New Product Preannouncement: Phantom Products, Unexpected Cannibalization and the Osborne Effect

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Abstract

By making new product preannouncements (NPP) firms encourage consumers to postpone purchase and wait for the firms' new product that in turn cannibalizes current sales, both own and competitor's. Profitability of NPP depends on which firm's sales are cannibalized and relative margins on current and future products. A stylized fact, particularly in the tech world, is the unexpected cannibalization of own sales following NPP that can lead to severe financial problems. This has resulted in folk wisdom that firms should never preannounce. Our paper bridges the gap between theory and practice by incorporating the 'phantom product effect' into NPP analysis and demonstrating a plausible reason for the high level of cannibalization of current sales (i.e., the Osborne Effect) that extant NPP models would find to be unforeseen. We show that: 1. mere exposure to NPP can dramatically affect the relative preferences of consumers, even if they choose not to postpone their purchase, and that, in turn, can explain the stylized observation of NPP leading to unexpectedly high level of cannibalization of current sales; 2. managers should depart from conventional NPP analysis when they tailor their competitive strategies in equilibrium keeping in mind the interaction of NPP and consumers' relative preferences for existing products.

(New Product Preannouncement; Phantom Products; Loss Aversion; Reference Dependent Preferences; Competition; Osborne Effect)

1 Introduction

Firms sometimes prefer to preannounce their new products well ahead of their actual release dates. For example, in the Spring of 2005 Sony preannounced its PlayStation 3, which was going to be released only in the Spring of 2006, and in January 2007 Apple preannounced its first iPhone, which was going to be released only in June of 2007. The extant literature on new product preannouncement (NPP) documents several reasons why firms preannounce their new products: creating demand for the preannounced product, helping firms to test new product designs and prices, forecasting future market potential, reducing customers' costs of switching to the new products, and deterring entry of competitors (Eliashberg and Robertson, 1988; Rabino and Moore, 1989; Lilly and Walters, 1997; Guiltinan, 1999; Kohli, 1999; Mishra and Bhabra, 2001; Su and Rao, 2010). Among these the most salient one is encouraging consumers to forego purchase of existing products in favor of waiting for the firm's new product. Purchase postponement would occur if the firm's preannouncement makes consumers to revise the time at which the new and better product would be available to be sooner. Thus, preannouncement can cannibalize sales of existing products as a result of consumers postponing their purchase. This leads to the managerially relevant question: under what conditions, and for what reasons, would new product preannouncement be a profitable strategy?

Clearly, for preannouncement to be profitable, at least one of two conditions must hold. The first condition is that cannibalization should occur more for a competitor's product than for the firm's own product. In this case the preannouncing firm can gain market share, albeit in the future. The second condition is that realized profit margins on the new product are sufficiently higher so that the preannouncing firm makes gains through higher margins. For a firm that has no product in the market preannouncement is obviously profitable since cannibalization is not an issue. But for firms with current product offerings in the market the question of profitability can only be answered through careful analysis. Consider a vertically differentiated duopoly with each firm having a single product in the market. Any preannouncement is likely to result in postponement of purchase by consumers that would have bought the higher quality product absent preannouncement. So the firm with the higher quality product should examine if the higher margins in the future, appropriately discounted, justifies preannouncement. In general, we can expect that if the firm with the higher quality product finds preannouncement to be profitable, then the firm with the lower quality also would find it profitable. It stands to gain market share in addition to higher margins since sales of the rival's product are cannibalized. And yet in the hi-tech world there is widespread belief that a firm should not make preannouncements because it runs the risk of encountering the Osborne effect (Patrizio, 2014; Spence, 2014; Gassee, 2011; Bons, 2011).

The Osborne effect essentially refers to a very high degree of cannibalization of own brand sales. Over the years a sort of folk wisdom that is very much against NPP has emerged based on the experience in several instances of very high, unexpected decline in the sales of the preannouncing firms' existing products resulting in firms going into serious financial troubles. Among the famous examples of Osborne effect considered by the hi-tech world are Sega Corporation's announcement of Dreamcast (next generation game console) in 1997, RIM's (Research In Motion) announcement of BlackBerry 10 in 2011, and Nokia' announcement of Windows Phones (known as Lumia 710) in 2011. The question we then ask is: Is the hi-tech industry paranoid about the Osborne effect?

It is useful to recall the origin of the Osborne effect. "In 1983, founder Adam Osborne preannounced several next-generation computer models (the "Executive" and "Vixen" models), which had not yet been built, highlighting the fact that they would outperform the existing model." ("Osborne effect," Wikipedia, The Free Encyclopedia). At that time Osborne's main competitor, Kaypro, had a superior entry, making it the firm with a higher quality offering. Ostensibly, Osborne wanted Kaypro customers to wait for the new products consisting of several models. Unfortunately for Osborne, its sales fell precipitously while Kaypro sales remained robust. And Osborne was unable to recover even after the new products appeared, and eventually went bankrupt. Obviously for a company to go bankrupt there would have to be management failure on many counts but the lingering effect of this dramatic event is for many in the tech-world to have concluded that preannouncement is a bad idea.[1]

In this paper we offer an explanation which can account for this large-scale cannibalization of current sales as a result of NPP, and thereby bridge the gap between theory and real life experiences. We accomplish this by analyzing a game theoretic model of a vertically differentiated duopoly in which one of the firms is contemplating preannouncing a new product. In our model utility maximizing consumers have rational expectations of the future and may decide to postpone current purchase. We innovate by contrasting a situation in which consumers' relative preferences for existing products are endogenous, meaning they are affected by the preannouncement of a new product or remain exogenous and so are unaffected by the preannouncement, which the existing literature has maintained as an assumption. We then show that other things being equal, with relative preferences being exogenous, if preannouncement is profitable for the firm with high quality product, then it is also profitable for the low quality firm. On the other hand, if relative preferences are endogenous, not only does preannouncement affect the profitability of preannouncement adversely, the firm with the lower quality offering suffers a much higher degree of cannibalization and could therefore well find preannouncement unprofitable even if its competitor finds it profitable. Thus, endogenous preferences cause the relative desirability of preannouncement across

[1] Preannouncement decisions are complicated in reality because of uncertainty, backward compatibility and interests of complementors. Our focus though is on the cannibalization issue.

firms to be reversed due to a high level of cannibalization of the lower quality firm's current sales. This results in firm behavior that contradicts conventional wisdom in the NPP literature. In this way, our analysis offers managers guidance on how they should think about their preannouncement decision based on theory. Moreover, it allows a more deliberate way to look upon the preannouncement decision that has now come to be dominated by folk wisdom, and is sometimes bemoaned by some in the tech world (Bisson, 2014).

To put our research in perspective it is useful to briefly discuss what we mean by relative preferences being endogenous to the preannouncement decision. Preannouncement of a new and better product decreases consumers' preference for current products in favor of the new one which will be available in the future. However, the extant literature on NPP ignores the effect of NPP on consumers' relative preference for the existing products. More specifically, the relative preference of consumers who do not wait for the new product by postponing their purchase can be dramatically altered by just being exposed to NPP. Indeed, past research provides evidence for NPP affecting consumers' relative preference for the existing products. A new product that is preannounced, but currently is not available is in fact a "phantom" product (Farquhar and Pratkanis, 1987; Pratkanis and Farquhar, 1992; Ge et al., 2009; Doyle et al., 1999).[2] Extensive experimental studies in various contexts show that a phantom product that is added to a choice set of two, in which neither product dominates the other, increases the preference for the available product that is located closer to it in the attribute space. This well-studied effect of phantom products implies that when a firm preannounces a new product that is higher in quality than the existing products and will be available in the future, preferences of consumers who do not want to postpone but buy one of the currently available products, will be affected. More specifically, these consumers' preferences for the currently lower quality product will suffer, while their preferences for the currently higher quality product will increase. From now on, we will refer to this effect of NPP as phantom product effect. Our analysis shows that, as expected, this shift in consumers' relative preferences for the existing products always increases profits of the firm which currently offers the higher quality product from NPP and hence, its incentive to preannounce. In general, the opposite is true for the firm with the lower quality product. However, surprisingly, under certain conditions this shift in consumers' preferences can cause the firm which currently offers the lower quality product also to benefit from NPP, which in turn increases its incentives to preannounce. Therefore, the interplay of the phantom product effect and NPP is not straightforward and is in need of careful analysis.

Our analysis also leads to several results that are different from those found in the literature. The

[2] For example, in Farquhar and Pratkanis (1987), during the experiments conducted to study the effect of phantom products on the preferences for available products, subjects were told that phantom was unavailable for reasons. One of the reasons used in the experiments was 'preannounced, but not yet on the market'.

extant literature in NPP posits that: 1. higher the likelihood of a competitor's new product entry, the less profitable is preannouncing a firm's new product, hence the firm would gain less by making consumers to postpone their purchase, which in turn makes it less inclined to preannounce its new product (Su and Rao, 2010), and 2. due to the cannibalization of current sales the dominant firm (i.e., currently with a higher market share) has less incentive to preannounce than the non-dominant firm (Su and Rao, 2010). Contrary to the foregoing, we find that as competitive activity increases a firm's profit gain from preannouncing may increase. Even more surprisingly, this outcome can happen for the competitively disadvantaged firm (i.e., the firm currently with a lower quality product). We also show that the higher quality (dominant) firm may have more incentive to preannounce than the lower quality (non-dominant) firm. Thus, we believe that our paper provides guidelines for a more informed managerial decision in the context of NPP.

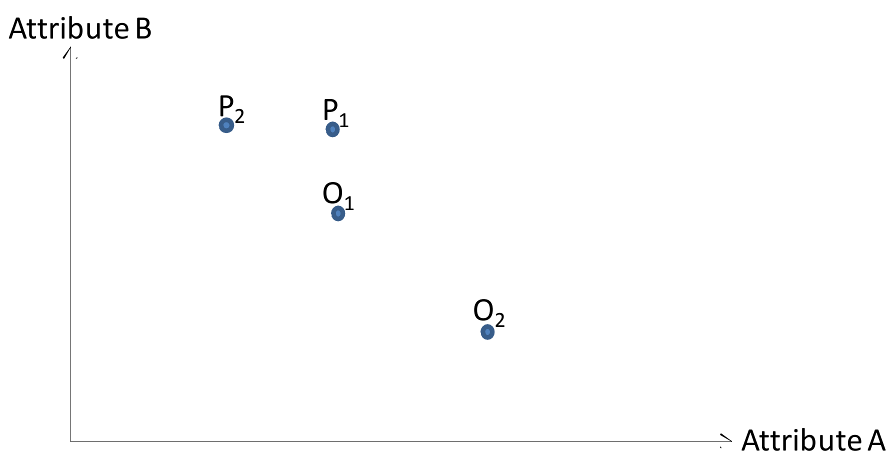
The remainder of the paper is organized as follows. In the next section we discuss the phantom product literature and the extant analytical work in NPP. In Section 3, we lay out our basic model and in Section 4 we analyze the benchmark case in which we ignore the phantom product effect of NPP. In Section 5, we integrate the phantom product effect of NPP and investigate how this effect impacts the profitability of NPP for firms and firms' preannouncement strategies. Finally, Section 6 summarizes the results and discusses managerial implications and directions for future work.

2 Literature Review

Our analysis of new product preannouncement decision under competition extends prior work. We start with a benchmark case based on existing models of preannouncement. We then augment this by incorporating the phantom product effect since preannouncements necessarily imply the existence of a phantom product. In this section we first briefly outline the literature on phantom products and then review the broader literature on NPP.

Consider a consumer with a choice set of two products. Now suppose a phantom product is added to this choice set. Experimental studies show that the phantom product increases the preference for the available product that is located closer to it in the attribute space. Such a positive effect can happen regardless of whether the phantom asymmetrically dominates this product (Farquhar and Pratkanis, 1987; Pratkanis and Farquhar, 1992; Highhouse, 1996; Hedgcock et al., 2009; Scarpi and Pizzi, 2012; Pettibone and Wedell, 2000, 2007) or the phantom does not dominate any of the available products in the choice set, but becomes a new extreme option (Ge et al., 2009; Hedgcock et al., 2009; Simonson and Tversky, 1992). Figure 1 pictorially illustrates existing options in the choice set (O_1 and O_2) and two types of phantom product (P_1 and P_2). P_1 is an example of a phantom that asymmetrically dominates one of the products in the choice set (i.e., O_1) and P_2 is an example of a phantom that does not dominate any of the available products in the choice set, but becomes a new extreme option. Why might we observe this phantom product effect resulting in a change in preferences over existing products? Although there are various models explaining this effect, the one that finds the strongest empirical support is loss aversion based on relative advantage model (Simonson and Tversky, 1992; Pratkanis and Farquhar, 1992; Highhouse, 1996; Hedgcock et al., 2009; Pettibone and Wedell, 2007). According to this model, consumers evaluate the options available in a choice set based on their losses and gains compared to a reference point that is a function of the choice set, and the original reference point that was used to evaluate the existing options in the set is updated after the introduction of a phantom product.[3] As a result of this shift in the reference point, both the losses and gains that consumers will incur if they choose the product that is closer to the phantom in the attribute space become less than the losses and gains that they will incur if they choose the other one. Due to loss aversion, losses loom larger than gains and as a result, consumers' preference for the product that is closer to the phantom increases. In the Appendix (please see pages 24-26), by using loss aversion based on relative advantage model we mathematically show how the addition of the phantom product P_1 or P_2 increases the preference for O_1.

Figure 1: Placement of Phantom Products



We now briefly describe extant analytical work in NPP since our work builds on it. Preannouncement, as a strategy, may well depend on the extent to which the future product represents a substantially improved one for consumers. This has been studied by Gerlach (2004) by analyzing the decision of an entrant with an opportunity to leapfrog the incumbent's current product. Gerlach (2004) assumes that the entrant can develop with some probability a superior product whose quality is fixed exogenously.

[3] Hedgcock et al. (2009) suggests the reference point as an average of the attribute values in the choice set.

Moreover, it is assumed that the incumbent cannot develop a new product. Consumers are heterogeneous in terms of their willingness to pay for quality. Also, they have a switching cost that they learn after buying the incumbent's product in the first period. If they buy the incumbent's product they may not find it profitable to switch to the entrant's later regardless of the size of the innovation and the price of the new product if their switching cost is high. Thus, the switching cost affects consumer decision to wait for a new product. After the entrant learns whether it will be able to develop the new product it must decide whether to preannounce it. The goal of the preannouncement is to encourage consumers to wait. However, it also affects competitive action. When the entrant announces, the incumbent also learns of the entrant's state and so can decrease its first period monopoly price to deter entry. Low monopoly price leaves only few consumers with the high switching cost to buy the entrant's product, which in turn makes the entry unprofitable. So, the preannouncement strategy must make a trade-off between positive demand pull effect of preannouncement and negative competitive reaction effect. The author shows that unless the quality of the entrant's product is much higher than the incumbent's the entrant does not prefer to preannounce. Farrell and Saloner (1986) analyze the interplay of network externality and preannouncement. In their model, a firm is planning to introduce a product that is incompatible with the incumbent's product. Consumers arrive sequentially and must decide which technology to adopt. Preannouncement induces the new consumers not to adopt the existing technology and instead wait for the new one because they think that future consumers would prefer the new product and hence the new technology would have a bigger customer base. Setting aside firms' pricing decisions, the authors show that preannouncement is always good for the entrant in the presence of network externality. It is important to note that both Gerlach (2004) and Farrell and Saloner (1986) assume that NPP is truthful.

What if a firm engages in untruthful NPP? This leads to the issue of vaporware. Choi et al. (2005) and Choi et al. (2010) investigate a context in which there is a single firm with an ability to develop a new product that can be either of high quality or not. The firm knows the product quality and can announce the quality to make consumers to postpone their purchase even by lying in its preannouncement. The authors show that under certain conditions there exists an equilibrium in which the high type firm would not lie about the quality of the new product. In Jung (2011), the entrant is planning to enter with a new product whose quality is unknown to consumers. The entrant decides whether to preannounce and if so what quality to preannounce to encourage consumers not to buy the incumbent's product now and wait for the entrant's new product. If consumers can be expected to find the actual quality to be much less than the preannounced quality the entrant does not want to engage in vaporware because that would hurt its sales. Finally, Ofek and Turut (2013) investigate an incumbent's incentive to engage in vaporware when facing an entrant contemplating entry. If the incumbent preannounces that it is pursuing an innovation, for which the demand is uncertain, this signals the entrant that the incumbent thinks highly of the demand, but can also be preemptive. Consumers also hear this announcement and a proportion of them prefers to postpone its purchase and wait for the incumbent's new product. The authors show that even without any cost to engage in vaporware the incumbent does not want to engage in vaporware so as not to signal the high market potential of the innovation to the entrant.

