Thus, her payoff is given by $2w$ if she makes a purchase in the first period.

4. Subgame (D, H)

Finally, let us analyze a subgame in which consumer 1 delayed her purchase, and the quality realization of the new product in the second period is high. First, let us analyze the firm's optimal price for the high-quality product. The optimal price for the firm is either $p = \bar{\nu}_H$ or $\underline{\nu}_H$. If the firm charges $\bar{\nu}_H$, consumers will buy the product only with probability α. Thus, the expected payoff is given by $\alpha(2\bar{\nu}_H)$. In contrast, if the firm charges $\underline{\nu}_H$, consumers buy the product for sure and obtains a profit of $2\underline{\nu}_H$. Inequality (1) above implies that $\alpha < \frac{\underline{\nu}_H}{\bar{\nu}_H}$. Thus, the optimal price for the firm is $p = \underline{\nu}_H$, with $\pi_D^H = 2\underline{\nu}_H$. As a result, when consumer 1 decides to wait until period 2, her expected surplus is given by $w + \Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H)$. Recall that her expected payoff is given by $2w$ if she makes a purchase in the first period. To have a meaningful analysis, we assume that:

(Assumption 3) $$w < \Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H) \tag{2}$$

The condition above says that consumer 1 will prefer to wait if the new product is known to be of high quality.

So far we have solved the four subgames in period two. Now we analyze consumer 1's choice in period one. We denote consumers' belief that the firm has a high-quality product by μ. We find that consumer 1 would not wait for the new product if she knows that the new product is of low quality, while she would wait for the new product if she knows that it is of high quality. Thus, there exists a critical level of $\bar{\mu}$ between zero and one at which consumer 1 is indifferent between waiting and not waiting. The following equation derives the level of $\bar{\mu}$.

$$\bar{\mu}(2w) + (1 - \bar{\mu})(2w + \Delta) = \bar{\mu}[w + \Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H)] + (1 - \bar{\mu})(w + \Delta)$$

The left-hand side of the equation above measures consumer 1's net benefit from not waiting, while the right-hand side of that does consumer 1's net benefit from waiting. Thus, we have,

$$\bar{\mu} = \frac{w}{\Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H)} \tag{3}$$

We assume that $\bar{\mu}$ is between θ_1 and θ_2.

(Assumption 4) $$\theta_1 < \bar{\mu} < \theta_2$$

Consumer 1 wants to wait for the new product until period two if and only if the new product is of high quality. θ_i measures the probability that the firm of type i develops and introduces a high-quality product. Since $\theta_1 < \bar{\mu} < \theta_2$, consumer 1 would wait for the new product if she knows that the firm's type is θ_2.

To sum up our results so far, when consumer 1 waits, the firm with a high-quality product earns $\pi_D^H = 2\underline{\nu}_H$, while the firm with a low-quality product earns $\pi_D^L = 2\nu_L$. When consumer 1 does not wait, the firm's corresponding profits are $\pi_{ND}^H = (\underline{\nu}_H - \Delta)$ and $\pi_{ND}^L = 0$, respectively.

Let us analyze whether the firm's pre-announcement can have any effects on consumers' adoption behaviors. See inequality (2) and that $\pi_D^H > \pi_{ND}^H$. When the firm introduces a high-quality one, consumer 1's waiting increases not only the firm's profit but also the consumer welfare. Thus, the firm and consumers have incentive to 'communicate.'

However, since the firm with a low-quality product would have higher profits when the first-period consumer waits, the firm with a low quality one would find it profitable to make a false announcement on its quality. Thus, product pre-announcements are simply not credible for one product cycle. The next section, however, shows that product pre-announcements can impart information to consumers if the game is played twice.

Notice that $[\pi_D^H - \pi_{ND}^H] > [\pi_D^L - \pi_{ND}^L]$ since $(\underline{\nu}_H + \Delta) > 2\nu_L$ by our assumption. This implies that the firm gains more from consumer 1's delay of purchase when it has a high-quality product than when it has a low-quality product. This fact will play an important role in our analysis later.

IV. *The Existence of an Informative Equilibrium*

We extend the analysis in the previous section to allow for repeated interactions between consumers and the firm. More specifically, we consider a situation in which the game described above is played twice. There are two product cycles in which the firm can produce a new product. In each product cycle, the firm is allowed to announce the product quality in the first period, prior to its release in the second period. We analyze how reputations are formed in equilibrium and how concern over reputation affects cheap talk. We can capture differences in the importance of the two product cycles by the discount factor δ.[18] As before, we solve the game by backward induction, starting from the second-product cycle.

