Technical Appendix for:

New Product Preannouncement: Phantom Products and the Osborne Effect

May 7, 2018

Technical Appendix

In the following we will provide the analysis for: (1) whether Proposition 5 can be replicated in case of monopoly, (2) whether the results in Propositions 5 and 6 (i.e., the shift from Section 4 to Section 5) can be derived by just adding λ to quality sensitivity θ, and (3) whether the results in Propositions 5 and 6 change if $\Sigma < \Delta$.

1 Monopoly Case

Lets check firms' first period profits after NPP in case of competition. Remember that after NPP segment 2 consumers postpone and segment 1 consumers buy in the first period. We will calculate the profits first ignoring the reference effect. That means following NPP the reference quality in the first period will stay the same as $\frac{\Delta}{2}$. In this case, $\pi_H = (1-\alpha)\frac{(2\Delta\theta_1+\varphi)^2}{9\Delta\theta_1}$ and $\pi_L = (1-\alpha)\frac{(\Delta\theta_1-\varphi)^2}{9\Delta\theta_1}$, where $\varphi = \frac{3\Delta\lambda}{2}$, where π_H denote the first period profits of the firm with currently higher product quality and π_L denote the first period profits of the firm with currently lower product quality.

However, remember that if one takes into consideration the reference effect then firms' profits in the first period following NPP would be equal to $\pi_H = (1-\alpha)\frac{(2\Delta\theta_1+\psi)^2}{9\Delta\theta_1}$ and $\pi_L = (1-\alpha)\frac{(\Delta\theta_1-\psi)^2}{9\Delta\theta_1}$, where $\psi = \frac{(4\Delta+\Sigma)\lambda}{3}$, if $\Sigma < 2\Delta$ and equal to $\pi_H = (1-\alpha)\frac{(2\Delta\theta_1+\rho)^2}{9\Delta\theta_1}$ and $\pi_L = (1-\alpha)\frac{(\Delta\theta_1-\rho)^2}{9\Delta\theta_1}$, where $\rho = 2\Delta\lambda$, if $\Sigma > 2\Delta$.

Comparing the competition profits in the absence of reference effect with the ones in the presence of it, one can see that $\frac{(2\Delta\theta_1+\psi)^2}{9\Delta\theta_1} > \frac{(2\Delta\theta_1+\varphi)^2}{9\Delta\theta_1}$, $\frac{(\Delta\theta_1-\varphi)^2}{9\Delta\theta_1} > \frac{(\Delta\theta_1-\psi)^2}{9\Delta\theta_1}$, $\frac{(2\Delta\theta_1+\rho)^2}{9\Delta\theta_1} > \frac{(2\Delta\theta_1+\varphi)^2}{9\Delta\theta_1}$, and $\frac{(\Delta\theta_1-\varphi)^2}{9\Delta\theta_1} > \frac{(\Delta\theta_1-\rho)^2}{9\Delta\theta_1}$. This means that the reference effect of NPP increases π_H and decreases π_L.

In order to validate whether in monopoly we can replicate the result in Proposition 5 one needs to show that there exist two sets of conditions; under one set of conditions the impact of reference effect on the monopolist's first period profits should be positive and under the other set of conditions the impact of reference effect on the monopolist's first period profits should be negative. Then we can conclude that due to reference effect the monopolist firm's incentive to preannounce sometimes increases and sometimes decreases.

Lets first solve for what happens if one ignores the reference effect: Let π_M denote the monopolist's profits in the absence of reference effect.

If in the first period monopolist sells only the high quality product (i.e., the product $v+\Delta$) and the market is not covered: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Delta}{2}$ vs. Δ) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_M = (1-\alpha)\frac{(\Delta\theta_1+v+\lambda\frac{\Delta}{2})^2}{4\Delta\theta_1}$. Note that for this to happen we need $\Delta\theta_1 > v+\lambda\frac{\Delta}{2}$.

If in the first period monopolist sells product line (both the basic product and the product $v+\Delta$): $\pi_M = (1-\alpha)\left(v+\frac{\Delta(4\theta_1^2-4\lambda\theta_1+9\lambda^2)}{16\theta_1}\right)$. Note that for this to happen we need $v > \lambda\Delta$ and $\theta_1 > \frac{3\lambda}{2}$.