We use a base model of competing firms and NPP that contains the general characteristics of extant models of truthful NPP. In this way we ensure that our results can be understood clearly. Indeed, it can be seen in Section 4 that, absent phantom product effect, our model replicates the findings of the extant literature in NPP.

3 Model Setup

We model a vertically differentiated duopoly in which currently firm 1 sells a product with quality q (i.e., the basic product) and firm 2 sells a product with quality $q + \Delta$. Both firms have plans to upgrade their existing products with a new one that is higher in quality than the existing products. We assume that this new product with quality $q + \Sigma$ which will be launched in the future, replaces the firm's existing product if it succeeds in developing it. We normalize both firms' development costs to zero. Denote by x the probability that firm 1 will be able to develop this product and by y the corresponding probability for firm 2.

In addition to vertical differentiation, we assume that firms are also horizontally differentiated. Firms are located at the ends of a Hotelling line of unit length. There are two segments of consumers. Segment 1 consumer located at a l-distance away from a product with quality $q + Q$ receives utility of $q + \theta_1 Q - tl - price$, where θ_1 is the consumer's willingness to pay for extra quality and $Q \epsilon \{0, \Delta, \Sigma\}$. Segment 2 consumers are highly quality conscious and hence care only for quality. When segment 2 consumer buys a product with quality $q+Q$, he receives utility of $q+\theta_2 Q - price$, where θ_2 is the consumer's willingness to pay for extra quality and $\theta_2 > \theta_1$. α proportion of consumers is segment 1 and $1 - \alpha$ proportion of consumers is segment 2. Currently consumers do not have a working product and are in the market to buy at most one unit of product.

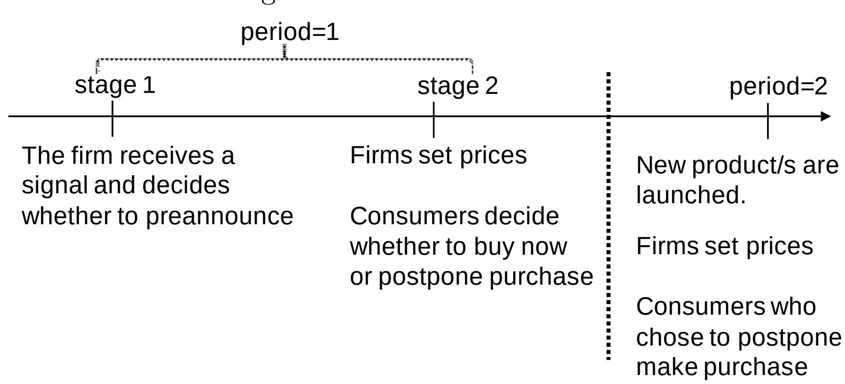
We model the preannouncement game as consisting of two periods, the current period and a future period. The game unfolds as follows. In the first period, there are two stages. At stage 1 a firm (i.e., either firm 1 or 2) receives a signal as to whether or not it will be able to develop the new product in the second period. If the signal is positive the firm will have the new product and if the signal is negative it will not have such a product.[4] Consumers are assumed to know that the firm receives a signal as to

[4] One may wonder why we do not let both firms to receive a signal as to whether or not they will be able to develop the

whether or not it will be able to develop the product, but they do not know the value of the signal. We assume that the value of the signal is known to the rival.[5] If the firm learns that it will be able to develop the new product it needs to decide whether to preannounce this or not. In our analysis we do not allow vaporware, so there is no lying. At stage 2 firms simultaneously set prices and consumers decide whether to buy one of the available products (i.e., q or $q + \Delta$) or wait till the second period for the product with $q + \Sigma$, where $\Sigma > 2\Delta$. If a consumer buys one of the currently available products he does not buy another product in the next period; he uses the product that he purchases now for two periods. Therefore, consumers need to make a trade-off between buying a product now and utilize it for two periods and waiting for a higher quality product till the second period. Consumers' discount factor is equal to δ, where $\delta < 1$. In the second period, new product/s are launched, firms set prices, and consumers (if postponed) make their purchasing decision (Figure 2 depicts the timeline of the game). When a firm launches its new product, it is assumed not to change its position on the Hotelling line. It is also possible that in the second period neither of the firms are able to develop the new product. In that case, firms set prices for their old products and consumers (if postponed) make their purchasing decision.

We want to explore the profitability of NPP for a firm depending on whether its current offering is of lower quality or higher quality compared to its competitor. Therefore we analyze two separate cases: the case in which firm 1 receives a signal and the case in which firm 2 receives a signal as to whether or not it will be able to develop the new product.

Figure 2: Timeline of The Game



We assume that q is high enough that by the end of the second period all the consumers buy one unit of product (i.e., the market is fully covered). Finally, we assume that discount factor for firms is equal

new product. We discuss the reasons behind our modeling choice in Section 6.

[5] We would like to note that if the value of the signal is not known to the rival, then when the firm is deciding whether to preannounce, it will be concerned about the information revealed by its preannouncement to the rival and the effect of this on rival's pricing as well. Since our focus is on the demand-side effect of NPP, by assuming that rival knows the value of the firm's signal we are able to disentangle the competitive effects of NPP from its demand-side effects.

to 1.

4 Benchmark Case - No Phantom Product Effect

We begin by analyzing the benchmark case that does not include the phantom product effect of NPP. Later we will compare the results of the case in which we integrate the phantom product effect with those of this benchmark case and draw conclusions on how the phantom product effect changes the profitability of NPP and firms' preannouncement strategy. All proofs can be found in the Appendix.

We first characterize, in Lemmas 1 and 2, consumers' decision to postpone their purchase or buy in period 1. Then, we elaborate on our equilibrium concept and define announcement equilibrium as the separating equilibrium in which a firm that receives a positive signal finds it optimal to preannounce. Following this, we derive, in Propositions 1 and 2, the conditions for an announcement equilibrium by firms 1 and 2 respectively. We end the section by establishing two results that are consistent with the findings of the extant literature. This lends credibility to our base model.

Lemma 1 *There exists Σ^* such that for $\Sigma < \Sigma^*$ segment 1 consumers will prefer to buy in the first period.*

The lemma follows from comparing the utility of buying now and utility of buying later. If a consumer chooses not to buy either firm's product in the first period but instead waits till the second period to buy the advanced product, then he receives zero utility in the first period and his utility in the second period is less than $q + \Sigma$. Therefore, his expected utility from waiting is less than $\delta(q + \Sigma)$. On the other hand, if he chooses to buy one of the existing product in the first period he receives utility of $(1 + \delta)(q + \theta_1 Q - tl) - price$, where $Q \epsilon \{0, \Delta\}$ and l is the consumer's distance from the product with quality Q. If Σ is not so high, regardless of whether segment 2 consumers postpone and wait for the new product or not, in equilibrium segment 1 consumers buy in the first period. Therefore, for $\Sigma < \Sigma^*$ only segment 2 consumers would consider postponing their purchase. Essentially, the condition on Σ rules out revolutionary products. It follows from Lemma 1 that the decision to buy in the first period or to wait till the second period is endogenous for *all* the consumers in our model.

In order to study the impact of the phantom product effect on the profitability of NPP and on the firms' preannouncement strategy, both firms should have positive sales in the first period. Thus, we conduct the rest of our analysis for parameter region in which $\Sigma < \Sigma^*$ and both firms have positive sales in the first period.

Lemma 2 *There exist conditions under which segment 2 consumers prefer to postpone their purchase iff there is a preannouncement.*

Lemma 2 specifies conditions under which consumers in segment 2 find it optimal to postpone their purchase upon hearing a preannouncement. Moreover, note that if a firm wants consumers to postpone their purchase it has to preannounce. Obviously, conditions of Lemma 2 also guarantee that firm 2 does not find it profitable to persuade the consumers, who are willing to postpone, to buy in the first period by decreasing the price of its product with quality $q + \Delta$ too much. Note that without these conditions preannouncement would not have force. So, for the rest of our analysis we assume the conditions of Lemma 2 hold.

We invoke the Perfect Bayesian Equilibrium concept to characterize the firms' decision. In our model this leads to two pure strategy equilibria outcomes depending on the parameters. In one case, if the firm receives a positive signal, it preannounces its new product with quality $q+\Sigma$. We call this 'announcement' equilibrium. In the announcement equilibrium, when the firm preannounces, consumers know that the firm will be able to develop the new product in the second period and when the firm is silent, consumers know that the firm will not be able to develop the new product. So this is a separating equilibrium. In the second case, the firm does not preannounce even if it receives a positive signal-i.e., the firm is always silent. We call this 'always silent' equilibrium. In the always silent equilibrium, firms' prices are the same both when the firm's signal is positive and when the firm's signal is negative. This means that the prices will not provide any information regarding the value of the firm's signal. Thus, in this equilibrium consumers' posterior is equal to their prior. This is a pooling equilibrium. What if the firm deviates and preannounces? Since vaporware is not allowed in our model, consumers' off-the-equilibrium-path-belief will be that the firm will develop the new product. There are other possible deviations to consider. The firm may not deviate by preannouncing, but it may deviate from its equilibrium price in the first period. Alternatively, given that the rival knows the value of the firm's signal, the rival may want to deviate from its equilibrium price in the first period. Either deviation has a signaling value for consumers. For ease of exposition, we provide in our proofs in the Appendix the off-the-equilibrium-path-beliefs in case of such deviations in firms' prices in the first period. In this paper our focus in on the announcement equilibrium, and so we need not consider the equilibrium in which the firm is always silent, but prices differ depending on the value of its signal because such an equilibrium is equivalent to 'announcement' equilibrium since it is also separating.

We will first investigate the case in which it is firm 1 that receives a signal regarding whether it will be able to develop the new product. The following proposition characterizes the conditions for a unique 'announcement' equilibrium under which firm 1 prefers to preannounce its new product if it gets a positive signal.

Proposition 1 *There exists Σ_1 such that if $\Sigma > \Sigma_1$ firm 1 prefers to preannounce that it will launch a* *new product with quality $q + \Sigma$ in the second period.*

We note that Σ is a function of the parameters Δ, t, α, δ, θ_1, θ_2, and y. Proposition 1 has a straightforward interpretation. If firm 1 receives a positive signal, it can benefit from preannouncing by making segment 2 to wait for its new product with quality $q + \Sigma$ rather than buy firm 2's product with quality $q + \Delta$ in the first period. But, the preannouncement can also lower firm 1's profit in the first period. This happens because when segment 2 consumers postpone their purchase, firm 2 will not be able to sell to them and so in the first period the price competition between the firms becomes more severe. Furthermore, if firm 2 also develops the advanced product in the second period firm 1 will not be able to receive any positive profits. Obviously, as the quality of the new product increases firm 1 will be able to charge a higher price and hence earn higher profits when it becomes the only provider of the advanced product in the second period. For that reason, only if the quality of the new product is sufficiently high (i.e., $\Sigma > \Sigma_1$) would firm 1 take the risk of intensifying the competition in the first period by preannouncing to encourage consumers to wait for its new product.

Next, we consider the case in which firm 2 receives a signal regarding whether it will be able to develop the new product in the second period. The following proposition characterizes the condition for the unique 'announcement' equilibrium under which firm 2 prefers to preannounce its new product if it learns that it will be able to develop it.

Proposition 2 *There exists Σ_2 such that if $\Sigma > \Sigma_2$ firm 2 prefers to preannounce that it will launch a new product with quality $q + \Sigma$ in the second period.*

As in Proposition 1, we should keep in mind that Σ_2 is a function of the parameters Δ, t, α, δ, θ_1, θ_2, and x. When firm 2 learns that it will be able to develop the new product in the second period, it can profit from preannouncement by making segment 2 consumers wait for its new product with quality $q + \Sigma$ rather than buy its currently available product with quality $q + \Delta$ in the first period because of higher profit margins on product with quality $q + \Sigma$. However, the higher profit margins may not be realized if firm 1 also successfully develops the new product with quality $q + \Sigma$ and competes with firm 2 in the second period. Therefore, firm 2 will preannounce its new product even if that means losing some of these consumers to firm 1 only if the quality of the new product is sufficiently high (i.e., $\Sigma > \Sigma_2$).

Corollary 1 *For $x = y$, firm 1 has a higher incentive to preannounce than firm 2.*

Corollary 1 is easily understood. The condition $x = y$ simply holds all things equal except quality. Note that even when segment 2 consumers do not postpone, firm 1 does not serve them in the first period because they only care for quality. Firm 2, on the other hand, can sell its currently available product with quality $q + \Delta$ to segment 2 consumers in the first period. Thus, firm 2 cannibalizes its sales in the first period by encouraging these consumers to postpone their purchase and so it has more to lose than firm 1. For that reason, firm 2 has less incentive to preannounce than firm 1. It is useful to note that this outcome is consistent with findings in the extant literature that claims that the dominant firm (i.e., the firm currently with a higher market share) has less incentive to issue new product preannouncement than the non-dominant firm because the dominant firm experiences higher cannibalization of current sales as a result of new product preannouncement than the non-dominant firm. In our model, since firm 2 enjoys a higher market share than firm 1 in the first period it can be considered the dominant firm.

Corollary 2 *Both firms' profit gain from preannouncing decreases as the probability of the rival successfully developing the new product increases (i.e., as y and x increase respectively).*

Obviously, both firms' expected profits from the new product in the second period decrease as the probability of the rival successfully developing the new product increases, which in turn decreases their gain from preannouncing. This result is also in line with findings in the extant literature that as the competitive activity increases (or the attractiveness of the competitive environment decreases) firms benefit less from preannouncing. In our model, the probability of the rival successfully developing the new product represents competitive activity. The higher this probability the preannouncing firm's expectation of competitiveness of the market for the new product in the second period is also higher.

Our benchmark model is consistent with both theoretical and empirical extant work on preannouncements as can be seen in its set up and its implications. We are now in a position to see what happens if phantom product effect is integrated into this model.

5 The Case With The Phantom Product Effect

In this section we explore how the phantom product effect influences a firm's NPP decision. To this end we augment our base model by incorporating the loss aversion based on relative advantage model, as explained in Section 2, into consumers' utility function that in turn determines their relative preference for existing products. To do this we modify consumer utility function such that a consumer's utility is assumed to be the sum of two components: first, absolute utilities for each attribute and second, relative utilities consisting of gains and losses on each attribute compared to a reference point.[6] The point that bears emphasis is that the reference point is not independent of the choice set. In our model the choice

[6] This type of utility modeling is also known as linear Loss Aversion Model and has been used extensively in recent work on the effects of choice set on consumers' preferences (Ho et al., 2006; Koszegi and Rabin, 2006; Orhun, 2009; Chen and Turut, 2013; Narasimhan and Turut, 2013).

set is endogenous in the sense that it depends on firms' NPP strategies. In other words, consumer utility function is also endogenous in our model.

In the modified utility function when a consumer buys product j with quality Q_j, the comparative utility from quality is given by $\lambda_q(Q_j - R_q)$ if $Q_j > R_q$ and $\gamma_q(Q_j - R_q)$ if $Q_j < R_q$, where R_q is the reference quality, and λ_q and γ_q denote respectively consumers' gain and loss sensitivities to quality. Under loss aversion losses loom larger than gains, and so $\gamma_q > \lambda_q$. Similarly, when a consumer buys product j with price $price_j$, the comparative utility from price is given by $\lambda_p(R_p - price_j)$ if $R_p > price_j$ and $\gamma_p(R_p - price_j)$ if $price_j > R_p$, where R_p is the reference price, and λ_p and γ_p denote respectively consumers' gain and loss sensitivities to price ($\lambda_p < \gamma_p$). We can arrive at a more simplified utility function by appealing to the empirical evidence on loss aversion. Much of this evidence points to consumers exhibiting higher loss aversion on quality dimension than on price dimension. For example, using scanner panel data for refrigerated orange juice, Hardie et al. (1993) shows that consumers tend to be considerably more loss averse for quality than for price. In their experimental studies conducted in different product categories, such as magnifying power binoculars and dental insurance, Simonson and Tversky (1992) show that consumers exhibit loss aversion for quality, but little or no loss aversion for price. Similarly, in experiments with product categories such as apartment rental, automobiles, health insurance policy, and residential trash disposal services, Luce et al. (1999) found that losses on the quality dimension increase consumers' tendency to choose a high quality alternative, but losses on price do not affect choice. Finally, Hedgcock et al. (2009) also experimentally validates that consumers' loss aversion is stronger for quality than for price. Based on these empirical findings, we assume that $\gamma_p = \lambda_p = \lambda_q = 0$ and $\gamma_q = \gamma$.