[18] We also maintain the same sequential structure across product cycles in which consumer 1 chooses first in the first period and consumer 2 makes choices in the second period. Or, we can think of consumers in the second product cycle as different groups but with the knowledge of past history in the market. Alternatively, we could assume that they make the decision simultaneously in the second product cycle since both of them are already there. Allowing the consumers in the second product cycle to make simultaneous choices would not change the qualitative results of this paper.

1. The Second-product Cycle

The first-period consumer would make the buy or wait decision based on their updated belief about the firm's chance of introducing a high-quality product. We find that the firm would have higher profits when first-period consumers wait for the new product. Since the second product cycle is the last interactions between the firm and consumers, we have the end game effects in the second product cycle, and the firm's announcement at the second product cycle cannot have any information contents. However, consumers can infer the firm's type from the firm's behavior in the first product cycle.[19]

Let μ_2 denote the consumers' updated belief of the firm's product being high quality in the second cycle. If μ_2 is higher than the critical value defined by $\bar{\mu}=\frac{w}{\Delta+\alpha(\bar{\nu}_H-\underline{\nu}_H)}$ (see equation (3)), consumer 1 will delay her purchase until period two. Otherwise, consumer 1 will not wait. As in the previous analysis, consumer 2's optimal adoption decision depends on whether consumer 1 delays her purchase and whether the product is of high quality or of low quality.

Here, let us calculate the firm's ex ante expected profit in the second product cycle. If consumer 1 does not delay her purchase until the second period, a firm of type θ's *ex ante* expected profit from the second product cycle (i.e., before knowing whether it has a high- or low-quality product), is given by $\pi_{ND}(\theta)=\theta\pi^H_{ND}+(1-\theta)\pi^L_{ND}=\theta(\underline{\nu}_H-\Delta)$. However, if consumers 1 delays her purchase, the firm's *ex ante* expected profit from the second product cycle is $\pi_D(\theta)=\theta\pi^H_D+(1-\theta)\pi^L_D=\theta(2\underline{\nu}_H)+(1-\theta)(2\nu_L)$. Note that $[\pi_D(\theta)-\pi_{ND}(\theta)]=\theta(\underline{\nu}_H+\Delta)+(1-\theta)(2\nu_L)$ is increasing in θ since $(\underline{\nu}_H+\Delta)>2\nu_L$ by our assumption.

Obviously, all types benefit from consumer 1's waiting, but the beneficial effects differ across types of the firm. The firm's incremental benefits from consumer 1's waiting gets larger when the firm's chance of introducing a high-quality product is higher. That is, type θ_2 benefits more from consumer 1's waiting than type θ_1 does. The result comes from the fact that the firm gains more from consumer 1's waiting when it has a high-quality product than when it has a low-quality product ($\underline{\nu}_H+\Delta$ vs. $2\nu_L$). As the type parameter θ increases, the firm is more likely to produce a high-quality product and benefits more when consumer 1 is induced to wait. This implies that we can obtain a separating equilibrium in which type θ_1 and type θ_2 have different reputation concerns and behave differently in the first product cycle.[20]

Also, the firm's (expected) profit difference between the cases of consumer 1's waiting and of her not waiting is increasing in Δ, the size of network effects. When consumer 1 does not wait for the new product, the firm introducing the new product has to compensate consumer 2 for loss of network effects in order to sell its product. Thus, when Δ is larger, the firm's expected profit becomes lower if consumer 1 does not wait. Thus, the firm has a stronger incentive to induce consumer 1 to wait. This implies that as Δ, the size of network effects, is

[19] Pricing and advertising could be a method of signaling quality in an experience good. One question to ask is why a high-type firm cannot signal its type either by pricing or advertising. In our model, the product is *not* an experience good. Once a product is developed and introduced in the market, consumers are aware of the quality of the product. In contrast, information asymmetry in our model arises during the product development stage. Thus, pricing signal has no bite since there is no product available, yet.

[20] See Mas-Colell, Whinston, and Green (1995) for more details.

larger, reputation concerns become more important.