If in the first period monopolist sells only the high quality product and covers the market: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Delta}{2}$ vs. Δ) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_M = (1-\alpha)(v+\lambda\frac{\Delta}{2})$.

Obviously,

for $v > \lambda\Delta$: the monopolist prefers to sell product line if $\theta_1 > \frac{3\lambda}{2}$ and sell only the high quality product and cover the market otherwise.

for $v < \lambda\Delta$: the monopolist prefers to sell only the high quality product and market is not covered if $\Delta\theta_1 > v+\lambda\frac{\Delta}{2}$ and it prefers to sell only the high quality product and cover the market otherwise.

Next, we solve for what happens if one takes into consideration the reference effect: Let $\pi_{M,R}$ denote the monopolist's profits in the presence of reference effect.

For $\Sigma < 2\Delta$:

If in the first period monopolist sells only the high quality product and the market is not covered: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Sigma+\Delta}{2}$ vs. $\frac{\Sigma+\Delta}{3}$) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_{M,R} = (1-\alpha)\frac{(\Delta\theta_1+v+\lambda\frac{(2\Delta-\Sigma)}{3})^2}{4\Delta\theta_1}$. Note that for this to happen we need $\Delta\theta_1 > v+\lambda\frac{(2\Delta-\Sigma)}{3}$.

If in the first period monopolist sells product line: $\pi_{M,R} = (1-\alpha)\left(v+\frac{9(\Delta\theta_1)^2-18\lambda\Delta\theta_1\Sigma+\lambda^2(4\Delta+\Sigma)^2}{36\Delta\theta_1}\right)$. Note that for this to happen we need $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 > \frac{\lambda(4\Delta+\Sigma)}{3\Delta}$.

If in the first period monopolist sells only the high quality product and covers the market: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Sigma+\Delta}{2}$ vs. $\frac{\Sigma+\Delta}{3}$) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_{M,R} = (1-\alpha)(v+\lambda\frac{(2\Delta-\Sigma)}{3})$.

Obviously,

for $v > \frac{2\lambda(\Sigma+\Delta)}{3}$: the monopolist prefers to sell product line if $\theta_1 > \frac{\lambda(4\Delta+\Sigma)}{3\Delta}$ and sell only the high quality product and cover the market otherwise.

for $v < \frac{2\lambda(\Sigma+\Delta)}{3}$: the monopolist prefers to sell only the high quality product and market is not covered if $\Delta\theta_1 > v + \lambda\frac{(2\Delta-\Sigma)}{3}$ and it prefers to sell only the high quality product and cover the market otherwise.

For $\Sigma > 2\Delta$:

If in the first period monopolist sells only the high quality product and the market is not covered: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Sigma+\Delta}{2}$ vs. $\frac{\Sigma+\Delta}{3}$) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_{M,R} = (1-\alpha)\frac{(\Delta\theta_1+v-2\lambda\frac{(\Sigma-2\Delta)}{3})^2}{4\Delta\theta_1}$. Note that for this to happen we need $\Delta\theta_1 > v - 2\lambda\frac{(\Sigma-2\Delta)}{3}$.

If in the first period monopolist sells product line: $\pi_{M,R} = (1-\alpha)\left(v + \frac{3\Delta\theta_1^2-4\lambda\theta_1(2\Sigma-\Delta)+12\lambda^2\Delta}{12\theta_1}\right)$. Note that for this to happen we need $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 > 2\lambda$.

If in the first period monopolist sells only the high quality product and covers the market: In this case even if the monopolist prefers to sell only its currently available higher quality product $v+\Delta$ it is better off offering the basic product, but at an unreasonably high price as well. This way the reference quality would be lower ($\frac{\Sigma+\Delta}{2}$ vs. $\frac{\Sigma+\Delta}{3}$) and the monopolist can extract a higher rent for its higher quality product. Thus, $\pi_M = (1-\alpha)(v - 2\lambda\frac{(\Sigma-2\Delta)}{3})$.