With our simplified model, it remains for us to define the reference quality based on the choice set. We follow the suggestion of Hedgcock et al. (2009) and model the reference quality as the average of the qualities of options in the choice set. The average is indeed the most common way of modeling the reference point, as in the recent work on the effects of choice set on consumers' preferences (Kivetz et al., 2004; Orhun, 2009; Chen and Turut, 2013; Narasimhan and Turut, 2013). With this definition, changes in the choice set (even changes which do not affect the range of attributes) affect the reference point and so, the model is versatile in capturing the effect of choice set on consumer preferences.

Turning to our model, we will first consider consumer's utilities if he chooses to buy one of the existing products in period 1 and then we will consider consumer's expected utilities if he chooses to postpone his purchase and wait till period 2.

Denote $U_{i,Q}$ to be the utility of a consumer in segment i, $i = 1, 2$, from buying product with quality Q, given that the consumer i is located at a distance l from product with quality Q. For ease of exposition let $price_Q$ denote the price of product with quality Q; $price_Q$ corresponding to each situation is the equilibrium price in the corresponding game that must be determined. Denote z to be the probability of the firm's rival developing the new product and $z \in \{x, y\}$. Therefore, if firm 1 receives a signal, then the rival is firm 2 and $z = y$, and if firm 2 receives a signal, then the rival is firm 1 and $z = x$.

<u>Consumer chooses to buy in period 1</u>

Announcement equilibrium:

If the firm preannounces, then consumers' choice set consists of three quality levels $Q \epsilon \{\Sigma, \Delta, 0\}$. We can therefore see that the reference quality R is given by $R = \frac{\Sigma+\Delta}{3}$. Note that consumers face a loss on the quality dimension regardless of which product they buy in the first period. If a consumer chooses to buy in period 1 his utility is as follows:

$$\begin{aligned}
U_{1,0}(period\ 1) &= (1+\delta)(q - tl - \gamma\theta_1 \tfrac{\Sigma+\Delta}{3}) - price_0 \\
U_{1,\Delta}(period\ 1) &= (1+\delta)(q + \theta_1\Delta - tl - \gamma\theta_1 \tfrac{\Sigma-2\Delta}{3}) - price_\Delta \\
U_{2,0}(period\ 1) &= (1+\delta)(q - \gamma\theta_2 \tfrac{\Sigma+\Delta}{3}) - price_0 \\
U_{2,\Delta}(period\ 1) &= (1+\delta)(q + \theta_2\Delta - \gamma\theta_2 \tfrac{\Sigma-2\Delta}{3}) - price_\Delta
\end{aligned}$$

If the firm is silent, then consumers' choice set consists of either two quality levels $Q \epsilon \{\Delta, 0\}$ or three quality levels $Q \epsilon \{\Sigma, \Delta, 0\}$. These two events occur with probability $1 - z$ and z respectively. Thus, $R = \frac{\Delta}{2}$ with probability $1 - z$ and $R = \frac{\Sigma+\Delta}{3}$ with probability z. Consumers face a loss on the quality dimension if they were to buy product with $Q = 0$. On the other hand, if they were to buy product with $Q = \Delta$ they face the loss only if there is a successful entry of quality Σ in the second period. That occurs with probability z (i.e., when the firm's rival develops the new product). Therefore, if a consumer chooses to buy in period 1 his utility is as follows:

$$\begin{aligned}
U_{1,0}(period\ 1) &= (1+\delta)(q - tl - \gamma\theta_1((1-z)\tfrac{\Delta}{2} + z\tfrac{\Sigma+\Delta}{3}) - price_0 \\
U_{1,\Delta}(period\ 1) &= (1+\delta)(q + \theta_1\Delta - tl - \gamma\theta_1 z\tfrac{\Sigma-2\Delta}{3}) - price_\Delta \\
U_{2,0}(period\ 1) &= (1+\delta)(q - \gamma\theta_2((1-z)\tfrac{\Delta}{2} + z\tfrac{\Sigma+\Delta}{3}) - price_0 \\
U_{2,\Delta}(period\ 1) &= (1+\delta)(q + \theta_2\Delta - \gamma\theta_2 z\tfrac{\Sigma-2\Delta}{3}) - price_\Delta
\end{aligned}$$

Always silent equilibrium:

Consumers' choice set consists of either two quality levels $Q \epsilon \{\Delta, 0\}$ or three quality levels $Q \epsilon \{\Sigma, \Delta, 0\}$. These two events occur with probability $1 - x - y + xy$ and $x + y - xy$ respectively. Thus, $R = \frac{\Delta}{2}$ with probability $1 - x - y + xy$ and $R = \frac{\Sigma+\Delta}{3}$ with probability $x + y - xy$. Note that consumers face a loss on the quality dimension if they were to buy the product with $Q = 0$. On the other hand, if they were to buy the product with $Q = \Delta$ they face the loss only if there is a successful entry of quality Σ in the second period. That occurs with probability $x + y - xy$. If a consumer chooses to buy in period 1 his utility is as follows:

$$U_{1,0}(period\ 1) = (1+\delta)(q - tl - \gamma\theta_1((1-x-y+xy)\tfrac{\Delta}{2} + (x+y-xy)\tfrac{\Sigma+\Delta}{3}) - price_0$$
$$U_{1,\Delta}(period\ 1) = (1+\delta)(q + \theta_1\Delta - tl - \gamma\theta_1(x+y-xy)\tfrac{\Sigma-2\Delta}{3}) - price_\Delta$$
$$U_{2,0}(period\ 1) = (1+\delta)(q - \gamma\theta_2((1-x-y+xy)\tfrac{\Delta}{2} + (x+y-xy)\tfrac{\Sigma+\Delta}{3}) - price_0$$
$$U_{2,\Delta}(period\ 1) = (1+\delta)(q + \theta_2\Delta - \gamma\theta_2(x+y-xy)\tfrac{\Sigma-2\Delta}{3}) - price_\Delta$$

Consumer chooses to wait till period 2

If in any equilibrium a consumer chooses to postpone his purchase, then his choice set in period 2 will consist of $Q\epsilon\{\Delta, 0\}$ if neither firm is successful, $Q\epsilon\{\Sigma, \Delta\}$ if only firm 1 is successful, $Q\epsilon\{\Sigma, 0\}$ if only firm 2 is successful, and $Q\epsilon\{\Sigma, \Sigma\}$ if both firms are successful. Therefore, $R = \frac{\Delta}{2}$ if neither firm is successful, $R = \frac{\Sigma+\Delta}{2}$ if only firm 1 is successful, $R = \frac{\Sigma}{2}$ if only firm 2 is successful, and $R = \Sigma$ if both firms are successful. Note that the probability of each state happening in period 2 depends on whether it is 'announcement' equilibrium or 'always silent' equilibrium, and if it is 'announcement' equilibrium, it also depends on the announcing firm's action (i.e., whether the firm preannounces or stays silent). For example, if it is 'announcement' equilibrium in which firm 1 receives signal and firm 1 preannounces, then in period 2 with probability y both firms are successful in developing the new product and with probability $(1-y)$ only firm 1 is successful. However, it is 'announcement' equilibrium in which firm 2 receives signal and firm 2 is silent, then in period 2 with probability x only firm 1 is successful and with probability $(1-x)$ neither firm is successful. If it is 'always silent' equilibrium, then with probability $(1-x)(1-y)$ neither firm is successful, with probability $x(1-y)$ only firm 1 is successful, with probability $y(1-x)$ only firm 2 is successful, and with probability xy both firms are successful.

Therefore, if in an equilibrium consumer i chooses to postpone his purchase, his utility U_{iQ} from waiting till period 2 and buying product with quality Q conditional on firms' success in new product development is as follows:

$$U_{1,0}(period\ 2\ |\text{neither firm succeeds}) = \delta\left(q - tl - \gamma\theta_1\tfrac{\Delta}{2} - price_0\right)$$
$$U_{1,\Delta}(period\ 2\ |\text{neither firm succeeds}) = \delta\left(q + \theta_1\Delta - tl - price_\Delta\right)$$
$$U_{2,0}(period\ 2\ |\text{neither firm succeeds}) = \delta\left(q - \gamma\theta_2\tfrac{\Delta}{2} - price_0\right)$$
$$U_{2,\Delta}(period\ 2\ |\text{neither firm succeeds}) = \delta\left(q + \theta_2\Delta - price_\Delta\right)$$

$$U_{1,\Sigma}(period\ 2\ |\text{only firm 1 succeeds}) = \delta\left(q + \theta_1\Sigma - tl - price_\Sigma\right)$$
$$U_{1,\Delta}(period\ 2\ |\text{only firm 1 succeeds}) = \delta\left(q + \theta_1\Delta - tl - \gamma\theta_1\tfrac{\Sigma-\Delta}{2} - price_\Delta\right)$$
$$U_{2,\Sigma}(period\ 2\ |\text{only firm 1 succeeds}) = \delta\left(q + \theta_2\Sigma - price_\Sigma\right)$$
$$U_{2,\Delta}(period\ 2\ |\text{only firm 1 succeeds}) = \delta\left(q + \theta_2\Delta - \gamma\theta_2\tfrac{\Sigma-\Delta}{2} - price_\Delta\right)$$

$$U_{1,0}(period\ 2\ |\text{only firm 2 succeeds}) = \delta\left(q - tl - \gamma\theta_1\frac{\Sigma}{2} - price_0\right)$$
$$U_{1,\Sigma}(period\ 2\ |\text{only firm 2 succeeds}) = \delta\left(q + \theta_1\Sigma - tl - price_\Sigma\right)$$
$$U_{2,0}(period\ 2\ |\text{only firm 2 succeeds}) = \delta\left(q - \gamma\theta_2\frac{\Sigma}{2} - price_0\right)$$
$$U_{2,\Sigma}(period\ 2\ |\text{only firm 2 succeeds}) = \delta\left(q + \theta_2\Sigma - price_\Sigma\right)$$

$$U_{1,\Sigma}(period\ 2\ |\text{both firms succeeds}) = \delta\left(q + \theta_1\Sigma - tl - price_\Sigma\right)$$
$$U_{2,\Sigma}(period\ 2\ |\text{both firms succeeds}) = \delta\left(q + \theta_2\Sigma - price_\Sigma\right)$$

From the utility functions above we can see what the consumers' trade-off is both in 'announcement' equilibrium and in 'always silent' equilibrium.

Recall that our analysis of the benchmark case assumed that the conditions of Lemmas 1 and 2 hold. To meaningfully assess how the phantom product effect changes firms' incentive to preannounce the rest of our analysis with $\gamma > 0$ also assumes that conditions from Lemmas 1 and 2 hold.

Suppose a firm decides to preannounce its new product, and some consumers choose to postpone their purchase. How does this affect period 1 market shares and prices in the presence of phantom product effect? Once we establish this, we can work backward and analyze the conditions under which a firm's best strategy is to engage in NPP. Faced with NPP, the phantom product effect should make consumers, who choose not to postpone their purchases, to prefer less the currently lower quality product q and more the higher quality product $q + \Delta$ at prevailing equilibrium prices. We first verify that phantom product effect indeed has this disproportionate adverse effect on preferences for the lower quality product under equilibrium prices. Recall from the benchmark case that when a firm preannounces its new product, only segment 2 consumers prefer to postpone and not buy the product with quality $q + \Delta$. As a result of more intense competition for the remaining consumers, the market share and the price of the product with quality q decrease as does its period 1 profits. We should expect this decrease in profits to be higher in the presence of the phantom product effect than in the benchmark case. The following lemma verifies that.

Lemma 3 *The decrease in firm 1's price and market share in the first period due to preannouncement is higher in the presence of the phantom product effect.*

When a firm preannounces its new product, consumers become certain of the existence of the new product in the future and as a result the reference quality in the first period shifts upward to $\frac{\Sigma+\Delta}{3}$. As a result, the loss consumers incur in the first period from buying either the product with quality q or the product with quality $q + \Delta$ increases, decreasing the consumers' utility from either product. However, the loss is higher when consumers buy quality q than when they buy the product with quality $q + \Delta$ (i.e., $\gamma\theta_i\frac{\Sigma+\Delta}{3}$ vs $\gamma\theta_i\frac{\Sigma-2\Delta}{3}$). For that reason, in the first period consumers' willingness to pay for firm 1's product (the product with quality q) is far less. Thus, we see from Lemma 3 that our model captures an essential feature of phantom products described and mathematically illustrated in the Section 2.

Proposition 3 *There exist γ^* and α^* such that if $\gamma > \gamma^*$ and $\alpha < \alpha^*$ firm 1 has a higher incentive to preannounce in the phantom product case than in the benchmark case. Otherwise, firm 1 has a lower incentive to preannounce. For firm 2 the incentive to preannounce is higher in the phantom product case than in the benchmark case.*

First note that under some conditions, the incentive for firm 1 to preannounce is lower in the phantom product case than in the benchmark case. This is because, as established in Lemma 3, preannouncement in the case of phantom product effect results in lower price and market share of firm 1 in period 1. This is a direct consequence of the decrease in consumers' preference for firm 1's product (of quality q) relative to firm 2's product (of quality $q+\Delta$). Therefore, what is surprising is the first part of Proposition 3 that says firm 1's incentive to preannounce can actually be higher in the phantom product case than in the benchmark case. How can this happen? To understand it we must recognize that the adverse effect on profits in period 1 due to loss aversion in the presence of a phantom product could be overcome in period 2 if loss aversion sensitivity is high enough. As we know from the benchmark case, the reason that firm 1 wants to preannounce is to encourage segment 2 consumers not to buy firm 2's product in the first period, but instead wait till the second period and buy firm 1's advanced product with quality $q+\Sigma$. On the one hand, as we know from Lemma 3, when firm 1 preannounces its new product, due to the increase in the reference quality firm 1's profits in the first period decreases. On the other hand, if only firm 1 develops the advanced product in the second period, due to loss aversion, segment 2 consumers face a loss on quality dimension if they choose firm 2's product and this loss increases as loss sensitivity (γ) increases. As a result, if γ is high enough (i.e., $\gamma > \gamma^*$) firm 1 is able to charge a higher price for its new product in the second period. Additionally, if the size of segment 2 is not too small (i.e., $\alpha < \alpha^*$) then firm 1's gain in the second period offsets its loss in the first period, hence it receives a higher profit than in the benchmark case. Therefore, if consumers' loss aversion is high and the proportion of consumers who are willing to postpone is high enough the latter positive effect of preannouncement dominates the former negative effect and firm 1 would be more willing to preannounce in the presence of the phantom product effect than in the benchmark case. Thus, we see that the relationship between the phantom product effect and the profitability of NPP for firms is not obvious.

When firm 2 preannounces its new product, firm 2's profits increase both in the first and second period. Due the phantom product effect, preannouncement increases firm 2's profits in the first period. Furthermore, in the second period if only firm 2 develops the product, consumers who postpone their purchase face a higher loss on quality dimension if they choose firm 1's product, leading to higher prices and profits for firm 2 in period 2. Thus, under phantom product effect preannouncement is more attractive for firm 2.

Corollary 3 *Firm 2 prefers to preannounce even if* $\alpha = 1$.