2. The First-product Cycle

In this section we search for an informative equilibrium in which in the first-product cycle the high-type firm (θ_2) makes always true announcements on its product quality, while the low-type (θ_1) firm always tells that its product is of high quality.[21]

We now derive conditions under which the proposed firm's strategies above constitute an equilibrium. To this end, let us analyze consumers' optimal behaviors given the firm's strategy above.

When the firm makes an announcement that the product is of low quality in the first cycle, consumer 1 knows for sure that the product is low quality and would not wait for the new product. However, since consumer 1realizes that the firm's type is high type (θ_2), she would wait for the new product in the second cycle.

Suppose that the firm announces a high-quality product in the first cycle. In the proposed firm's strategies described above, the high-type firm makes truthfully reports. As a result, the announcement of "high quality" has some informational content. When consumer 1 gets the announcement that the product is of high quality, she updates her belief that the product is of high quality, following the Bayes rule. The updated belief based on the equilibrium strategies of the firm above is as follows,

$$\mu_1{}^H=\left(\frac{q}{q\theta_2+(1-q)}\right)\theta_2+\left(\frac{(1-q)}{q\theta_2+(1-q)}\right)\theta_1 \tag{4}$$

The updated belief constitutes an upward revision of the prior belief that the product is of high quality, i.e., $\mu_1{}^H>q\theta_2+(1-q)\theta_1$. We assume the following assumption;

(Assumption 5) $$\mu_1{}^H>\bar{\mu} \tag{5}$$

Since consumer are indifferent between waiting and not waiting at $\bar{\mu}$ (see equation (3)), assumption 5 thus implies that consumer 1 will wait for the new product in the first cycle on a high-quality product announcement.

After the quality of the product is revealed, consumers update their beliefs on the firm's type. If the quality of the new product is of low, then this is a sure signal that the firm is of the low-type (θ_1) as the high-type firm will not make such a false announcement according to the equilibrium strategies specified above. Thus, consumer 1 would not wait for the new product in the second product cycle.

When the quality of the new product turns out to be of high, the posterior probability that the firm is a high type is derived as:

$$\begin{aligned}&Pr(\theta=\theta_2\,|\,Quality=H)\\&=\frac{Pr\,(\theta=\theta_2)Pr\,(Quality=H|\,\theta=\theta_2)}{Pr(\theta=\theta_2)Pr(Quality=H|\,\theta=\theta_2)+Pr(\theta=\theta_1)Pr(Quality=H|\,\theta=\theta_2)}\\&=\frac{q\theta_2}{q\theta_2+(1-q)\theta_1}\end{aligned}$$

[21] The building of this informative equilibrium closely follows Choi, et al (2010).

Thus, the updated belief that the product is of high quality in the second cycle (μ_2) becomes $\frac{q\theta_2}{q\theta_2+(1-q)\theta_1}\theta_2+\left(\frac{(1-q)\theta_1}{q\theta_2+(1-q)\theta_1}\right)\theta_1$. Since $\frac{q\theta_2}{q\theta_2+(1-q)\theta_1}>\frac{q\theta_2}{q\theta_2+(1-q)}$, condition (5) implies that $\frac{q\theta_2}{q\theta_2+(1-q)\theta_1}\theta_2+\left(\frac{(1-q)\theta_1}{q\theta_2+(1-q)\theta_1}\right)\theta_1>\bar{\mu}$. Thus, if the quality of the new product turns out to be high quality, consumer 1 would wait for the new product in the second product cycle.

So far, given the firm's strategy, we check the consumer's Bayesian update and its optimal choice. From now on we check whether the firm's strategies are optimal. When the firm has a high-quality product, it is optimal for it to tell a true announcement.

When the firm has a low-quality product in the first cycle, there are tradeoffs between profits from the first product cycle and profits from the second product cycle. By making a false announcement, the firm with low quality one can make $\pi_D^L=2\,\nu_L$ in the first cycle. However, the firm loses its credibility, and consumer 1 will not delay her purchase in the second product cycle. If the firm with low quality one makes a true announcement on its quality, it gets π_{ND}^L in the first product cycle, and its expected profit in the second product cycle becomes $\delta\pi_D(\theta)=\delta[\theta\pi_D^H+(1-\theta)\pi_D^L]$.