Obviously,

for $v > \frac{2\lambda(\Sigma+\Delta)}{3}$: the monopolist prefers to sell product line if $\theta_1 > 2\lambda$ and sell only the high quality product and cover the market otherwise.

for $v < \frac{2\lambda(\Sigma+\Delta)}{3}$: the monopolist prefers to sell only the high quality product and market is not covered if $\Delta\theta_1 > v - 2\lambda\frac{(\Sigma-2\Delta)}{3}$ and it prefers to sell only the high quality product and cover the market otherwise.

Next, we will compare the monopolist's profits in the absence of reference effect with its profits in the presence of reference effect.

Case of $\Sigma < 2\Delta$:

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 > \frac{\lambda(4\Delta+\Sigma)}{3\Delta}$: both in the absence and in the presence of reference effect the monopolist prefers to sell product line. Thus, $\pi_M = (1-\alpha)\left(v + \frac{\Delta(4\theta_1^2-4\lambda\theta_1+9\lambda^2)}{16\theta_1}\right) > \pi_{M,R} = (1-\alpha)\left(v + \frac{9(\Delta\theta_1)^2-18\lambda\Delta\theta_1\Sigma+\lambda^2(4\Delta+\Sigma)^2}{36\Delta\theta_1}\right)$.

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\frac{\lambda(4\Delta+\Sigma)}{3\Delta} > \theta_1 > \frac{3\lambda}{2}$: the monopolist prefers to sell product line in the absence of reference effect and prefers to sell only the high quality product and cover the market in the presence of it. Thus, $\pi_M = (1-\alpha)\left(v + \frac{\Delta(4\theta_1^2-4\lambda\theta_1+9\lambda^2)}{16\theta_1}\right) > \pi_{M,R} = (1-\alpha)(v + \lambda\frac{(2\Delta-\Sigma)}{3})$.

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 < \frac{3\lambda}{2}$: both in the absence and in the presence of reference effect the monopolist prefers to sell only the high quality product and cover the market. Thus, $\pi_M = (1-\alpha)(v+\lambda\frac{\Delta}{2}) > \pi_{M,R} = (1-\alpha)(v+\lambda\frac{(2\Delta-\Sigma)}{3})$.

For $\frac{2\lambda(\Sigma+\Delta)}{3} > v$: for these values in the presence of reference effect the monopolist prefers to sell only its high quality product. Depending on whether θ_1 is greater or less than $v+\lambda\frac{(2\Delta-\Sigma)}{3}$, it prefers to cover the market or not. However, one can show that under either product strategy the monopolist's profits are higher in the absence of reference effect than in the presence of it. One can see this from $\pi_M = (1-\alpha)\frac{(\Delta\theta_1+v+\lambda\frac{\Delta}{2})^2}{4\Delta\theta_1} > \pi_{M,R} = (1-\alpha)\frac{(\Delta\theta_1+v+\lambda\frac{(2\Delta-\Sigma)}{3})^2}{4\Delta\theta_1}$ and $\pi_M = (1-\alpha)(v+\lambda\frac{\Delta}{2}) > \pi_{M,R} = (1-\alpha)(v+\lambda\frac{(2\Delta-\Sigma)}{3})$.

This proves that the impact of reference effect of NPP on the monopolist's first period profits is negative when $\Sigma < 2\Delta$.

Case of $\Sigma > 2\Delta$:

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 > 2\lambda$: both in the absence and in the presence of reference effect the monopolist prefers to sell product line. Thus, $\pi_M = (1-\alpha)\left(v+\frac{\Delta(4\theta_1^2-4\lambda\theta_1+9\lambda^2)}{16\theta_1}\right) > \pi_{M,R} = (1-\alpha)\left(v+\frac{3\Delta\theta_1^2-4\lambda\theta_1(2\Sigma-\Delta)+12\lambda^2\Delta}{12\theta_1}\right)$.

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $2\lambda > \theta_1 > \frac{3\lambda}{2}$: the monopolist prefers to sell product line in the absence of reference effect and prefers to sell only the high quality product and cover the market in the presence of it. Thus, $\pi_M = (1-\alpha)\left(v+\frac{\Delta(4\theta_1^2-4\lambda\theta_1+9\lambda^2)}{16\theta_1}\right) > \pi_{M,R} = (1-\alpha)(v-2\lambda\frac{(\Sigma-2\Delta)}{3})$.