In the benchmark case the only reason for a firm to preannounce its new product is to encourage segment 2 consumers to postpone their purchase and wait for the new product. However, due to the phantom product effect, preannouncement decreases segment 1 consumers' willingness to pay for firm 1's product, which in turn leads firm 2 to earn higher profits in the first period. For that reason, even if there were no consumers who are willing to postpone purchase, firm 2 may want to preannounce its new product. This result can be seen as a "pure" consequence of the phantom product effect and obtains only for firm 2 who has the higher quality product.

Proposition 4 *There exist* $\hat{\gamma}$ *and* $\hat{x}$ *such that for* $\gamma > \hat{\gamma}$ *and* $y = x < \hat{x}$ *firm 2 has more incentive to preannounce than firm 1.*

Recall from Section 4 (see Corollary 1), in the benchmark case, as conventional wisdom suggests, the non-dominant firm (firm 1) has greater incentive to preannounce the new product. However, according to Proposition 4, in the presence of the phantom product effect the dominant firm (i.e., firm 2) can have a higher incentive to preannounce if consumers' loss aversion is high enough and the probability of the rival successfully developing the new product in the second period is not too high. Unlike firm 1, firm 2 is able to serve segment 2 consumers even if it does not preannounce and as consumers' loss aversion sensitivity increases it charges higher price in the first period regardless of it preannounces or not. However, if only firm 2 develops the new product in the second period, due to loss aversion, it can charge $\Sigma\frac{\gamma}{2}$ more and hence earn $(1-x)(1-\alpha)\Sigma\frac{\gamma}{2}$ more profits. On the other hand, for $y = x$, if only firm 1 develops the new product in the second period, due to loss aversion, it can charge $(\Sigma - \Delta)\frac{\gamma}{2}$ more and hence earn $(1-x)(1-\alpha)(\Sigma - \Delta)\frac{\gamma}{2}$ more profits. The second and third effects of loss aversion on firms' profits increases firm 2's relative incentive to preannounce. Thus, if loss aversion sensitivity is high and the probability of the rival successfully developing the new product in the second period is not too high, then firm 2's profit gain relative to firm 1 due to loss aversion in the second period dominates its profit gain due to loss aversion in the first period and as a result firm 2 will have a higher incentive to preannounce than firm 1 has.

Given our results in this section, we believe that one explanation for the discrepancy between the Osborne effect and preannouncement theory may lie in the phantom product effect. What conventional preannouncement theory does not fully account for is the adverse effect of NPP in period 1 becoming more severe for firm 1 with the low quality product due to phantom product effect. In the examples cited in the Introduction and that hi-tech experts dub as Osborne effect, a common feature is that around the time of preannouncement the preannouncing company's existing product was facing rival products of higher quality. Given our results, it could be that preannouncement caused a drop in sales of existing products that was much higher than expected because of not taking into account the phantom product effect. The "unexpected" drop in sales can be explained by our analysis.

Proposition 5 *There exist $\bar{\Sigma}$ such that if $\Sigma < \bar{\Sigma}$ firm 1's profit gain from preannouncing is higher as the probability of firm 2 successfully developing the new product (i.e., y) increases.*

We know from Corollary 2 that in the benchmark case, as conventional wisdom suggests, a firm's profit gain from preannouncing decreases as the competitive activity in the market increases. However, according to Proposition 5, the phantom product effect can moderate the relationship between firm 1's profit gain from preannouncing and the degree of competitive activity in the market such that firm 1 can benefit more from preannouncing as the competitive activity increases. This result is surprising because it is the competitively disadvantaged firm whose gain from preannouncing increases as the competitive activity increases. How can this happen? When firm 1 preannounces its new product, the reference quality in the first period shifts upward, which in turn decreases firm 1's first period profits. As the probability of firm 2 successfully developing the new product in the second period (i.e., y) increases two things happen. On the one hand, as y increases consumers' expectation of product quality in the second period increases even in the absence of any new product preannouncement. Thus, as y increases the impact of preannouncement on the reference quality in the first period decreases. This naturally reduces the negative phantom product effect of preannouncement on firm 1's profits in the first period. On the other hand, as y increases the probability of firm 2 successfully developing the new product increases, which in turn decreases firm 1's expected profits in the second period. While the former effect of increase in y raises firm 1's gain from preannouncing, the latter lowers it. We know from Proposition 4 that firm 1's profit gain from loss aversion in the second period is equal to $(1-y)(1-\alpha)(\Sigma-\Delta)\frac{\gamma}{2}$. Thus, if Σ is not too high the latter negative effect of change in y on firm 1's second period profits will be offset by the former positive effect of change in y on firm 1's first period profits. As a result, as y increases firm 1 will benefit even more from preannouncing.

6 Conclusion

Firms preannounce new products to encourage consumers to postpone their purchase and wait for the new products. When a firm preannounces its new product, some consumers who prefer to wait for the new product do not buy its existing products. Therefore, preannouncement causes "planned" cannibalization of the sales of the firm's existing products. As long as the future gain from the sales of the new product is higher than the loss of the sales of the existing products, NPP is profitable for the firm. However, over the years in various examples NPP caused unexpectedly high level of cannibalization of the preannouncing firm' current sales and as a result especially in the hi-tech market a folk wisdom that is against NPP has emerged. According to some industry experts, a company should never preannounce, otherwise this will be the end of the company. In this paper we offer an explanation for this hitherto unforeseen magnitude of cannibalization and bridge the gap between theory and practice.

We argue that 'phantom product effect' can explain why in some cases NPP can cause a much higher degree of cannibalization of the preannouncing firm's current sales than existing literature has assumed. Specifically our contention is that the addition of a phantom product to consumers' choice set shifts the preference of even those consumers who do not want to postpone their purchase by increasing their preference for the currently higher quality product and decreasing their preference for the currently lower quality product. Therefore, if the preannouncing firm's existing product is the lower quality one NPP will not only cannibalize the sales from consumers who prefer to postpone their purchase and wait for the new product, but will also cannibalize the sales from the consumers who prefer not to wait for the new product. These consumers would then want to buy the currently higher quality rival product. This accounts for the "unexpectedly" high cannibalization that practitioners have no explanation for.

We find that phantom product effect increases the preannouncement incentive of the firm which currently offers the higher quality product. However, the phantom product effect under certain conditions decreases the preannouncement incentive of the firm which currently offers the lower quality product due to large-scale of cannibalization of the firm's current sale. Given the phantom product effect, we also find that unless competitive activity in the market is too high, as competitive activity increases so does a firm's profit gain from preannouncing. Moreover, the dominant firm may have a greater incentive to preannounce than the non-dominant firm.

We would like to note that in our model only one firm receives a signal about the new product. An alternative may be to suppose that both firms receive signals. Then their NPP actions may provide consumers some information about the value of each other's signal. There is no well-accepted way to analyze a model with this feature of two firms signaling to consumers. We have therefore restricted our model to one that is amenable to analysis.

Finally, we note that our paper adds to the growing marketing literature that uses the behavioral economics paradigm to obtain normative results (Amaldoss and Jain, 2005a,b; Cui et al., 2007; Lim and Ho, 2007; Amaldoss and Jain, 2008a,b; Ho and Zhang, 2008; Syam et al., 2008; Jain, 2009; Orhun, 2009; Chen et al., 2010; Chen and Cui, 2013; Chen and Turut, 2013; Narasimhan and Turut, 2013) that provide guidance to managers, and positive results that provide empirically testable hypotheses for future research. On the normative side, our results help to resolve the mystery of the Osborne effect. On the positive side, for example, it is reasonable to suppose that in product categories characterized by rapid technological improvement the phantom product effect should be significant. So based on our analysis the dominant firm should preannounce with relatively greater frequency than in other product categories that are not so dynamic in quality improvement. Another testable implication is that if rival R&D is intense then a lower quality firm should exhibit relatively greater frequency of preannouncement.

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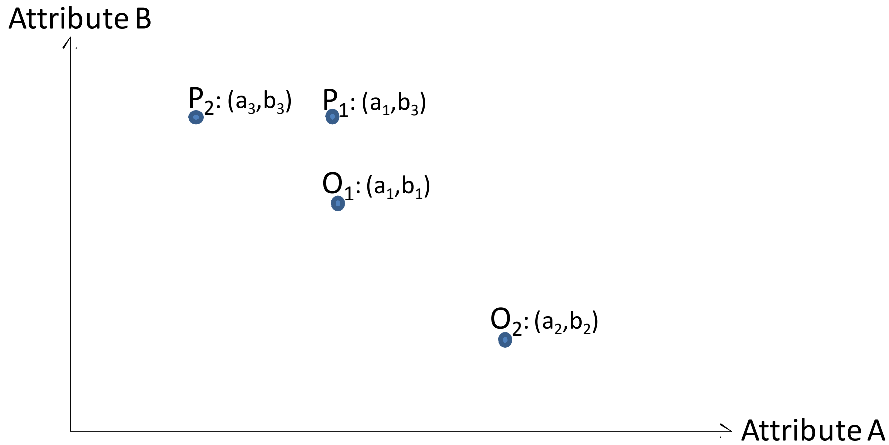
Appendix:

Illustration of How a Phantom Product Affects Consumers' Relative Preferences of Existing Products:

Let (a, b) in Figure 3 denote a product's attribute values on Attribute A and Attribute B dimensions respectively. The choice set before the addition of phantom product consists of O_1 and O_2. Either P_1 phantom product or P_2 phantom product is added to the choice set.

Figure 3: Consumers' Choice Set



For our illustration, based on (Hedgcock et al., 2009)'s suggestion, we will use reference point as an average of the attribute values in the choice set. Therefore, before the addition of a phantom product the reference point on Attribute A dimension is $R_a = \frac{a_1+a_2}{2}$ and the reference point on Attribute B dimension is $R_b = \frac{b_1+b_2}{2}$. After the addition of P_1, the reference point on Attribute A dimension becomes $R_a = \frac{2a_1+a_2}{3}$ and the reference point on Attribute B dimension becomes $R_b = \frac{b_1+b_2+b_3}{3}$. After the addition of P_2, the reference point on Attribute A dimension becomes $R_a = \frac{a_1+a_2+a_3}{3}$ and the reference point on Attribute B dimension becomes $R_b = \frac{b_1+b_2+b_3}{3}$.

Before the addition of a phantom product: if a consumer chooses O_1 his loss is only on Attribute A dimension and equal to $\frac{a_2-a_1}{2}$, while his gain is on Attribute B dimension and equal to $\frac{b_1-b_2}{2}$. On the other hand, if a consumer chooses O_2 his loss is only on Attribute B dimension and equal to $\frac{b_1-b_2}{2}$, while his gain is on Attribute A dimension and equal to $\frac{a_2-a_1}{2}$.

After the addition of P_1: if a consumer chooses O_1 his loss is on Attribute A is equal to $\frac{a_2-a_1}{3}$. If $b_2+b_3 > 2b_1$ then he also losses on Attribute B dimension and his loss is equal to $\frac{b_2+b_3-2b_1}{3}$. Otherwise, his gain on Attribute B dimension is equal to $\frac{2b_1-b_2-b_3}{3}$. If a consumer chooses O_2 his loss is only on Attribute B dimension and equal to $\frac{b_1+b_3-2b_2}{3}$, while his gain is on Attribute A dimension and equal to $\frac{2(a_2-a_1)}{3}$.

The worst case for O_1 happens if $b_2+b_3 > 2b_1$. In this case, for O_1 the change in losses due to the addition of P_1 is equal to $\frac{b_2+b_3-2b_1}{3} - \frac{a_2-a_1}{6}$ and change in gains due to the addition of P_1 is equal to $-(\frac{b_1-b_2}{2})$. On the other hand, for O_2 the change in losses due to the addition of P_1 is equal to $\frac{b_1+b_3-2b_2}{3} - \frac{b_1-b_2}{2} > 0$ and change in gains due to the addition of P_1 is equal to $\frac{a_2-a_1}{6}$. The difference between the change in O_2's losses and the change in O_1's losses is equal to $\frac{3(b_1-b_2)+a_2-a_1}{6} > 0$ and difference between the change in O_2's gains and the change in O_1's gains is equal to $\frac{3(b_1-b_2)+a_2-a_1}{6}$. Since due to loss aversion losses loom larger than gains consumers will prefer more O_1 after the addition of P_1.

After the addition of P_2: if a consumer chooses O_1 his loss on Attribute A is equal to $\frac{a_2+a_3-2a_1}{3}$ if $a_2+a_3 > 2a_1$ and his loss on Attribute B is equal to $\frac{b_2+b_3-2b_1}{3}$ if $b_2+b_3 > 2b_1$. This means that if $a_2+a_3 > 2a_1$ and $b_2+b_3 > 2b_1$ the consumer's gain is zero. If a consumer chooses O_2 his loss is only on Attribute B dimension and equal to $\frac{b_1+b_3-2b_2}{3}$, while his gain is on Attribute A dimension and equal to $\frac{2a_2-a_3-a_1}{3}$.

The worst case for O_1 happens if $a_2+a_3 > 2a_1$ and $b_2+b_3 > 2b_1$. In this case, for O_1 the change in losses due to the addition of P_1 is equal to $\frac{b_2+b_3-2b_1}{3} + \frac{a_2+a_3-2a_1}{3} - \frac{a_2-a_1}{2}$ and change in gains due to the addition of P_1 is equal to $-(\frac{b_1-b_2}{2})$. On the other hand, for O_2 the change in losses due to the addition of P_1 is equal to $\frac{b_1+b_3-2b_2}{3} - \frac{b_1-b_2}{2} > 0$ and change in gains due to the addition of P_1 is equal to $\frac{2a_2-a_3-a_1}{3} - \frac{a_2-a_1}{2}$. The difference between the change in O_2's losses and the change in O_1's losses is equal to $\frac{3(b_1-b_2)+a_2+a_1-2a_3}{6} > 0$ and difference between the change in O_2's gains and the change in O_1's gains is equal to $\frac{3(b_1-b_2)+a_2+a_1-2a_3}{6}$. Since due to loss aversion losses loom larger than gains consumers will prefer more O_1 after the addition of P_1.

Proof of Lemma 1:

First, we will consider the case in which segment 2 consumers postpone. In this case, if segment 1 consumers do not postpone then a segment 1 consumer who is $l-$distance away from firm 1's product receives utility of $(1+\delta)(q-tl)-p_1$ from buying firm 1's product and utility $(1+\delta)(q+\theta_1\Delta-t(1-l))-p_2$ from buying firm 2's product, where p_2 and p_1 are the first period prices and $p_2 = \frac{(1+\delta)(t+\theta_1\Delta)+p_1}{2}$ and $p_1 = \frac{p_2-(1+\delta)(\theta_1\Delta-t)}{2}$. Note that the maximum value p_1 can take is equal to $\frac{(q+t)(1+\delta)}{2}$ and the maximum value p_2 can take is equal to $\frac{(q+t+\theta_1\Delta)(1+\delta)}{2}$. If a segment 1 consumer who is $l-$distance away from firm 1's product deviates and postpones then his expected utility will be less than $\delta(q+\Sigma\theta_1-t(1-l))$ if he buys the new product from firm 2 and less than $\delta(q+\Sigma\theta_1-tl)$ if he buys the new product from firm 1. One can show that if $\Sigma < \frac{(1-\delta)q-(3+\delta)t}{2\delta\theta_1}$ then none of the segment 1 consumers prefer to postpone.

Next, we will consider the case in which segment 2 consumers do not postpone. In this case, if segment 1 consumers postpone then in the first period $p_2 = (1+\delta)\theta_2\Delta$ and $p_1 = 0$. The expected utility of a segment 1 consumer will be less than $\delta(q+\theta_1\Sigma)$. If a segment 1 consumer deviates and buys now, then he will receive utility more than $(1+\delta)(q-t)$. This means that if $\Sigma < \frac{q-(1+\delta)t}{\delta\theta_1}$ then none of the segment 1 consumers prefer to postpone.

Since $\frac{q-(1+\delta)t}{\delta\theta_1} > \frac{(1-\delta)q-(3+\delta)t}{2\delta\theta_1}$ we will conduct the rest of our analysis for $\Sigma < \frac{(1-\delta)q-(3+\delta)t}{2\delta\theta_1}$.$\square$

Proof of Lemma 2:

First, recall that under the condition of Lemma 1 (i.e., $\Sigma < \frac{(1-\delta)q-(3+\delta)t}{2\delta\theta_1}$) segment 1 consumers will not postpone their purchases regardless of the firm's preannouncement decision.