We would find conditions for type θ_2 with a low-quality product to make a true announcement and for type θ_1 with a low-quality product to make a false announcement. When the following condition holds, type θ_2 with a low-quality product optimally makes a true announcement in the first cycle:

$$\pi_{ND}^L+\delta[\theta_2\pi_D^H+(1-\theta_2)\,\pi_D^L]\;\geq\;\pi_D^L+\delta[\theta_2\pi_{ND}^H+(1-\theta_2)\,\pi_{ND}^L] \tag{6}$$

The corresponding condition for type θ_1 with a low-quality product to make a false announcement in the first cycle is given by:

$$\pi_D^L+\delta[\theta_1\pi_{ND}^H+(1-\theta_1)\,\pi_{ND}^L]\geq\pi_{ND}^L+\delta[\theta_1\pi_D^H+(1-\theta_1)\,\pi_D^L] \tag{7}$$

In our model, the two conditions above can be rewritten as:

$$\theta_1<\frac{1-\delta}{\delta}\,\frac{2\nu_L}{\underline{\nu}_H+\Delta-2\nu_L}<\theta_2 \tag{8}$$

The first inequality in condition (8) is a restatement of the incentive constraint for the low type θ_1 that it will make a false announcement in the first cycle if it has a low-quality product. The condition ensures that the low type's short-term benefit from false announcement outweighs the long-term cost of diminished credibility since its innovativeness or research capability is sufficiently low. The second inequality in condition (8) is a restatement of the incentive constraint for the high type θ_2 that it will make a truthful announcement in the first cycle if it has a low-quality product. When the second inequality holds, the high-type firm refrains from false announcement since the long-term cost of diminished credibility is too important to disregard. We summarize our discussion so far in the following Proposition. [22]

[22] It can easily be verified that the set of parameters satisfying conditions (5) and (8) is non-empty.

Proposition 1. If conditions (5) and (8) are satisfied, there exists an informative semi-separating equilibrium in the first product cycle, in which the high type (θ_2) firm makes a truthful announcement whereas the low-type (θ_1) firm always makes an announcement that its product is of high quality.

We have derived conditions for the existence of a partially revealing equilibrium in which the high-type firm makes a truthful announcement. Let us describe the equilibrium path in the informative equilibrium: Since low-type firm (θ_1) always tells that its product is of high quality, when consumer 1 gets the announcement that the product is of high quality, she takes it partially true and would wait for the new product on the updated belief in the first cycle. After the quality the new product is realized in the second period, consumer 1 updates its belief on the firm's type. If the quality is of high quality, consumer 1 makes upward adjustment of the firm's type and wait for the new product in the second product cycle. On the contrary, when the quality is of low quality, she makes downward adjustment of the firm's type and would not wait for the new product in the second cycle.

This type of equilibrium is not unique to the existence of network effects and can exist even in the absence of network effects, as is shown in Choi et al (2010). Thus, it is worth mentioning the role of network effects in our model. First, we can observe that the existence of network effects facilitates the existence of informative semi-separating equilibrium, which explains that most of product pre-announcements take place in markets characterized network effects.

Proposition 2. The existence of network effects facilitates the existence of informative semi-separating equilibrium.

To see this, note that the truth-telling condition (6) can be written as $\theta \geq \theta^*(\Delta)$, where $\theta^*(\Delta) = \frac{1-\delta}{\delta} \frac{2\nu_L}{\underline{\nu}_H + \Delta - 2\nu_L}$ is a decreasing function of Δ. Thus, the truth-telling condition is relaxed as network effects become more important. As network effects become more important, it is more likely that we have an informative equilibrium.

The incentive to tell the truth hinges on the cost-benefit analysis of making a false announcement. For a given type, the cost of lying is from diminished credibility in the future, which is given by $[\pi_D(\theta) - \pi_{ND}(\theta)] = \theta(\underline{\nu}_H + \Delta) + (1-\theta)(2\nu_L)$. The cost increases in the size of network effects (Δ). In contrast, the short-run benefit of lying when the firm has a low-quality product in the first product cycle is given by $[\pi_D^L - \pi_{ND}^L] = 2\nu_L$, which is independent of Δ.[23] Thus, the marginal incentive to tell the truth increases in the size of network effects (Δ), which expands the set of parameters that allows informative pre-announcements.