For $v > \frac{2\lambda(\Sigma+\Delta)}{3}$ and $\theta_1 < \frac{3\lambda}{2}$: both in the absence and in the presence of reference effect the monopolist prefers to sell only the high quality product and cover the market. Thus, $\pi_M = (1-\alpha)(v+\lambda\frac{\Delta}{2}) > \pi_{M,R} = (1-\alpha)(v-2\lambda\frac{(\Sigma-2\Delta)}{3})$.

For $\frac{2\lambda(\Sigma+\Delta)}{3} > v$: for these values in the presence of reference effect the monopolist prefers to sell only its high quality product. Depending on whether θ_1 is greater or less than $v-2\lambda\frac{(\Sigma-2\Delta)}{3}$, it prefers to cover the market or not. However, one can show that under either product strategy the monopolist's profits are higher in the absence of reference effect than in the presence of it. One can see this from $\pi_M = (1-\alpha)\frac{(\Delta\theta_1+v+\lambda\frac{\Delta}{2})^2}{4\Delta\theta_1} > \pi_{M,R} = (1-\alpha)\frac{(\Delta\theta_1+v-2\lambda\frac{(\Sigma-2\Delta)}{3})^2}{4\Delta\theta_1}$ and $\pi_M = (1-\alpha)(v+\lambda\frac{\Delta}{2}) > \pi_{M,R} = (1-\alpha)(v-2\lambda\frac{(\Sigma-2\Delta)}{3})$.

This proves that the impact of reference effect of NPP on the monopolist's first period profits is negative when $\Sigma > 2\Delta$.

This analysis shows that the impact of reference effect of NPP on the monopolist's first period profits is always negative. This means that the presence of reference effect can never increase a monopolist's incentive to preannounce. Therefore, the result in Proposition 5 cannot be replicated in case of monopoly.$\square$

2 Increasing quality sensitivity

In this section we will show that the change from Proposition 2 to Proposition 5 and the change from Proposition 3 to Proposition 6 cannot happen just by simply changing the sensitivity to quality from θ to $\theta+\lambda$. When one changes the sensitivity to quality to $\theta+\lambda$, in the modified model consumer utility becomes equal to $v+(\theta+\lambda)Q-p$, where p is price and $Q=\{0,\Delta,\Sigma\}$.

By following the same logic as in the original model, we first characterize the conditions for preannouncement-equilibrium to be unique both in Case 1 and Case 2. The conditions are:

$\min\left\{\frac{\Delta(3(1-\alpha)^2+4\delta_F(1-2\alpha-\alpha^2))}{4\delta_F(1-2\alpha-\alpha^2)},\frac{3\Delta(1-\alpha)^2}{2\delta_F(1-2\alpha-\alpha^2)},\frac{3v(1-\delta)-\Delta(\theta_1+\lambda)}{3\delta(\theta_1+\lambda)},\frac{3(1-\alpha)v}{(1+\alpha)(\theta_1+\lambda)}\right\}>\Sigma>$
$\max\left\{\frac{3(1-\alpha)((\theta_2+\lambda)\Delta+v(1-\delta))}{\delta(3(1-\alpha)(\theta_2+\lambda)-2(1+\alpha)(\theta_1+\lambda))},\frac{5\Delta}{4}\right\}$

$v>\max\left\{\frac{2\Delta(\theta_1+\lambda)}{3(1-\alpha)(1-\delta)},\frac{(1+3\delta(1-\alpha))\Delta(\theta_1+\lambda)}{3(1-\alpha)(1-\delta)}\right\}$

$\frac{(1+\alpha)(2-\alpha)}{9\alpha(1-\alpha)}(\theta_1+\lambda)>(\theta_2+\lambda)>\frac{2(1+\alpha)}{3(1-\alpha)}(\theta_1+\lambda)$

$x<\hat{x}$, where $\delta(v+\hat{x}(\Sigma(\theta_2+\lambda)-\frac{2(1+\alpha)(\theta_1+\lambda)(\Sigma-\Delta)}{3(1-\alpha)})+(1-\hat{x})(\Delta(\theta_2+\lambda)-\frac{2(1+\alpha)(\theta_1+\lambda)\Delta}{3(1-\alpha)}))=v+\Delta(\theta_2+\lambda)-\frac{2\Delta(\theta_1+\lambda)}{3}$.