<u>In the second period:</u>

If segment 2 consumers postpone their purchase, then:

When both firms develop the new product, firms' prices and profits will be equal to zero. When only firm

1 develops the new product, firm 1's price is $p_{F1,2} = \theta_2(\Sigma - \Delta)$ and its profit is $\pi_{F1,2} = (1-\alpha)\theta_2(\Sigma - \Delta)$, and firm 2's price and profit are equal to zero. When only firm 2 develops the new product, firm 2's price will be $p_{F2,2} = \theta_2\Sigma$ and its profit will be $\pi_{F2,2} = (1-\alpha)\theta_2\Sigma$, and firm 1's price and profit will be equal to zero. When no firm develops the new product, firm 2's price will be $p_{F2,2} = \theta_2\Delta$ and its profit will be $\pi_{F2,2} = (1-\alpha)\theta_2\Delta$, and firm 1's price and profit will be equal to zero.

In the first period:

First, note that the utility from firm 2's product for a segment 1 consumer who locates at l-distance from firm 1 is equal to $(1+\delta)(q+\theta_1\Delta - t(1-l)) - p_{F2,1}$. The utility from firm 1's product for a segment 1 consumer who locates at l-distance from firm 1 is equal to $(1+\delta)(q - tl) - p_{F1,1}$.

In the following we will solve for the first period prices and profits when the firm preannounces and segment 2 consumers choose to postpone, and when the firm is silent and segment 2 consumers choose not to postpone.

When the firm preannounces, consumers know that the firm will be able to develop the new product in the second period. If for given $(p_{F1,1}, p_{F2,1})$ segment 2 consumers choose to postpone then for $\frac{3t}{\Delta} > \theta_1$, $p_{F2,1} = \frac{(1+\delta)(3t+\Delta\theta_1)}{3}$, $p_{F1,1} = \frac{(1+\delta)(3t-\Delta\theta_1)}{3}$, $\pi_{F2,1} = \alpha\frac{(1+\delta)(3t+\Delta\theta_1)^2}{18t}$, and $\pi_{F1,1} = \alpha\frac{(1+\delta)(3t-\Delta\theta_1)^2}{18t}$. We conduct our analysis for $\frac{3t}{\Delta} > \theta_1$ because for $\frac{3t}{\Delta} < \theta_1$ none of segment 1 consumers would buy firm 1's product in the first period and hence, firm 1's existing product would be just redundant. For segment 1 consumers' utility to be positive in the first period we need $q > \frac{(3t-\Delta\theta_1)}{2}$.

When the firm is silent, regardless of consumers' belief regarding whether the firm will be able to develop the new product, if for given $(p_{F1,1}, p_{F2,1})$ the segment 2 consumers choose not to postpone, then for $\frac{(2+\alpha)t}{\Delta\alpha} > \theta_1 > \frac{(2-5\alpha)t}{\Delta\alpha}$, $\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\alpha}{3\Delta\alpha}, \frac{t+\Delta\theta_1}{\Delta}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta t\theta_1}{18\alpha\Delta t(1-\alpha)}$, $p_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha}$, $p_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)}{3\alpha}$, $\pi_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)^2}{18\alpha t}$, and $\pi_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)^2}{18\alpha t}$. For the segment 1 consumers' utility to be positive we need $q > \frac{((2+\alpha)t-\Delta\theta_1\alpha)}{2\alpha}$.

Since $\frac{3t}{\Delta} < \frac{(2+\alpha)t}{\Delta\alpha}$, we conduct our analysis for $\frac{3t}{\Delta} > \theta_1 > \frac{(2-5\alpha)t}{\Delta\alpha}$, $\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\alpha}{3\Delta\alpha}, \frac{t+\Delta\theta_1}{\Delta}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta t\theta_1}{18\alpha\Delta t(1-\alpha)}$ and $q > \frac{(2+\alpha)t-\Delta\theta_1\alpha}{2\alpha}$ because for these values both firms will be able to serve segment 1 consumers.

Armed with prices and profits both in the first period and the second period, in the following we will characterize the necessary and sufficient conditions under which segment 2 consumers postpone their purchase when the firm preannounces and do not postpone when the firm is silent. Note that since segment 2 consumers will never find it worthwhile to buy firm 1's product in the first period we assume that firm 1's price in the first period does not affect these consumers' beliefs about whether the product with quality $q + \Sigma$ will be launched in the second period or not (i.e., firm 1's price in the first period does not have a signaling value for these consumers).

Case 1: firm 1 receives a signal

In the following we will characterize the necessary conditions under which when firm 1 preannounces, segment 2 consumers postpone and do not to buy firm 2's existing product in the first period and when firm 1 is silent, segment 2 consumers do not postpone and buy firm 2's existing product in the first period.

When firm 1 preannounces, consumers know that firm 1 will be able to develop the new product in the second period. In this case, given the prices of the firms, for segment 2 consumers to postpone in the first period, the necessary condition is $(1+\delta)(q+\Delta\theta_2) - \frac{(1+\delta)(3t+\Delta\theta_1)}{3} < \delta(q+\theta_2 y\Sigma + (1-y)\Delta\theta_2)$. Thus, we need $\Sigma > \frac{3q+3\Delta\theta_2(1+\delta y)-(1+\delta)(3t+\Delta\theta_1)}{3\delta y\theta_2}$.

However, this condition is not sufficient for segment 2 consumers to postpone in the first period when firm 1 preannounces. We also need to guarantee that firm 2 does not want to charge a lower price than $\frac{(1+\delta)(3t+\Delta\theta_1)}{3}$ to convince these consumers to buy in the first period. Firm 2 should charge a lower price $p'_{F2,1}$ such that $(1+\delta)(q+\Delta\theta_2) - p'_{F2,1} > \delta(q+\theta_2 y\Sigma + (1-y)\Delta\theta_2)$ to convince segment 2 consumers to buy in the first period. If $p'_{F2,1} < \alpha\frac{(1+\delta)(3t+\Delta\theta_1)^2}{18t}$ then firm 2 will not find it profitable to do so. This means that it is sufficient to have $\Sigma > \frac{18t(q+\Delta\theta_2(1+\delta y))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\delta y\theta_2}$ for firm 2 not to convince segment 2 consumers to buy in the first period. Similarly, after preannouncement firm 1 may want to charge a very low price $p'_{F1,1}$ to convince segment 2 consumers to buy in the first period. For this to happen, $p'_{F1,1}$ should be such that $(1+\delta)q - p'_{F1,1} > \delta(q+\theta_2\Sigma y + (1-y)\Delta\theta_2)$. However, if $p'_{F1,1} < \alpha\frac{(1+\delta)(3t-\Delta\theta_1)^2}{18t} + (1-y)\alpha\theta_2(\Sigma-\Delta)$ then firm 1 will not find it profitable to do so. This means that it is sufficient to have $\Sigma > \frac{18t(q-\Delta\theta_2\delta(1-y))-\alpha(1+\delta)(3t-\Delta\theta_1)^2+18t\alpha\Delta\theta_2(1-y)}{18t\theta_2(\delta y+\alpha(1-y))}$ for firm 1 not to try to convince segment 2 consumers to buy in the first period.

When firm 1 is silent, consumers may either think that firm 1 will not be able to develop the new product in the second period (i.e., Prob(firm 1 develops the new product|firm 1 is silent) = 0) or their posterior may be equal to their prior (i.e., Prob(firm 1 develops the new product|firm 1 is silent) = x).
If consumers think that firm 1 will not be able to develop the new product in the second period: In this case, given the prices of the firms, segment 2 consumers would not want to postpone because regardless of firm 2 develops the new product or not these consumers' surplus will be equal to zero if they buy in the second period.
If consumers' posterior is equal to their prior: In this case, given the prices of the firms, for segment 2 consumers not to postpone the necessary condition is
$(1+\delta)(q+\theta_2\Delta) - \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha} > \delta(q+xy\theta_2\Sigma + x(1-y)\theta_2\Delta)$. This means that for segment 2 consumers not to postpone the necessary condition is $\Sigma < \frac{3\alpha q+3\Delta\alpha\theta_2(1+\delta(1-x(1-y)))-(1+\delta)(t(4-\alpha)+\alpha\theta_1\Delta)}{3\alpha\delta xy\theta_2}$.

When firm 2 knows that firm 1 will not be able to develop the new product, given that it can develop the new product with probability y, it may want to convince segment 2 consumers to postpone their purchase. Firm 2 can try to do this by increasing its price so much. However, if $(1+\delta)q - \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)}{3\alpha} > \delta q$ (i.e., $q > \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)}{3\alpha}$), then segment 2 consumers prefer to buy firm 1's product in the first period rather than postponing.

Case 2: Firm 2 receives a signal

In the following we will characterize the necessary conditions under which when firm 2 preannounces, segment 2 consumers postpone and do not to buy firm 2's existing product in the first period, and when firm 2 is silent, segment 2 consumers do not postpone and buy firm 2's existing product in the first period.

When firm 2 preannounces, consumers know that firm 2 will be able to develop the new product in the second period. In this case, given the prices of the firms, for segment 2 consumers to postpone the necessary condition is
$(1+\delta)(q+\theta_2\Delta) - \frac{(1+\delta)(3t+\Delta\theta_1)}{3} < \delta(q+\theta_2 x\Sigma)$. This means that the necessary condition for segment 2 consumers to postpone is $\Sigma > \frac{3q+3\Delta\theta_2(1+\delta)-(1+\delta)(3t+\Delta\theta_1)}{3\delta x\theta_2}$.

However, this condition is not sufficient for segment 2 consumers to postpone in the first period when firm 2 preannounces. We also need to guarantee that firm 2 does not decrease its price so low to convince segment 2 consumers to buy now. This can happen if firm 2 charges $p'_{F2,1}$ such that $(1+\delta)(q+\theta_2\Delta) - p'_{F2,1} > \delta(q+\theta_2 x\Sigma)$. If $p'_{F2,1} < \alpha\frac{(1+\delta)(3t+\Delta\theta_1)^2}{18t} + (1-x)\alpha\Sigma\theta_2$ then such thing will not happen. For this it is sufficient to have $\Sigma > \frac{18t(q+\theta_2\Delta(1+\delta))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\theta_2(x\delta+(1-x)\alpha)}$. Similarly firm 1 may want to charge a lower price $p'_{F1,1}$ such that $(1+\delta)q - p'_{F1,1} > \delta(q+\theta_2 x\Sigma)$ to convince segment 2 consumers to buy in the first period. If $p'_{F1,1} < \alpha\frac{(1+\delta)(3t-\Delta\theta_1)^2}{18t}$ then firm 1 will not find it profitable to do so. For this it is sufficient to have $\Sigma > \frac{18tq-\alpha(1+\delta)(3t-\Delta\theta_1)^2}{18t\delta x\theta_2}$.

When firm 2 is silent, consumers may either think that firm 2 will not be able to develop the new product in the second period (i.e., Prob(firm 2 develops the new product|firm 2 is silent) = 0) or their posterior may be equal to their prior (i.e., Prob(firm 2 develops the new product|firm 2 is silent) = y). If consumers think that firm 2 will not be able to develop the new product in the second period: In this case, given the prices of the firms, for segment 2 consumers not to postpone the necessary condition is $(1+\delta)(q+\theta_2\Delta) - \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha} > \delta(q+x\Delta\theta_2)$, which holds if $q > \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)-3\theta_2\alpha\Delta(1+\delta(1-x))}{3\alpha}$.
If consumers' posterior is equal to their prior: In this case, as in firm 1's case, if
$\Sigma < \frac{3\alpha q+3\Delta\alpha\theta_2(1+\delta(1-x(1-y)))-(1+\delta)(t(4-\alpha)+\alpha\theta_1\Delta)}{3\alpha\delta xy\theta_2}$ segment 2 consumers prefer not to postpone.

Therefore, the list of the conditions sufficient in an equilibrium for segment 2 consumers in the first period to postpone when the firm preannounces and not to postpone when the firm is silent and for segment 1 consumers always prefer to buy in the first period (i.e., the condition from Lemma 1) are as follows:

$$\frac{3t}{\Delta} > \theta_1 > \frac{(2-5\alpha)t}{\Delta\alpha},\ \max\left\{\frac{(4-\alpha)t+\Delta\theta_1\alpha}{3\Delta\alpha}, \frac{t+\Delta\theta_1}{\Delta}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta t\theta_1}{18\alpha\Delta t(1-\alpha)},$$
$$\min\left\{\frac{3\alpha q+3\Delta\alpha\theta_2(1+\delta(1-x(1-y)))-(1+\delta)(t(4-\alpha)+\alpha\theta_1\Delta)}{3\alpha\delta xy\theta_2}, \frac{(1-\delta)q-(3+\delta)t}{2\delta\theta_1}\right\} > \Sigma >$$
$$\max\{\frac{18t(q+\Delta\theta_2(1+\delta y))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\delta y\theta_2}, \frac{18t(q-\Delta\theta_2\delta(1-y))-\alpha(1+\delta)(3t-\Delta\theta_1)^2+18t\alpha\Delta\theta_2(1-y)}{18t\theta_2(\delta y+\alpha(1-y))},$$
$$\frac{18t(q+\theta_2\Delta(1+\delta))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\theta_2(x\delta+(1-x)\alpha)}, \frac{18tq-\alpha(1+\delta)(3t-\Delta\theta_1)^2}{18t\delta x\theta_2}, \frac{3q+3\Delta\theta_2(1+\delta)-(1+\delta)(3t+\Delta\theta_1)}{3\delta x\theta_2}, 2\Delta\},$$

and $q > \max\left\{\frac{(2+\alpha)t-\alpha\Delta\theta_1}{2\alpha}, \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)}{3\alpha}, \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)-3\theta_2\alpha\Delta(1+\delta(1-x))}{3\alpha}\right\}$.$\square$

Proof of Proposition 1:

'Announcement' equilibrium: In this equilibrium, firm 1 preannounces its new product if it learns that it will be able to develop the new product and stays silent otherwise. In this equilibrium consumers' beliefs are such that Prob(firm 1 develops the new product|firm 1 preannounces) = 1 and Prob(firm 1 develops the new product|firm 1 is silent) = 0.

When firm 1 learns that it will be able to develop the new product and preannounces, its profit is equal to $(1-\alpha)(1-y)(\Sigma-\Delta)\theta_2 + (1+\delta)\alpha\frac{(3t-\Delta\theta_1)^2}{18t}$. If firm 1 deviates to silence it will receive profit of $\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)^2}{18\alpha t}$. Therefore, firm 1 will not deviate if $\Sigma > \Delta + \frac{2(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}$. Since Σ has to be greater than 2Δ, this equilibrium exists if $\Sigma > \max\left\{2\Delta, \frac{4(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}\right\}$.

'Always Silent' equilibrium: In this equilibrium firm 1 does not preannounce when it learns that it will be able to develop the new product, and firms' prices are the same both when firm 1 learns that it will be able to develop the new product and when it learns that it will not be able to develop the new product. This means that the firms' prices will not provide any information regarding the value of firm 1's signal. Thus, in this equilibrium consumers' posterior is equal to their prior (i.e., Prob(firm 1 develops the new product|firm 1 is silent) = x). Recall that firm 2 also knows the value of firm 1's signal. We will not consider the equilibrium in which prices differ depending on the value of firm 1's signal because such equilibrium is equivalent to the 'Announcement' equilibrium.

When firm 1 learns that it will be able to develop the new product and keeps its silence, its profit is equal to $\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)^2}{18\alpha t}$. If firm 1 deviates and preannounces it will receive profits of $(1-\alpha)(1-y)(\Sigma-\Delta)\theta_2 + (1+\delta)\alpha\frac{(3t-\Delta\theta_1)^2}{18t}$. Thus, firm 1 will not deviate if $\Sigma < \Delta + \frac{2(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}$.

This means that for $\Sigma > \Sigma_1$, where $\Sigma_1 \equiv \max\left\{2\Delta, \frac{4(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}\right\}$, firm 1 prefers to preannounce.$\square$

Numerical example: for $t = 0.9$, $\Delta = 1.5$, $q = 100$, $74 < \Sigma < 89.35$, $\theta_1 = 1.5$, $\theta_2 = 8$, $\alpha = 0.9$, $\delta = 0.32$, $x = 0.6$, and $y = 0.6$ all the conditions above hold and firm 1 prefers to preannounce.