The logic behind this result is as follows: when consumer 1 does not wait and buys the currently available product, consumer 2, by choosing the new product, suffers from the loss of network effects. Thus, the firm introducing the new product has to adjust its price to make a

[23] The independence result hinges on our assumption that the produce of a low-quality product cannot overcome the installed base effect when the first period consumer purchases in the first period. However, we can relax this assumption. More generally, as long as the high-quality product firm makes more sales than the low quality one and enjoys higher network benefits, our result that the marginal incentive to tell the truth increases in the size of network effects would be valid.

compensation for the loss of the network effects in order to sell its product. Thus, when Δ, the size of network effects, is larger, the firm's expected profit becomes lower if consumer 1 does not wait. Thus, reputation concerns become more important, and the marginal incentive to tell the truth increases in the size of network effects. As result, as the network effects get larger, we are more likely to have an informative equilibrium.

V. *Welfare Analysis*

As discussed in the Introduction, antitrust concerns of product pre-announcement arise mostly in the network industries. Thus, it is imperative to analyze welfare effects of product pre-announcements in a model that explicitly accounts for network effects. This is exactly what we intend to do in this section.

Proposition 3. Allowing pre-announcement increases consumer welfare in the presence of network effects.

Proof. See the Appendix.

In the Appendix, we prove that ex ante consumers taken together are always better off with product pre-announcements, even if the firm is allowed to make misleading claims about its future product. We get the welfare result because reputation concerns discipline the firm's incentives to make false claims and consumers make rational decisions by taking the possibility of false claims into consideration.

The firm that introduces a new product in period two adjusts its price based on network effects by first-period consumer's choice. Thus, it turns out that consumer 2's surplus is independent of consumer 1's purchase/delay decision. More specifically, consumer 2's surplus is $(w+\Delta)$ if the product is of low quality whereas it is given by $(w+\alpha(\bar{\nu}_H-\underline{\nu}_H)+\Delta)$ if the product is of high quality, regardless of whether consumer 1 waits in the first period or not. Therefore, product pre-announcements have no effects on consumer 2's welfare.

We turn our attention to consumer 1's welfare and argue that consumer 1 is unambiguously better off with product pre-announcements. The intuition for this result is the same as in Choi et al. (2010). In Choi et al. (2010), we showed that the ex ante effect of product announcements on consumer welfare is positive, because in a semi-separating equilibrium a firm's announcement delivers some information, which helps consumers make better decisions. However, in Choi et al. (2010) there is no externalities among consumers. Here we find that this result is robust to the introduction of network effects.[24]

We can also show that in this simple, twice-repeated cheap-talk game, the firm's *ex ante* profit also increases. Thus, the total surplus (consumer surplus+firm's profit) also increases with product pre-announcements. By making product announcements, the firm can send signal on its type, which improves social welfare. In general, we can have 'excessive' signaling, which

[24] One can ask why antitrust policy cannot focus only on false claims made by the firm, allowing only truthful product pre-announcements. However, it would be difficult to implement such a policy because of the ambiguity associated with ascertaining whether the firm actually delivered the promised quality, especially when the new features promised are something non-existent at the time of announcement. This fact makes direct contracting between the firm and consumers infeasible in the first place.

reduces social welfare, when signaling is costly. However, in our article an announcement on product quality is cheap-talk, we have this clear welfare result. This 'cheap talk' helps coordination between consumers and the firm introducing a new product.

Proposition 3. The firm's *ex ante* profit increases with the possibility of product pre-announcements. Thus, social welfare also increases with product pre-announcements.

Proof. See the Appendix.

This result is in a sense consistent with Choi (1994) who shows that early potential users tend to adopt an irreversible technology too early compared to the social optimum in the presence of network effects. Since the role of product pre-announcements is to induce a delay of technology adoption for early potential users, product pre-announcements can mitigate the inefficiency identified in Choi (1994).

This is in sharp contrast to Farrell and Saloner (1986) who show that product pre-announcements may influence which product prevails in the marketplace and lead to socially inefficient technology adoption. The inefficiency in their paper arises from "stranding" of consumers who were unaware of the availability of the new product in the future and have already been locked in the old product before announcement.[25] This suggests that we may need an element of "surprise" to derive inefficiencies associated with product pre-announcements, which is absent in our model.

Out model consists of two product cycles. However, the qualitative results will easily carry over to the multiple product cycle model as reputation concerns become more important as the number of product cycles increases.

IV. *Concluding Remarks*

In industries characterized by network effects, such as the computer industry, early lock-ins might preclude the emergence of superior technologies in these industries. Firms that introduce a non-compatible product with existing products have strong incentives to make product announcement. Product pre-announcement affects which product prevails especially in markets with network effects. We find that firms can use cheap talk to convey *partial information* when they have reputational concerns. As a result, product pre-announcements can make consumers better off as long as consumers are aware of the incentives of low-type firms to mislead consumers. We show that when the network effects are larger, it is more likely for the informative equilibrium to exists.