$\delta_F<\frac{2-\alpha}{2+\alpha}$

$\alpha<\frac{1}{2}$

Additionally, in Case 1 we need $\Sigma>\Delta(1+\frac{(2-\alpha)}{4\delta_F(2+\alpha)})$ so that firm 1 preannounces when it learns that it will be able to develop the new product and does not deviate to silence and similarly, in Case 2 we need $\Sigma>\frac{\Delta(2-\alpha)}{\delta_F(2+\alpha)}$ so that firm 2 preannounces when it learns that it will be able to develop the new product and does not deviate to silence.

One can show that $\frac{\Delta(2-\alpha)}{\delta_F(2+\alpha)}>\Delta(1+\frac{(2-\alpha)}{4\delta_F(2+\alpha)})$ if $\delta_F<\frac{3(2-\alpha)}{4(2+\alpha)}$. This means that if $\delta_F<\frac{3(2-\alpha)}{4(2+\alpha)}$, as in Proposition 2, firm 1 has a higher incentive to preannounce than firm 2.
Therefore, as in Proposition 2, if $\min\left\{\frac{\Delta(3(1-\alpha)^2+4\delta_F(1-2\alpha-\alpha^2))}{4\delta_F(1-2\alpha-\alpha^2)},\frac{3\Delta(1-\alpha)^2}{2\delta_F(1-2\alpha-\alpha^2)},\frac{3v(1-\delta)-\Delta(\theta_1+\lambda)}{3\delta(\theta_1+\lambda)},\frac{3(1-\alpha)v}{(1+\alpha)(\theta_1+\lambda)}\right\}>\frac{\Delta(2-\alpha)}{\delta_F(2+\alpha)}>\max\{\frac{3(1-\alpha)((\theta_2+\lambda)\Delta+v(1-\delta))}{\delta(3(1-\alpha)(\theta_2+\lambda)-2(1+\alpha)(\theta_1+\lambda))},\frac{5\Delta}{4}\}$ and $\delta_F<\frac{3(2-\alpha)}{4(2+\alpha)}$ then for every Σ value firm 2 prefers to preannounce so does firm 1 and there exist Σ values for which firm 2 does not prefer to preannounce, but firm 1 does.

One can show that:

$\delta_F<\frac{3(2-\alpha)}{4(2+\alpha)}$,

$\min\left\{\frac{\Delta(3(1-\alpha)^2+4\delta_F(1-2\alpha-\alpha^2))}{4\delta_F(1-2\alpha-\alpha^2)},\frac{3\Delta(1-\alpha)^2}{2\delta_F(1-2\alpha-\alpha^2)},\frac{3v(1-\delta)-\Delta(\theta_1+\lambda)}{3\delta(\theta_1+\lambda)},\frac{3(1-\alpha)v}{(1+\alpha)(\theta_1+\lambda)}\right\}>\frac{\Delta(2-\alpha)}{\delta_F(2+\alpha)}>$
$\max\left\{\frac{3(1-\alpha)((\theta_2+\lambda)\Delta+v(1-\delta))}{\delta(3(1-\alpha)(\theta_2+\lambda)-2(1+\alpha)(\theta_1+\lambda))},\frac{5\Delta}{4}\right\}$,

$v>\max\left\{\frac{2\Delta(\theta_1+\lambda)}{3(1-\alpha)(1-\delta)},\frac{(1+3\delta(1-\alpha))\Delta(\theta_1+\lambda)}{3(1-\alpha)(1-\delta)}\right\}$,

$\frac{(1+\alpha)(2-\alpha)}{9\alpha(1-\alpha)}(\theta_1+\lambda)>(\theta_2+\lambda)>\frac{2(1+\alpha)}{3(1-\alpha)}(\theta_1+\lambda)$,

$x<\hat{x}$,

$\alpha < \frac{1}{2}$ conditions can hold simultaneously.

Note that the only difference between these conditions and the set of conditions in the benchmark case of the original model (please see page 36 of the paper) is the transformation of θ_1 and θ_2 to $\theta_1 + \lambda$ and $\theta_2 + \lambda$ respectively. Therefore, by following the same logic as in the benchmark case one can show that the conditions above can hold simultaneously.