Proof of Proposition 2:

'Announcement' equilibrium: In this equilibrium, firm 2 preannounces its new product if it learns that it will be able to develop the new product and stays silent otherwise. In this equilibrium consumers' beliefs are such that Prob(firm 2 develops the new product|firm 2 preannounces) = 1 and Prob(firm 2 develops the new product|firm 2 is silent) = 0.

When firm 2 learns that it will be able to develop the new product and preannounces, its profit is equal to $\alpha(1+\delta)\frac{(3t+\Delta\theta_1)^2}{18t} + (1-\alpha)(1-x)\Sigma\theta_2$. If firm 2 deviates to silence it will receive profit of $(1+\delta)\frac{((4-\alpha)t+\alpha\Delta\theta_1)^2}{18\alpha t}$. Therefore, firm 2 will not deviate if $\Sigma > \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}$. Since Σ has to be greater than 2Δ, for firm 2 not to deviate it is sufficient to have $\Sigma > \max\left\{2\Delta, \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}\right\}$.This means that for $\Sigma > \Sigma_2$, where $\Sigma_2 \equiv \max\left\{2\Delta, \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}\right\}$, firm 2 prefers to preannounce.

Note that $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha} > \frac{(1+\delta)(3t+\Delta\theta_1)}{3}$. For that reason, firm 2 with a new product would like to want to deviate to silence and set its price in the first period equal to $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha} + \varepsilon$ to signal segment 2 consumers that it will develop the new product in the second period. This will make segment 2 consumers to postpone their purchase. However, knowing this, when firm 2 with a new product deviates to silence, firm 1 should set its price equal to $\frac{(1+\delta)(3t-\Delta\theta_1)}{3}$ in the first period and this would make firm 2 to set its price to $\frac{(1+\delta)(3t+\Delta\theta_1)}{3}$. This means that $\Sigma > \Sigma_2$ is sufficient condition for such deviation not to happen.

'Always Silent' equilibrium: In this equilibrium firm 2 does not preannounce when it learns that it will be able to develop the new product, and firms' prices are the same both when firm 2 learns that it will be able to develop the new product and when it learns that it will not be able to develop the new product. This means that the firms' prices will not provide any information regarding the value of firm 2's signal. Thus, in this equilibrium consumers' posterior is equal to their prior (i.e., Prob(firm 2 develops the new product|firm 2 is silent) $= y$). We will not consider the equilibrium in which prices differ depending on the value of firm 2's signal because such equilibrium is equivalent to the 'Announcement' equilibrium.
When firm 2 learns that it will be able to develop the new product and keeps its silence, its profit is equal to $(1+\delta)\frac{((4-\alpha)t+\alpha\Delta\theta_1)^2}{18\alpha t}$. If firm 2 deviates and preannounces it will receive profits of $\alpha(1+\delta)\frac{(3t+\Delta\theta_1)^2}{18t} + (1-\alpha)(1-x)\Sigma\theta_2$. Thus, firm 2 will not deviate if $\Sigma < \Sigma_2$.
Furthermore, when firm 2 learns that it will be able to develop the new product, it can deviate from this equilibrium also by increasing its price an ε in the first period. However, if firm 2's profit from segment 2 in the first period is higher than its expected profit from segment 2 in the second period then firm 2 will not deviate. This means that if $\frac{(4-\alpha)t+\alpha\Delta\theta_1}{3\alpha} > (1-x)\Sigma\theta_2$ (i.e., $\Sigma < \frac{(4-\alpha)t+\alpha\Delta\theta_1}{3\alpha(1-x)\theta_2}$) then firm 2 will not deviate. Therefore, for this equilibrium to exist we need $\Sigma < \min\left\{\Sigma_2, \frac{(4-\alpha)t+\alpha\Delta\theta_1}{3\alpha(1-x)\theta_2}\right\}$.□

Numerical example: for $t = 0.9$, $\Delta = 1.5$, $q = 100$, $74 < \Sigma < 89.35$, $\theta_1 = 1.5$, $\theta_2 = 8$, $\alpha = 0.9$, $\delta = 0.32$, $x = 0.6$, and $y = 0.6$ all the conditions above hold and firm 2 prefers to preannounce.

Proof of Corollary 1:

Since $\frac{4(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2} < \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}$ for $x = y$, whenever firm 2 finds it optimal to preannounce so does firm 1, but not vice versa.□

Proof of Corollary 2:

We know from the proof of Proposition 1 that firm 1's incentive to preannounce is equal to $(1-\alpha)(1-y)(\Sigma-\Delta)\theta_2+(1+\delta)\alpha\frac{(3t-\Delta\theta_1)^2}{18t}-\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)^2}{18\alpha t}$. $\frac{\partial\left((1-\alpha)(1-y)(\Sigma-\Delta)\theta_2+(1+\delta)\alpha\frac{(3t-\Delta\theta_1)^2}{18t}-\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)^2}{18\alpha t}\right)}{\partial y} < 0$.

Similarly, we know from the proof of Proposition 2 that that firm 2's incentive to preannounce is equal to $\alpha(1+\delta)\frac{(3t+\Delta\theta_1)^2}{18t} + (1-\alpha)(1-x)\Sigma\theta_2 - (1+\delta)\frac{((4-\alpha)t+\alpha\Delta\theta_1)^2}{18\alpha t}$.
$\frac{\partial\left(\alpha(1+\delta)\frac{(3t+\Delta\theta_1)^2}{18t}+(1-\alpha)(1-x)\Sigma\theta_2-(1+\delta)\frac{((4-\alpha)t+\alpha\Delta\theta_1)^2}{18\alpha t}\right)}{\partial x} < 0$.□

Conditions for the Case with Phantom Product Effect:

In the following, as we did in the benchmark case, we will characterize the necessary and sufficient conditions under which segment 1 consumers will always prefer to buy in the first period and segment 2 consumers prefers to postpone their purchase iff there is a preannouncement.

The necessary and sufficient conditions under which segment 1 consumers will always prefer to buy in the first period:

First, we will consider the case in which segment 2 consumers postpone and at least one of the firms will launch the new product. In this case, if segment 1 consumers do not postpone then a segment 1 consumer who is $l-$distance away from firm 1's product receives utility of $(1+\delta)(q-tl-\gamma\theta_1\frac{\Sigma+\Delta}{3})-p_1$ from buying firm 1's product and utility $(1+\delta)(q+\theta_1\Delta-t(1-l)-\gamma\theta_1\frac{\Sigma-2\Delta}{3})-p_2$ from buying firm 2's product, where p_2 and p_1 are first period prices and $p_2=\frac{(1+\delta)(t+\theta_1(1+\gamma)\Delta)+p_1}{2}$ and $p_1=\frac{p_2-(1+\delta)(\theta_1(1+\gamma)\Delta-t)}{2}$. Note that the maximum value p_1 can take is equal to $\frac{(1+\delta)(3(q+t)-\gamma\theta_1(\Sigma+\Delta))}{6}$ and the maximum value p_2 can take is equal to $\frac{(1+\delta)(3(q+t+\theta_1\Delta)-\gamma\theta_1(\Sigma-2\Delta))}{6}$. If segment 1 consumer who is $l-$distance away from firm 1's product deviates and postpones then his expected utility will be less than $\delta(q+\Sigma\theta_1-t(1-l))$ if he buys the new product from firm 2 and less than $\delta(q+\Sigma\theta_1-tl)$ if he buys the new product from firm 1. One can show that if $\Sigma<\frac{3(1-\delta)q-3(3+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(6\delta+\gamma(1+\delta))\theta_1}$ then none of the segment 1 consumers prefer to postpone.

Next, we will consider the case in which segment 2 consumers do not postpone. In this case, if segment 1 consumers postpone, then in the first period $p_2=(1+\delta)\theta_2(1+\gamma)\Delta$ and $p_1=0$. The expected utility of a segment 1 consumer will be less than $\delta(q+\theta_1\Sigma)$. If the segment 1 consumer deviates and buys now, then he will receive utility more than $(1+\delta)(q-t-\gamma\theta_1\frac{\Sigma+\Delta}{3})$. This means that if $\Sigma<\frac{3q-3(1+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(3\delta+\gamma(1+\delta))\theta_1}$, then none of the segment 1 consumers prefer to postpone.

Since $\frac{3q-3(1+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(3\delta+\gamma(1+\delta))\theta_1}>\frac{3(1-\delta)q-3(3+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(6\delta+\gamma(1+\delta))\theta_1}$ we will conduct the rest of our analysis for $\Sigma<\frac{3(1-\delta)q-3(3+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(6\delta+\gamma(1+\delta))\theta_1}$.$\square$

Next, we will characterize the necessary and sufficient conditions under which segment 2 consumers prefer to postpone their purchase iff there is a preannouncement.

In the second period:

If segment 2 consumers postpone their purchase, then based on the consumers' utilities given in tables in Section 5:

When both firms develop the new product, firms' prices and profits will be equal to zero. When only firm 1 develops the new product, firm 1's price is $p_{F1,2}=\theta_2\frac{2+\gamma}{2}(\Sigma-\Delta)$ and its profit is $\pi_{F1,2}=(1-\alpha)\theta_2\frac{2+\gamma}{2}(\Sigma-\Delta)$, and firm 2's price and profit are equal to zero. When only firm 2 develops the new product, firm 2's price will be $p_{F2,2}=\theta_2\frac{2+\gamma}{2}\Sigma$ and its profit will be $\pi_{F2,2}=(1-\alpha)\theta_2\frac{2+\gamma}{2}\Sigma$, and firm 1's price and profit will be equal to zero. When no firm develops the new product, firm 2's price will be $p_{F2,2}=\theta_2\frac{2+\gamma}{2}\Delta$ and its profit will be $\pi_{F2,2}=(1-\alpha)\theta_2\frac{2+\gamma}{2}\Delta$, and firm 1's price and profit will be equal to zero.

Note that for segment 2 consumers' utility in the second period to be positive, given the above prices, we need $\frac{2q}{\theta_2\gamma} > \Sigma$.

In the first period:

When the firm preannounces, consumers know that the firm will be able to develop the new product in the second period. If for given $(p_{F1,1}, p_{F2,1})$ segment 2 consumers choose to postpone, then based on the consumers' utilities given in Section 5, for $\frac{3t}{\Delta(1+\gamma)} > \theta_1$, $p_{F2,1} = \frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)}{3}$, $p_{F1,1} = \frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)}{3}$, $\pi_{F2,1} = \alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}$, and $\pi_{F1,1} = \alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t}$. We conduct our analysis for $\frac{3t}{\Delta(1+\gamma)} > \theta_1$ because for $\frac{3t}{\Delta(1+\gamma)} < \theta_1$ none of segment 1 consumers would buy firm 1's product in the first period and hence, firm 1's existing product would be just redundant. For segment 1 consumers' utility to be positive in the first period we need $\Sigma < \frac{6q-3(3t-\Delta(1+\gamma)\theta_1)-2\gamma\Delta\theta_1}{2\gamma\theta_1}$.

When firm 1 is silent and consumer believes that firm 1 will not be able to develop the new product, if the segment 2 consumers choose not to postpone, then based on the consumers' utilities given in Section 5, for $\theta_1 > \frac{(2-5\alpha)t}{\Delta\mu\alpha}$, $\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\mu\alpha}{3\Delta\mu\alpha}, \frac{t+\Delta\mu\theta_1}{\Delta\mu}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\mu\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\mu t\theta_1}{18\alpha\Delta\mu t(1-\alpha)}$, $p_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\mu\theta_1)}{3\alpha}$, $p_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)}{3\alpha}$, $\pi_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\mu\theta_1)^2}{18\alpha t}$, and $\pi_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)^2}{18\alpha t}$, where $\mu = \frac{2+\gamma(1+y)}{2}$. Note that, given these prices, segment 1 consumers' utility to be positive we need $\Sigma < \frac{6q\alpha-3((2+\alpha)t-\alpha\Delta\mu\theta_1)-\alpha\gamma\Delta\theta_1(3-y)}{2y\alpha\gamma\theta_1}$ and segment 2 consumers' utility to be positive we need $\Sigma < \frac{3q\alpha+\alpha\Delta\theta_2(3+2y\gamma)-((4-\alpha)t+\alpha\theta_1\mu\Delta)}{\theta_2\alpha\gamma y}$.

When firm 2 is silent and consumer believes that firm 2 will not be able to develop the new product, if the segment 2 consumers choose not to postpone, then based on the consumers' utilities given in Section 5, for $\theta_1 > \frac{(2-5\alpha)t}{\Delta\psi\alpha}$, $\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\psi\alpha}{3\Delta\psi\alpha}, \frac{t+\Delta\psi\theta_1}{\Delta\psi}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\psi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\psi t\theta_1}{18\alpha\Delta\psi t(1-\alpha)}$, $p_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)}{3\alpha}$, $p_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\psi\theta_1)}{3\alpha}$, $\pi_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)^2}{18\alpha t}$, and $\pi_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\psi\theta_1)^2}{18\alpha t}$, where $\psi = \frac{2+\gamma(1+x)}{2}$. Note that, given these prices, segment 1 consumers' utility to be positive we need $\Sigma < \frac{6q\alpha-3((2+\alpha)t-\alpha\Delta\psi\theta_1)-\alpha\gamma\Delta\theta_1(3-x)}{2x\alpha\gamma\theta_1}$ and segment 2 consumers' utility to be positive we need $\Sigma < \frac{3q\alpha+\alpha\Delta\theta_2(3+2x\gamma)-((4-\alpha)t+\alpha\theta_1\psi\Delta)}{\theta_2\alpha\gamma x}$.

When a firm (either firm 1 or firm 2) is silent and consumers' belief regarding whether the firm will be able to develop the new product is equal to their prior, if the segment 2 consumers choose not to postpone, then based on the consumers' utilities given in Section 5 for $\theta_1 > \frac{(2-5\alpha)t}{\Delta\varphi\alpha}$, $\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\varphi\alpha}{3\Delta\varphi\alpha}, \frac{t+\Delta\varphi\theta_1}{\Delta\varphi}\right\} < \theta_2 < \frac{((4-\alpha)t+\alpha\Delta\varphi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\varphi t\theta_1}{18\alpha\Delta\varphi t(1-\alpha)}$, $p_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)}{3\alpha}$, $p_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\varphi\theta_1)}{3\alpha}$, $\pi_{F2,1} = \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)^2}{18\alpha t}$, and $\pi_{F1,1} = \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\varphi\theta_1)^2}{18\alpha t}$, where $\varphi = \frac{2+\gamma(1+x+y-xy)}{2}$. Given these prices, segment 1 consumers' utility to be positive we need $\Sigma < \frac{6q\alpha-3((2+\alpha)t-\alpha\Delta\varphi\theta_1)-\alpha\gamma\Delta\theta_1(3-x-y+xy)}{2\alpha\gamma\theta_1(x+y-xy)}$ and segment 2 consumers' utility to be positive we need $\Sigma < \frac{3q\alpha+\alpha\Delta\theta_2(3-2\gamma(x+y-xy))-((4-\alpha)t+\alpha\theta_1\varphi\Delta)}{\theta_2\alpha\gamma(x+y-xy)}$.