Product announcements by the firm in our analysis are intended for consumers, and the price of the existing, old product is exogenously set. Rival firms do not react to the product announcement in our analysis. Rival firms as well as consumers might react to new product announcements (Gerlach (2004)). It would be interesting to have a rich analysis of 'cheap talk' game with multiple audiences, in which rival firms react to other firms' announcements.

[25] Their paper, however, considers only truthful pre-announcements and does not analyze the possibility of false announcements and consumers' inference problem about their informational content.

APPENDIX

Proposition 3. Allowing pre-announcement increases consumer welfare in the presence of network effects.

Proof. Let CS_D^H (CS_D^L) denote the sum of consumer surplus of consumer 1 and 2 in one product cycle when consumer 1 waits and the firm introduces a high-quality product (low-quality product) in period 2. Similarly, we denote the corresponding sum of consumer surplus of consumer 1 and 2 when consumer 1 does not wait and purchases the existing product in period 1 by CS_{ND}^H (CS_{ND}^L). In our model, we have

$$CS_D^H = 2[\mathrm{w} + \Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H)]$$
$$CS_D^L = 2[\mathrm{w} + \Delta]$$
$$CS_{ND}^H = (2\mathrm{w}) + [\mathrm{w} + \alpha(\bar{\nu}_H - \underline{\nu}_H) + \Delta] = 3\mathrm{w} + \alpha(\bar{\nu}_H - \underline{\nu}_H) + \Delta$$
$$CS_{ND}^L = (2\mathrm{w} + \Delta) + (\mathrm{w} + \Delta) = 3\mathrm{w} + 2\Delta$$

Then, the (expected) consumer welfare in the informative equilibrium with product pre-announcements in the first product cycle becomes $(1-q)[\theta_1 CS_D^H + (1-\theta_1) CS_D^L] + q(\theta_2 CS_D^H + (1-\theta_2) CS_{ND}^L)$. The (expected) consumer welfare in the informative equilibrium with product pre-announcements in the second product cycle becomes $[(1-q)\{\theta_1(\theta_1 CS_D^H + (1-\theta_1) CS_D^L) + (1-\theta_1)(\theta_1 CS_{ND}^H + (1-\theta_1) CS_{ND}^L)\} + q\{\theta_2(\theta_2 CS_D^H + (1-\theta_2) CS_D^L) + (1-\theta_2)(\theta_2 CS_D^H + (1-\theta_2) CS_D^L)\}]$.

Let us get the corresponding (expected) consumer welfare when product pre-announcements are not allowed. When the product pre-announcements are not available, there are two cases in the first-period in the first product cycle: in one case (case 1), consumer 1 will not wait for the new product, that is, $q\theta_2 + (1-q)\theta_1 < \bar{\mu}$; in the other case (case 2), consumer 1 would wait for the new product, $q\theta_2 + (1-q)\theta_1 > \bar{\mu}$.

(In case 1) Consumer 1 would not wait for the new product in the first cycle. The (expected) consumer welfare without product pre-announcements in the first product cycle becomes $(1-\mathrm{q})[\theta_1 CS_{ND}^H + (1-\theta_1) CS_{ND}^L] + q(\theta_2 CS_{ND}^H + (1-\theta_2) CS_{ND}^L)$.

However, the quality of the new product is revealed in the second period in the first cycle. Based on the quality, consumers in the second cycle update their beliefs of the firm's type being θ_2. In the second cycle, by condition (5) and the fact that $\frac{q(1-\theta_2)}{(1-q)(1-\theta_1)+q(1-\theta_2)} < q$, consumer 1 will not wait for a new product if and only if the product in the first cycle is of low quality. Thus, the (expected) consumer welfare without product pre-announcements in the second product cycle becomes $[(1-q)\{\theta_1(\theta_1 CS_D^H + (1-\theta_1) CS_D^L) + (1-\theta_1)(\theta_1 CS_{ND}^H + (1-\theta_1) CS_{ND}^L)\} + q\{\theta_2(\theta_2 CS_D^H + (1-\theta_2) CS_D^L) + (1-\theta_2)(\theta_2 CS_{ND}^H + (1-\theta_2) CS_{ND}^L)\}]$.