Furthermore, in Case 1, firm 1's equilibrium profits are equal to $(1-\alpha)\frac{\Delta(\theta_1+\lambda)}{9} + \frac{\delta_F 4(1+\alpha)^2(\Sigma-\Delta)(\theta_1+\lambda)}{9(1-\alpha)}$ if it preannounces and successfully develops the new product. However, after learning that it will be able to develop the new product if firm 1 deviates and not preannounces then its profits are equal to $\frac{\Delta(\theta_1+\lambda)}{9(1-\alpha)} + \frac{\delta_F 4(\Sigma-\Delta)(\theta_1+\lambda)}{9(1-\alpha)}$. Thus, firm 1's profit gain from preannouncing is equal to $\frac{\alpha(\theta_1+\lambda)(\delta_F 4(2+\alpha)(\Sigma-\Delta)-\Delta(2-\alpha))}{9(1-\alpha)}$. One can see that $\frac{\partial(\frac{\alpha(\theta_1+\lambda)(\delta_F 4(2+\alpha)(\Sigma-\Delta)-\Delta(2-\alpha))}{9(1-\alpha)})}{\partial\Sigma} > 0$. Similarly, in Case 2, firm 2's equilibrium profits are equal to $(1-\alpha)\frac{4\Delta(\theta_1+\lambda)}{9} + \frac{\delta_F 4(1+\alpha)^2\Sigma(\theta_1+\lambda)}{9(1-\alpha)}$ if it preannounces and successfully develops the new product. However, after learning that it will be able to develop the new product if firm 2 deviates and not preannounces then its profits are equal to $\frac{4\Delta(\theta_1+\lambda)}{9(1-\alpha)} + \frac{\delta_F 4\Sigma(\theta_1+\lambda)}{9(1-\alpha)}$. Thus, firm 2's profit gain from preannouncing is equal to $\frac{4\alpha(\theta_1+\lambda)(\delta_F(2+\alpha)\Sigma-\Delta(2-\alpha))}{9(1-\alpha)}$. One can see that $\frac{\partial(\frac{4\alpha(\theta_1+\lambda)(\delta_F(2+\alpha)\Sigma-\Delta(2-\alpha))}{9(1-\alpha)})}{\partial\Sigma} > 0$.

This proves that the results in Section 4 (Propositions 2 and 3) stay the same and the results in Section 5 (Propositions 5 and 6) cannot be derived if one just increases the sensitivity to quality by λ.□

3 What if the new product is not higher quality than currently existing products?

In this section we will investigate whether the results in Propositions 5 and 6 change if the quality of the new product Σ is lower than Δ.

Let $\hat{\Delta}$ represents the quality of the new product, where $\hat{\Delta} < \Delta$. Following the preannouncement of the new product with quality $\hat{\Delta}$ the reference quality in the fist period will be updated to $\frac{\Delta+\hat{\Delta}}{3}$. Note that $\frac{\Delta+\hat{\Delta}}{3} < \frac{\Delta}{2}$, where $\frac{\Delta}{2}$ is the reference quality without preannouncement, only if $\hat{\Delta} < \frac{\Delta}{2}$.

When firm 1 preannounces $\hat{\Delta}$, if $\hat{\Delta} < \frac{\Delta}{2}$ then the reference quality in the first period will decrease. Such a drop in the reference quality will positively affect firm 1's sales in the first period. Note that if $\hat{\Delta} = \Delta + \varepsilon$ the preannouncement of the new product will cause the largest drop in the first period reference quality. In this case, even if no consumer wants to postpone his purchase firm 1 will gain from preannouncement just because of this significant decrease in the reference quality. Naturally, as $\hat{\Delta}$ increases the decrease in the reference quality following NPP will be smaller and if $\hat{\Delta} > \frac{\Delta}{2}$ then NPP will cause an increase in the first period reference quality. This means that for the results in Propositions 5 and 6 to be challenged $\hat{\Delta}$ should be less than $\frac{\Delta}{2}$.

Recall that Proposition 6 shows that as the quality of the new product increases, unlike the benchmark case, the gain from preannouncement for firm 1 may decrease. This happens because following the preannouncement the reference quality in the first period increases and this increase will be higher as the quality of the new product increases. As a result, firm 1's profits in first period suffer.