We conduct the following analysis for $\frac{3t}{\Delta(1+\gamma)} > \theta_1 > \max\left\{\frac{(2-5\alpha)t}{\Delta\mu\alpha}, \frac{(2-5\alpha)t}{\Delta\psi\alpha}\right\}$, $\max\{\frac{(4-\alpha)t+\Delta\theta_1\mu\alpha}{3\Delta\mu\alpha}, \frac{t+\Delta\mu\theta_1}{\Delta\mu}, \frac{(4-\alpha)t+\Delta\theta_1\psi\alpha}{3\Delta\psi\alpha}, \frac{t+\Delta\psi\theta_1}{\Delta\psi}\} < \theta_2 < \min\{\frac{((4-\alpha)t+\alpha\Delta\mu\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\mu t\theta_1}{18\alpha\Delta\mu t(1-\alpha)}, \frac{((4-\alpha)t+\alpha\Delta\psi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\psi t\theta_1}{18\alpha\Delta\psi t(1-\alpha)}, \frac{((4-\alpha)t+\alpha\Delta\varphi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\varphi t\theta_1}{18\alpha\Delta\varphi t(1-\alpha)}\}$, and $\Sigma < \min\{\frac{2q}{\theta_2\gamma}, \frac{6q-3(3t-\Delta(1+\gamma)\theta_1)-2\gamma\Delta\theta_1}{2\gamma\theta_1},$

$\frac{6q\alpha-3((2+\alpha)t-\alpha\Delta\varphi\theta_1)-\alpha\gamma\Delta\theta_1(3-x-y+xy)}{2x\alpha\gamma\theta_1}, \frac{3q\alpha+\alpha\Delta\theta_2(3-2\gamma(x+y-xy))-((4-\alpha)t+\alpha\theta_1\varphi\Delta)}{\theta_2\alpha\gamma(x+y-xy)}, \frac{3(1-\delta)q-3(3+\delta)t-(1+\delta)\gamma\theta_1\Delta}{(6\delta+\gamma(1+\delta))\theta_1}\}.$

Armed with prices and profits both in the first period and the second period, in the following we will characterize the necessary and sufficient conditions under which segment 2 consumers postpone their purchase when the firm preannounces and do not postpone when the firm is silent. Note that since segment 2 consumers will never find it worth to buy firm 1's product we assume that firm 1's price in the first period does not affect these consumers' beliefs about whether the product with quality $q+\Sigma$ will be launched in the second period or not (i.e., firm 1's price in the first period does not have a signaling value for these consumers).

<u>Case 1: firm 1 receives a signal</u>

In the following we will characterize the necessary conditions under which when firm 1 preannounces, segment 2 consumers postpone and do not buy firm 2's existing product in the first period, and when firm 1 is silent, segment 2 consumers do not postpone and buy firm 2's existing product in the first period.

When firm 1 preannounces, consumers know that firm 1 will be able to develop the new product in the second period. In this case, given the prices of the firms, for segment 2 consumers to postpone the necessary condition is $(1+\delta)(q+\Delta\theta_2-\gamma\theta_2(\frac{\Sigma-2\Delta}{3}))-(1+\delta)(\frac{3t+\theta_1\Delta(1+\gamma)}{3}) < \delta(q+y\Sigma\theta_2+(1-y)\theta_2(\frac{\Delta(2+\gamma)-\Sigma\gamma}{2}))$. Therefore, we need $\Sigma > \frac{6q+\Delta\theta_2(2(1+\delta)(3+2\gamma)-3\delta(1-y)(2+\gamma))-2(1+\delta)(3t+\Delta\theta_1(1+\gamma))}{\theta_2(6\delta y+\gamma(2-\delta+3\delta y))}$.

However, this condition is not sufficient for segment 2 consumers to postpone in the first period when firm 1 preannounces. We also need to guarantee that firm 2 does not want to charge a lower price than $\frac{3t+\theta_1\Delta(1+\gamma)}{3}$ to convince these consumers to buy in the first period. Firm 2 should charge a lower price $p'_{F2,1}$ such that $(1+\delta)(q+\Delta\theta_2-\gamma\theta_2(\frac{\Sigma-2\Delta}{3}))-p'_{F2,1} > \delta(q+\theta_2 y\Sigma+(1-y)\theta_2(\frac{\Delta(2+\gamma)-\Sigma\gamma}{2}))$ to convince segment 2 consumers to buy in the first period. If $p'_{F2,1} < \alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}$ then firm 2 will not find it profitable to do so.

Thus, it is sufficient to have $\Sigma > \frac{18t(q+\Delta\theta_2(1+\delta y))-\alpha(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2+3t\Delta\theta_2\gamma(4+\delta(1+3y))}{3t\theta_2(6\delta y+\gamma(2-\delta+3\delta y))}$ for firm 2 not to convince segment 2 consumers to buy in the first period. Similarly, after preannouncement firm 1 may want to charge a very low price $p'_{F1,1}$ to convince segment 2 consumers to buy in the first period. For this to happen, $p'_{F1,1}$ should be such that $(1+\delta)(q-\gamma\theta_2(\frac{\Sigma+\Delta}{3}))-p'_{F1,1} > \delta(q+\theta_2 y\Sigma+(1-y)\theta_2(\frac{\Delta(2+\gamma)-\Sigma\gamma}{2}))$. However, if $p'_{F1,1} < \alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t}+(1-y)\alpha\theta_2(\frac{2+\gamma}{2})(\Sigma-\Delta)$, then firm 1 will not find it profitable to do so.

Thus, it is sufficient to have $\Sigma > \frac{18t(q-\Delta\theta_2\delta(1-y))-\alpha(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2+9t\alpha\Delta\theta_2(1-y)(2+\gamma)-3\Delta\theta_2 t\gamma(2+\delta(5-3y))}{3t\theta_2(6\delta y+3\alpha(1-y)(2+\gamma)+\gamma(2-\delta(1-3y)))}$ for firm 1 not to convince segment 2 consumers to buy in the first period.

When firm 1 is silent, consumers may either think that firm 1 will not be able to develop the new product in the second period (i.e., Prob(firm 1 develops the new product|firm 1 is silent) = 0) or their posterior may be equal to their prior (i.e., Prob(firm 1 develops the new product|firm 1 is silent) = x).

If consumers think that firm 1 will not be able to develop the new product in the second period: In this case, given the prices of the firms, for segment 2 consumers not to postpone the necessary condition is $(1+\delta)(q+\Delta\theta_2 - y\gamma\theta_2(\frac{\Sigma-2\Delta}{3})) - (1+\delta)(\frac{(4-\alpha)t+\alpha\theta_1\mu\Delta}{3\alpha}) > \delta(q-\theta_2\frac{\gamma\Sigma y}{2} - \theta_2\frac{\gamma\Delta(1-y)}{2})$. Thus, we need $\Sigma < \frac{6q\alpha+\alpha\theta_2\Delta(2(1+\delta)(3+2y\gamma)+3\delta(1-y)\gamma)-2(1+\delta)((4-\alpha)t+\alpha\theta_1\mu\Delta)}{\gamma y\alpha\theta_2(2-\delta)}$.

However, this condition is not sufficient for segment 2 consumers not to postpone in the first period when firm 1 is silent. When firm 2 knows that firm 1 will not be able to develop the new product, given that it can develop the new product with probability y, firm 2 may want to charge a higher price than $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\mu\theta_1)}{3\alpha}$ to encourage segment 2 consumers to postpone their purchase. Such thing would not happen if when segment 2 consumers prefer to buy firm 1's product in period 1 rather than postpone and wait till period 2-i.e., $(1+\delta)(q-y\gamma\theta_2(\frac{\Sigma+\Delta}{3})-(1-y)\gamma\theta_2\frac{\Delta}{2})-(1+\delta)(\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)}{3\alpha}) > \delta(q-\theta_2\frac{\gamma\Sigma y}{2}-\theta_2\frac{\gamma\Delta(1-y)}{2})$-i.e., $\Sigma < \frac{6q\alpha-\alpha\theta_2\Delta\gamma(3-y+2\delta y)-2(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)}{\gamma y\alpha\theta_2(2-\delta)}$.

One can see that $\Sigma < \frac{6q\alpha-\alpha\theta_2\Delta\gamma(3-y+2\delta y)-2(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)}{\gamma y\alpha\theta_2(2-\delta)}$ is sufficient for $\Sigma < \frac{6q\alpha+\alpha\theta_2\Delta(2(1+\delta)(3+2y\gamma)+3\delta(1-y)\gamma)-2(1+\delta)((4-\alpha)t+\alpha\theta_1\mu\Delta)}{\gamma y\alpha\theta_2(2-\delta)}$.

If consumers' posterior is equal to their prior: In this case, given the prices of the firms, for segment 2 consumers not to postpone the necessary condition is $(1+\delta)(q+\Delta\theta_2-(x+y-xy)\gamma\theta_2(\frac{\Sigma-2\Delta}{3})) - \frac{(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)}{3\alpha} > \delta(q+xy\Sigma\theta_2+x(1-y)\theta_2(\frac{\Delta(2+\gamma)-\Sigma\gamma}{2})-(1-x)y\frac{\gamma\Sigma\theta_2}{2}-(1-x)(1-y)\frac{\gamma\Delta\theta_2}{2})$. Hence, we need $\Sigma < \frac{6q\alpha-2(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)+\alpha\Delta\theta_2(2(1+\delta)(3+2\gamma(x+y-xy)-3\delta(1-y)(2x+\gamma(2x-1)))}{\alpha\theta_2(6\delta xy+\gamma((x+y-xy)(2-\delta)+3\delta xy))}$.

However, these conditions are not sufficient for segment 2 consumers not to postpone in the first period when firm 1 is silent. When firm 2 knows that firm 1 will not be able to develop the new product, given that it can develop the new product with probability y, firm 2 may want to charge a higher price than $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)}{3\alpha}$ and encourage segment 2 consumers to postpone and wait for its new product. Obviously, when such deviation happens consumers will know that firm 1 will not be able to develop the new product. Therefore, such thing would not happen if $\Sigma < \frac{6q\alpha-\alpha\theta_2\Delta\gamma(3-y+2\delta y)-2(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)}{\gamma y\alpha\theta_2(2-\delta)}$.

Case 2: firm 2 receives a signal

In the following we will characterize the necessary conditions under which when firm 2 preannounces, segment 2 consumers postpone and do not buy firm 2's existing product in the first period, and when firm 2 is silent, segment 2 consumers do not postpone and buy firm 2's existing product in the first period.

When firm 2 preannounces, consumers know that firm 2 will be able to develop the new product in the second period. In this case, given the prices of the firms, for segment 2 consumers to postpone the necessary condition is

$(1+\delta)(q+\Delta\theta_2-\gamma\theta_2(\frac{\Sigma-2\Delta}{3}))-(1+\delta)(\frac{3t+\theta_1\Delta(1+\gamma)}{3}) < \delta(q+x\Sigma\theta_2-(1-x)\theta_2\frac{\gamma\Sigma}{2})$. Therefore, we need $\Sigma > \frac{6q+2\Delta\theta_2(1+\delta)(3+2\gamma)-2(1+\delta)(3t+\Delta\theta_1(1+\gamma))}{\theta_2(6\delta x+\gamma(2-\delta+3x\delta))}$.

However, this condition is not sufficient for segment 2 consumers to postpone in the first period when firm 2 preannounces. We also need to guarantee that firm 2 does not decrease its price so low to convince segment 2 consumers to buy now. This can happen if firm 2 charges $p'_{F2,1}$ such that $(1+\delta)(q+\theta_2\Delta-\gamma\theta_2(\frac{\Sigma-2\Delta}{3}))-p'_{F2,1} > \delta(q+x\Sigma\theta_2-(1-x)\theta_2\frac{\gamma\Sigma}{2})$. If $p'_{F2,1} < \alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}+(1-x)\alpha\frac{(2+\gamma)}{2}\Sigma\theta_2$, then such thing will not happen. For this, it is sufficient to have $\Sigma > \frac{18t(q+\theta_2\Delta(1+\delta))+12\Delta\theta_2\gamma(1+\delta)-\alpha(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{3t\theta_2(6x\delta+6(1-x)\alpha+3\alpha\gamma(1-x)+2\gamma(1+\delta)-3(1-x)\gamma\delta)}$. Similarly, firm 1 may want to charge a lower price $p'_{F1,1}$ such that $(1+\delta)(q-\gamma\theta_2\frac{\Sigma+\Delta}{3})-p'_{F1,1} > \delta(q+x\Sigma\theta_2-(1-x)\theta_2\frac{\gamma\Sigma}{2})$ to convince segment 2 consumers to buy in the first period. If $p'_{F1,1} < \alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t}$, then firm 1 will not find it profitable to do so. For this, it is sufficient to have $\Sigma > \frac{18tq-6(1+\delta)\Delta\theta_2\gamma-\alpha(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{3t\theta_2(6x\delta+2\gamma(1+\delta)-3\gamma\delta(1-x))}$.

When firm 2 is silent, consumers may either think that firm 2 will not be able to develop the new product in the second period (i.e., Prob(firm 2 develops the new product|firm 2 is silent) = 0) or their posterior may be equal to their prior (i.e., Prob(firm 2 develops the new product|firm 2 is silent) = y).
If consumers think that firm 2 will not be able to develop the new product in the second period: In this case, given the prices of the firms, for segment 2 consumers not to postpone the necessary condition is $(1+\delta)(q+\Delta\theta_2-x\gamma\theta_2(\frac{\Sigma-2\Delta}{3}))-\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)}{3\alpha} > \delta(q-(1-x)\gamma\theta_2\frac{\Delta}{2}+x\theta_2(\frac{\Delta(2+\gamma)-\Sigma\gamma}{2})$. Therefore, we need $\Sigma < \frac{6q\alpha-2(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)+\alpha\Delta\theta_2(6+4x\gamma+\delta(6(1-x)+\gamma(3-2x)))}{\theta_2\alpha\gamma x(2-\delta)}$.
If consumers' posterior is equal to their prior: In this case, as in firm 1's case, if $\Sigma < \frac{6q\alpha-2(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)+\alpha\Delta\theta_2(2(1+\delta)(3+2\gamma(x+y-xy)-3\delta(1-y)(2x+\gamma(2x-1)))}{\alpha\theta_2(6\delta xy+\gamma((x+y-xy)(2-\delta)+3\delta xy))}$ then segment 2 consumers prefer not to postpone and buy in period 1.

All the conditions combined (i.e., the conditions from the benchmark case and the conditions from the case with phantom product effect):

$\frac{3t}{\Delta(1+\gamma)} > \theta_1 > \frac{(2-5\alpha)t}{\Delta\alpha}$,

$\max\left\{\frac{(4-\alpha)t+\Delta\theta_1\alpha}{3\Delta\alpha}, \frac{t+\Delta\theta_1}{\Delta}\right\} < \theta_2 < \min\{\frac{((4-\alpha)t+\alpha\Delta\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta t\theta_1}{18\alpha\Delta t(1-\alpha)}$, $\frac{((4-\alpha)t+\alpha\Delta\mu\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\mu t\theta_1}{18\alpha\Delta\mu t(1-\alpha)}$, $\frac{((4-\alpha)t+\alpha\Delta\psi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\psi t\theta_1}{18\alpha\Delta\psi t(1-\alpha)}$, $\frac{((4-\alpha)t+\alpha\Delta\varphi\theta_1)^2-6(2+\alpha)(1-\alpha)t^2+6\alpha(1-\alpha)\Delta\varphi t\theta_1}{18\alpha\Delta\varphi t(1-\alpha)}\}$,

$\Sigma > \max\{2\Delta, \frac{18t(q+\Delta\theta_2(1+\delta y))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\delta y\theta_2}, \frac{18t(q-\Delta\theta_2\delta(1-y))-\alpha(1+\delta)(3t-\Delta\theta_1)^2+18t\alpha\Delta\theta_2(1-y)}{18t\theta_2(\delta y+\alpha(1-y))}$, $\frac{18t(q+\theta_2\Delta(1+\delta))-\alpha(1+\delta)(3t+\Delta\theta_1)^2}{18t\theta_2(x\delta+(1-x)\alpha)}$, $\frac{18tq-\alpha(1+\delta)(3t-\Delta\theta_1)^2}{18t\delta x\theta_2}$, $\frac{18t(q+\Delta\theta_2(1+\delta y))-\alpha(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2+3t\Delta\theta_2(4+\delta(1+3y))}{3t\theta_2(6\delta y+\gamma(2-\delta+3\delta y))}$, $\frac{18t(q-\Delta\theta_2\delta(1-y))-\alpha(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2+9t\alpha\Delta\theta_2(1-y)(2+\gamma)-3\Delta\theta_2 t\gamma(2+\delta(5-3y))}{3t\theta_2(6\delta y+3\alpha(1-y)(2+\gamma)+\gamma(2-\delta(1-3y)))}$, $\frac{18t(q+\theta_2\Delta(1+\delta))+12\Delta\theta_2\gamma(1+\delta)-\alpha(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{3t\theta_2(6x\delta+6(1-x)\alpha+3\alpha\gamma(1-x)+2\gamma(1+\delta)-3(1-x)\gamma\delta)}$, $\frac{18tq-6(1+\delta)\Delta\theta_2\gamma-\alpha(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{3t\theta_2(6x\delta+2\gamma(1+\delta)-3\gamma\delta(1-x))}$, $\frac{3q+3(1+\delta)\Delta\theta_2-(1+\delta)(3t+\Delta\theta_1)}{3\delta x\theta_2}\}$,