Let us compare the consumer welfare level under the announcement case with that of no announcement (case 1). Under no announcement, the first period consumer does not wait for the new product in the first cycle, while she would wait for the new product when the firm announces a high-quality product under the announcement case. Thus, the first-cycle consumer welfare difference between the announcement and no announcement cases is $((1-q)\theta_1 + q\theta_2)(CS_D^H - CS_{ND}^H) + (1-q)(1-\theta_1)(CS_D^L - CS_{ND}^L)$, which is $((1-q)\theta_1 + q\theta_2)[\Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H) - \mathrm{w}] - (1-q)(1-\theta_1)\mathrm{w}$. If we divide the equation by $(1-q+q\theta_2)$, we get $\{\mu_1{}^H[\Delta + \alpha(\bar{\nu}_H - \underline{\nu}_H) - \mathrm{w}] - (1-\mu_1{}^H)\mathrm{w}\}$, where $\mu_1{}^H = \frac{q\theta_2}{q\theta_2 + (1-q)} - \left(\frac{1-q}{q\theta_2 + (1-q)}\right)\theta_1$. Since $\mu_1{}^H > \bar{\mu}$, the expression in the curly bracket above is positive (see equation (3) and assumption (5)).

We thus have that the product announcement increases the expected consumer welfare in the first product cycle.

Second, let us check the consumer welfare difference in the second product cycle between the announcement and no announcement (case 1). Under no announcement, period-one consumer in the second cycle would wait for a new product only if the quality of the product in the first cycle is high, while the firm of type θ_2, by making an honest product announcement in the first cycle, can induce period-one consumer in the second cycle to wait when the product announcement is allowed. Thus, the consumer welfare difference in the second product cycle between the announcement and no announcement becomes $q(1-\theta_2)[\theta_2\{\Delta+\alpha(\bar{\nu}_H-\underline{\nu}_H) - \mathrm{w}]-(1-\theta_2)\mathrm{w}]$. Since $\theta_2>\bar{\mu}$, the consumer welfare difference is positive. Thus, a product announcement increases consumer welfare in the second product cycle, too.

Let us check Case 2: consumer 1 will wait for a new product in the first cycle even without product preannouncement, and consumers in the second cycle would wait for the new product only if the product in the first cycle is of high quality. Thus, the (expected) consumer welfare without product pre-announcements in the first product cycle becomes $(1-q)[\theta_1 CS_D^H+(1-\theta_1)CS_D^L]+q(\theta_2 CS_D^H+(1-\theta_2)CS_D^L)$. The (expected) consumer welfare without product pre-announcements in the second product cycle is $[(1-q)\{\theta_1(\theta_1 CS_D^H+(1-\theta_1)\ CS_D^L)+(1-\theta_1)(\theta_1 CS_{ND}^H+(1-\theta_1)CS_{ND}^L)\}+q\{\theta_2(\theta_2 CS_D^H+(1-\theta_2)CS_D^L)+(1-\theta_2)(\theta_2 CS_{ND}^H+(1-\theta_2)CS_{ND}^L)\}]$.

Let us compare the consumer welfare level under the announcement case and that of no announcement (case 2). Under no announcement (case 2) first-cycle consumer always wait for the new product, while she would not wait for the new product when the firm announces a low-quality product under the announcement case. Thus, when the announcement is allowed, a consumer can save her waiting cost if the announced quality is low. Thus, the first-cycle consumer welfare difference between the announcement and no announcement is $q(1-\theta_2)(CS_{ND}^L-CS_D^L)=q(1-\theta_2)\mathrm{w}>0$. Second, the consumer welfare levels in the second product cycle are the same between the case 1 and case 2, and we have already shown that a product announcement increases consumer welfare in the second product cycle. (End of Proof)

Proposition 4. The firm's *ex ante* profit increases with the possibility of product pre-announcements. Thus, social welfare also increases with product pre-announcements.

Proof. The analysis of the effect of product announcements on the firm profit closely follows the method of proof above. When the firm is allowed to make product pre-announcements, the expected firm profit in the informative equilibrium is as follows,

$$\Pi^A=\Pi_1{}^A+\delta\Pi_2{}^A$$
$$=(1-q)[\theta_1\pi_D^H+(1-\theta_1)\pi_D^L]+q(\theta_2\pi_D^H+(1-\theta_2)\pi_{ND}^L)$$
$$+\delta[(1-q)\{\theta_1(\theta_1\pi_D^H+(1-\theta_1)\pi_D^L)+(1-\theta_1)(\theta_1\pi_{ND}^H+(1-\theta_1)\pi_{ND}^L)\}+q\{\theta_2(\theta_2\pi_D^H$$
$$+(1-\theta_2)\pi_D^L)+(1-\theta_2)(\theta_2\pi_D^H+(1-\theta_2)\pi_D^L)\}]$$

(where $\Pi_i{}^A$ denotes firm profit in product cycle i, $i=1,2$ when pre-announcements are allowed)

Let us get the corresponding (expected) the expected firm profit when product pre-announcements are not allowed. First, suppose that $q\theta_2+(1-q)\theta_1<\bar{\mu}$. When the product pre-announcements are not available, consumer 1 will not wait for the new product. By the same logic presented above, the total expected firm profit in this case can be written as follows:

$$\Pi^{NA}=\Pi_1{}^{NA}+\delta\Pi_2{}^{NA}$$

$=(1-q)[\theta_1\pi_{ND}^H+(1-\theta_1)\pi_{ND}^L]+q(\theta_2\pi_{ND}^H+(1-\theta_2)\pi_{ND}^L)$
$+\delta\,[(1-q)\{\theta_1(\theta_1\pi_D^H+(1-\theta_1)\pi_D^L)+(1-\theta_1)(\theta_1\pi_{ND}^H+(1-\theta_1)\pi_{ND}^L)\}+q\{\theta_2(\theta_2\pi_D^H$
$+(1-\theta_2)\pi_D^L)+(1-\theta_2)(\theta_2\pi_{ND}^H+(1-\theta_2)\pi_{ND}^L)\}]$
(where Π_i^{NA} denotes the expected firm's profit in product cycle i, $i=1,2$ when pre-announcements are not allowed)

Let us compare Π^A and Π^{NA}. First, $\Pi_1{}^A-\Pi_1{}^{NA}=((1-q)\theta_1+q\theta_2)(\pi_D^H-\pi_{ND}^H)+(1-q)(1-\theta_1)(\pi_D^L-\pi_{ND}^L)=((1-q)\theta_1+q\theta_2)[\underline{\nu}_H+\Delta]+(1-q)(1-\theta_1)(2\nu_L)>0$. Second, $\Pi_2{}^A-\Pi_2{}^{NA}=q(1-\theta_2)(\theta_2[\underline{\nu}_H+\Delta]+(1-\theta_2)(2\nu_L)>0$. Thus, we have $\Pi^A>\Pi^{NA}$.

Second, suppose that consumer 1 would wait for the new product even without a product announcement, $q\theta_2+(1-q)\theta_1>\bar{\mu}$. Consumer 1 will wait in the second cycle only if the product in the first cycle is of high quality as in the previous case. The expected firm profit can be written as follows:

$\tilde{\Pi}^{NA}=\tilde{\Pi}_1{}^{NA}+\delta\tilde{\Pi}_2{}^{NA}$
$=(1-q)[\theta_1\pi_D^H+(1-\theta_1)\pi_D^L]+q(\theta_2\pi_D^H+(1-\theta_2)\pi_D^L)$
$+\delta[(1-q)\{\theta_1(\theta_1\pi_D^H+(1-\theta_1)\pi_D^L)+(1-\theta_1)(\theta_1\pi_{ND}^H+(1-\theta_1)\pi_{ND}^L)\}+q\{\theta_2(\theta_2\pi_D^H$
$+(1-\theta_2)\pi_D^L)+(1-\theta_2)(\theta_2\pi_{ND}^H+(1-\theta_2)\pi_{ND}^L)\}]$

Let us compare Π^A and $\tilde{\Pi}^{NA}$. We find that $\Pi^A-\tilde{\Pi}^{NA}=-q(1-\theta_2)(2\nu_L)+\delta[q(1-\theta_2)(\theta_2[\underline{\nu}_H+\Delta]+(1-\theta_2)(2\nu_L))]=q(1-\theta_2)[\delta\{\theta_2(\underline{\nu}_H+\Delta)+(1-\theta_2)(2\nu_L)\}-2\nu_L]>0$ by condition (8). Combining these two cases, we can conclude that allowing pre-announcements also increases the ex ante firm profit. (End of Proof)

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