$\min\{\frac{2q}{\theta_2\gamma}, \frac{6q-3(3t-\Delta(1+\gamma)\theta_1)-2\gamma\theta_1\Delta}{2\gamma\theta_1}, \frac{6q\alpha-3((2+\alpha)t-\Delta\theta_1\alpha\varphi)-\Delta\theta_1\alpha\gamma(3-(x+y-xy))}{2\theta_1\alpha\gamma(x+y-xy)}$, $\frac{3q\alpha-((4-\alpha)t+\alpha\Delta\theta_1\varphi)+\theta_2\Delta\alpha(3-2\gamma(x+y-xy))}{\theta_2\alpha\gamma(x+y-xy)}$, $\frac{6q\alpha-2(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1\mu)-\alpha\theta_2\Delta\gamma(3-y+2\delta y)}{y\alpha\theta_2\gamma(2-\delta)}$, $\frac{3q(1-\delta)-3t(3+\delta)-(1+\delta)\gamma\theta_1\Delta}{\theta_1(6\delta+\gamma(1+\delta))}$, $\frac{3q\alpha-(1+\delta)((4-\alpha)t+\alpha\theta_1\Delta)+3\theta_2\Delta\alpha(1+\delta(1-x(1-y)))}{3\alpha\delta\theta_2 xy}$, $\frac{3\alpha q+3\alpha\Delta\theta_2(1+\delta(1-x(1-y))-(1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)}{3\alpha yx\delta\theta_2}$, $\frac{6q\alpha-2(1+\delta)((4-\alpha)t+\alpha\theta_1\Delta\varphi)+\theta_2\alpha\Delta(2(1+\delta)(3+2\gamma(x+y-xy)-3\delta(1-y)(2x+\gamma(2x-1)))}{\theta_2\alpha(6\delta xy+\gamma((x+y-xy)(2-\delta)+3\delta xy)}\} > \Sigma$, and

$q > \max\{\frac{(2+\alpha)t-\alpha\Delta\theta_1}{2\alpha}, \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\theta_1)}{3\alpha}, (1+\delta)((4-\alpha)t+\alpha\Delta\theta_1)-3\theta_2\alpha\Delta(1+\delta(1-x))_{3\alpha}\}$.

We conduct the rest of the analysis in the parameter regin defined by the set of conditions above.

Proof of Lemma 3:

Benchmark case

We know that in case of announcement the first period price and market share of the product with quality q are equal to $\frac{(1+\delta)(3t-\Delta\theta_1)}{3}$ and $\frac{3t-\Delta\theta_1}{6t}$ respectively. In case of silence, the first period price and market share of the product with quality q is equal to $\frac{(1+\delta)((2+\alpha)t-\Delta\alpha\theta_1)}{3\alpha}$ and $\frac{(2+\alpha)t-\Delta\alpha\theta_1}{6t\alpha}$ respectively.

Thus, due to preannouncement, the decrease in the first period price of the product with quality q is equal to $\frac{2(1+\delta)(1-\alpha)t}{3\alpha}$ and the decrease in the first period market share of the product with quality q is equal to $\frac{1-\alpha}{3}$.

In case of phantom product effect

We know that in case of announcement the first period price and market share of the product with quality q are equal to $\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)}{3}$ and $\frac{3t-\Delta(1+\gamma)\theta_1}{6t}$ respectively. In case of silence, if firm 1 receives a signal and consumers think that firm 1 will not develop the new product, then the first period price and market share of the product with quality q is equal to $\frac{(1+\delta)((2+\alpha)t-\Delta\alpha\mu\theta_1)}{3\alpha}$ and $\frac{(2+\alpha)t-\Delta\alpha\mu\theta_1}{6t\alpha}$ respectively. In case of silence, if firm 2 receives a signal and consumers think that firm 2 will not develop the new product, then the first period price and market share of the product with quality q is equal to $\frac{(1+\delta)((2+\alpha)t-\Delta\alpha\psi\theta_1)}{3\alpha}$ and $\frac{(2+\alpha)t-\Delta\alpha\psi\theta_1}{6t\alpha}$ respectively. In case of silence, if consumers' posterior is equal to their prior, then the first period price and market share of the product with quality q is equal to $\frac{(1+\delta)((2+\alpha)t-\Delta\alpha\varphi\theta_1)}{3\alpha}$ and $\frac{(2+\alpha)t-\Delta\alpha\varphi\theta_1}{6t\alpha}$ respectively.

Thus, due to preannouncement, the decrease in the first period price of the product with quality q is equal to $\frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-y))}{6\alpha}$, $\frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x))}{6\alpha}$, or $\frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)(1-y))}{6\alpha}$ and the decrease in the first period market share of the product with quality q is equal to $\frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-y)}{12t}$, $\frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)}{12t}$, or $\frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)(1-y)}{12t}$.
One can see that $\min\left\{\frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-y))}{6\alpha}, \frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x))}{6\alpha}, \frac{(1+\delta)(4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)(1-y))}{6\alpha}\right\} > \frac{2(1+\delta)(1-\alpha)t}{3\alpha}$ and $\min\left\{\frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-y)}{12t}, \frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)}{12t}, \frac{4(1-\alpha)t+\alpha\Delta\theta_1\gamma(1-x)(1-y)}{12t}\right\} > \frac{1-\alpha}{3}$.□

Proof of Proposition 3:

Case 1: firm 1 receives a signal

In 'Announcement' equilibrium, when firm 1 learns that it will be able to develop the new product and preannounces, its profit is equal to $(1-\alpha)(1-y)\theta_2(\Sigma-\Delta)\frac{2+\gamma}{2}+(1+\delta)\alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t}$. If firm 1 deviates to silence it will receive profit of $\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)^2}{18\alpha t}$. Therefore, firm 1 will not deviate if $\Sigma > \Delta+\frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$.

In 'Always Silent' equilibrium, when firm 1 learns that it will be able to develop the new product and keeps its silence, its profit is equal to $\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\varphi\theta_1)^2}{18\alpha t}$. If firm 1 deviates and preannounces it will receive profit of $(1-\alpha)(1-y)\theta_2(\Sigma-\Delta)\frac{2+\gamma}{2}+(1+\delta)\alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t}$. Therefore, firm 1 deviates if $\Sigma > \Delta+\frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\varphi-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\varphi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$.
Thus, since $\varphi>\mu$, firm 1 prefers to preannounce if $\Sigma > \Delta+\frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$.

Recall that in the benchmark case, firm 1 prefers to preannounce if $\Sigma > \Delta+\frac{2(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}$.

Thus, by comparing $\frac{2(1+\delta)(t(1+2\alpha)-\Delta\theta_1\alpha)}{9\alpha(1-y)\theta_2}$ and $\frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$, one can show that if $\gamma > \gamma^* = \frac{4(\Delta\theta_1\alpha^2(1+y)(3t-\Delta\theta_1)-2t^2(1-\alpha)(1+2\alpha))}{(\Delta\theta_1\alpha)^2(1+y)(3+y)}$ firm 1 has more incentive to preannounce in case of phantom product effect than in the benchmark case.

However, note that $\frac{\partial\gamma^*}{\partial\alpha} > 0$ and $\lim_{\alpha\to 1}\gamma^* \to \frac{4(3t-\Delta\theta_1)}{(3+y)\Delta\theta_1}$. Recall that we need $\frac{3t}{\Delta(1+\gamma)} > \theta_1$. Therefore, since $\frac{4(3t-\Delta\theta_1)}{(3+y)\Delta\theta_1} > \frac{3t-\Delta\theta_1}{\Delta\theta_1}$, α should not be too high for $\gamma > \gamma^*$. Thus, there exists a α^* such that firm 1 has more incentive to preannounce in case of phantom product effect than in the benchmark case if $\gamma > \gamma^*$ and $\alpha < \alpha^*$.

Case 2: firm 2 receives a signal

In 'Announcement' equilibrium, when firm 2 learns that it will be able to develop the new product and preannounces, its profit is equal to $(1-\alpha)(1-x)\theta_2\Sigma\frac{2+\gamma}{2} + (1+\delta)\alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}$. If firm 2 deviates to silence it will receive profits of $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)^2}{18\alpha t}$. Therefore, firm 2 will not deviate if $\Sigma > \frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\psi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\psi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}$.

In 'Always Silent' equilibrium, when firm 2 learns that it will be able to develop the new product and keeps its silence, its profit is equal to $\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\varphi\theta_1)^2}{18\alpha t}$. If firm 2 deviates and preannounces it will receive profits of $(1-\alpha)(1-x)\theta_2\Sigma\frac{2+\gamma}{2} + (1+\delta)\alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}$. Therefore, firm 2 deviates if $\Sigma > \frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\varphi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\varphi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}$.

Furthermore, when firm 2 learns that it will be able to develop the new product, it can deviate from this equilibrium also by increasing its price an ε in the first period. However, if firm 2's profit from segment 2 in the first period is higher than its expected profit from segment 2 in the second period then firm 2 will not deviate. This means that if $\frac{(4-\alpha)t+\alpha\varphi\Delta\theta_1}{3\alpha} > (1-x)\theta_2\Sigma\frac{2+\gamma}{2}$ (i.e., $\Sigma < \frac{2((4-\alpha)t+\alpha\varphi\Delta\theta_1)}{3\alpha(1-x)(2+\gamma)\theta_2}$) then firm 2 will not deviate. Therefore, for this equilibrium to exist we need $\Sigma < \min\left\{\frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\varphi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\varphi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}, \frac{2((4-\alpha)t+\alpha\varphi\Delta\theta_1)}{3\alpha(1-x)(2+\gamma)\theta_2}\right\}$.

Thus, since $\varphi > \psi$, firm 2 prefers to preannounce if $\Sigma > \frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\psi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\psi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}$. Recall that in the benchmark case, firm 2 prefers to preannounce if $\Sigma > \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}$. One can show that $\frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\psi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\psi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2} < \frac{4(1+\delta)((2+\alpha)t+\Delta\theta_1\alpha)}{9\alpha(1-x)\theta_2}$. This means that firm 2 has more incentive to preannounce in case of phantom product effect than in the benchmark case.□

Proof of Corollary 3:

Note that $\lim_{\alpha\to 1}(1-\alpha)(1-x)\theta_2\Sigma\frac{2+\gamma}{2} + (1+\delta)\alpha\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t} \to (1+\delta)\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t}$ and $\lim_{\alpha\to 1}\frac{(1+\delta)((4-\alpha)t+\alpha\Delta\psi\theta_1)^2}{18\alpha t} \to \frac{(1+\delta)(3t+\Delta\psi\theta_1)^2}{18t}$. Since $\psi < 1+\gamma$, $(1+\delta)\frac{(1+\delta)(3t+\Delta(1+\gamma)\theta_1)^2}{18t} > \frac{(1+\delta)(3t+\Delta\psi\theta_1)^2}{18t}$.□

Proof of Proposition 4:

First, for firm 2 to have more incentive to preannounce than firm 1, $\frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\psi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\psi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}$ has to be less than $\Delta + \frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$.

For this, we need $\gamma > \frac{(1-\alpha)(4t+4\Delta\theta_1\alpha-6\alpha(1-x)\Delta\theta_2)}{\alpha\Delta(3\theta_2(1-\alpha)(1-x)+2\theta_1(2\alpha-1-x))}$ and $x < \frac{3(1-\alpha)\theta_2+2\theta_1(2\alpha-1)}{3\theta_2(1-\alpha)+2\theta_1}$. Second, let $\Sigma = B + \rho$, where $B = \frac{(1+\delta)(4(1-\alpha)t+\alpha\theta_1\Delta(\psi-1-\gamma))(2(2+\alpha)t+\Delta\theta_1\alpha(\psi+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-x)\theta_2}$. Then, for firm 2 to have more incentive to preannounce than firm 1, we need $B+\rho-\Delta < A$, where $A = \frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2}$. Given that $\Sigma > 2\Delta$, Σ must be greater than $2B + 2\rho - 2A$. Since $\Sigma = B + \rho$, this means that $2A$ must be greater than $B + \rho$. Note that $2A > B$ if $\gamma > \frac{4(1-\alpha)(2t(1-\alpha)+\Delta\theta_1\alpha)}{\alpha\Delta\theta_1(1+8\alpha-x(5+4\alpha))}$ and $x < \frac{1+8\alpha}{5+4\alpha}$.

As a result, for firm 2 to have more incentive to preannounce than firm 1, $\gamma > \hat{\gamma} = \max\left\{\frac{(1-\alpha)(4t+4\Delta\theta_1\alpha-6\alpha(1-x)\Delta\theta_2)}{\alpha\Delta(3\theta_2(1-\alpha)(1-x)+2\theta_1(2\alpha-1-x))}, \frac{4(1-\alpha)(2t(1-\alpha)+\Delta\theta_1\alpha)}{\alpha\Delta\theta_1(1+8\alpha-x(5+4\alpha))}\right\}$ and $x < \hat{x} = \min\{\frac{3(1-\alpha)\theta_2+2\theta_1(2\alpha-1)}{3\theta_2(1-\alpha)+2\theta_1}, \frac{1+8\alpha}{5+4\alpha}\}$.

Numerical example: if $t = 0.9$, $\Delta = 1.5$, $q = 100$, $74 < \Sigma < 89.35$, $\theta_1 = 1.5$, $\theta_2 = 8$, $\alpha = 0.9$, $\delta = 0.32$, $\gamma = 0.15$, $x = 0.6$, and $y = 0.6$, then all the conditions above hold, firm 1 has more incentive to preannounce in case of phantom product effect than in the benchmark case, and firm 2 has more incentive to preannounce than firm 1 in case of phantom product effect (i.e., the results in Propositions 3 and 4 exist).□

Proof of Proposition 5:

As we know from the proof of Proposition 3, firm 1's profit gain from preannouncement is equal to $(1-\alpha)(1-y)\theta_2(\Sigma-\Delta)\frac{2+\gamma}{2} + (1+\delta)\alpha\frac{(1+\delta)(3t-\Delta(1+\gamma)\theta_1)^2}{18t} - \frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)^2}{18\alpha t}$. It is obvious that both $(1-\alpha)(1-y)\theta_2(\Sigma-\Delta)\frac{2+\gamma}{2}$ and $\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)^2}{18\alpha t}$ decrease in y. However, if $\Sigma < \bar{\Sigma} = \Delta + \frac{\Delta\theta_1(1+\delta)\gamma(2(2+\alpha)t-\alpha\Delta\theta_1(2+\gamma(1+y)))}{18t\theta_2(2+\gamma)(1-\alpha)}$, then $\left|\frac{\partial((1-\alpha)(1-y)\theta_2(\Sigma-\Delta)\frac{2+\gamma}{2})}{\partial y}\right| < \left|\frac{\partial(\frac{(1+\delta)((2+\alpha)t-\alpha\Delta\mu\theta_1)^2}{18\alpha t})}{\partial y}\right|$. Given the proof of Proposition 3, this means that if $\Delta + \frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2} < \Sigma < \bar{\Sigma}$ firm 1 prefers to preannounce and its profit gain from preannouncement increases as y increases. One can show that for $t = 0.9$, $\Delta = 5$, $q = 100$, $30 < \Sigma < 40$, $\theta_1 = 0.4$, $\theta_2 = 25$, $\alpha = 0.9999$, $\delta = 0.7$, $\gamma = 0.2$, $x = 0.6$, and $y = 0.6$ all the conditions above hold and $\Delta + \frac{(1+\delta)(2(1-\alpha)t-\alpha\theta_1\Delta(\mu-1-\gamma))(2(1+2\alpha)t-\Delta\theta_1\alpha(\mu+1+\gamma))}{9t\alpha(1-\alpha)(2+\gamma)(1-y)\theta_2} < \Sigma < \bar{\Sigma}$.□