When $\hat{\Delta} < \frac{\Delta}{2}$, unlike in the original model, the preannouncement can lead to increase in firm 1's first period profits as a result of decrease in the first period reference quality. However, note that as the quality of the new product increases the decrease in the first period reference quality due to preannoucement will be smaller. Therefore, the result in Proposition 6 does not disappear. Think about the simplest case in which $\hat{\Delta} = \varepsilon$ and δ is low enough hence no consumer postpones his purchase. As mentioned above, in such case preannouncement has a positive effect on the first period sales of firm 1 by decreasing the reference quality, however, as $\hat{\Delta}$ increases the decrease in reference quality in the first period will be smaller. As a result, as $\hat{\Delta}$ increases the gain from preannouncement decreases.

Remember that Proposition 5 shows that unlike the benchmark case, in equilibrium firm 2 prefers to preannounce, but not firm 1. This happens because as a result of the upward shift in the first period reference quality (i.e., reference effect) firm 2's profits in the first period increases while firm 1's profits decrease, thus for the same parameter values firm 2 may have a higher gain from preannouncement than firm 1 does. First, note that preannouncement can harm firm 2's first period profits due to decrease in the first period reference quality only when $\hat{\Delta} < \frac{\Delta}{2}$. Therefore, to confirm whether the result in Proposition 5 changes or not first we need to show that regardless of preannouncement considerations firm 2 is willing to develop a new product with quality $\hat{\Delta} < \frac{\Delta}{2}$. For that we investigate firm 2's profits when it launches the new product with quality $\hat{\Delta} < \Delta$.

First, recall that in the absence of new product firm 2 can receive profits of $\alpha\theta_2\Delta$ by just selling its old product to segment 2 consumers or profits of $\frac{4\theta_1}{9(1-\alpha)}$ by selling its old product to segment 2 consumers and segment 1 consumers with high enough willingness to pay for extra quality.

Scenario 1: Firm 2 sells its product with quality Δ to segment 2 consumers and the new product with quality $\hat{\Delta} < \Delta$ to segment 1 consumers. In this case firm 2's profits, when it launches the new product, are equal to $\alpha\theta_2(\Delta - \hat{\Delta}) + \frac{4\hat{\Delta}\theta_1}{9(1-\alpha)}$. Naturally, firm 2 will prefer to sell product line after launching its new product. Note that $\frac{4\Delta\theta_1}{9(1-\alpha)} < \alpha\theta_2(\Delta - \hat{\Delta}) + \frac{4\hat{\Delta}\theta_1}{9(1-\alpha)}$ if $\alpha\theta_2 > \frac{4\theta_1}{9(1-\alpha)}$. However, $\alpha\theta_2\Delta > \alpha\theta_2(\Delta - \hat{\Delta}) + \frac{4\hat{\Delta}\theta_1}{9(1-\alpha)}$ for $\alpha\theta_2 > \frac{4\theta_1}{9(1-\alpha)}$.

Scenario 2: Firm 2 sells its old product to both segment 2 consumers and segment 1 consumers with high enough willingness to pay, and sells its new product with $\hat{\Delta} < \Delta$ to segment 1 consumers with lower willingness to pay. In this case, firm 2's profits when it launches the new product are equal to $\frac{\theta_1(9\Delta + 7\hat{\Delta})}{36(1-\alpha)}$. One can show that $\frac{4\Delta\theta_1}{9(1-\alpha)} > \frac{\theta_1(9\Delta + 7\hat{\Delta})}{36(1-\alpha)}$.

Scenario 3: Firm 2 sells to the whole market. In this case,

- if firm 2 chooses to sell its old product only to segment 2 consumers its profits when it launches the new product with quality $\hat{\Delta} < \Delta$ are equal to $\alpha\theta_2(\Delta - \hat{\Delta})$. Note that $\alpha\theta_2(\Delta - \hat{\Delta})$ is less than $\alpha\theta_2\Delta$.

- if firm 2 sells its old product to both segment 2 consumers and segment 1 consumers with high enough willingness to pay, and sells the new product with quality $\hat{\Delta} < \Delta$ to segment 1 consumers with lower willingness to pay, its profits when it launches the new product are equal to $\frac{(\Delta-\hat{\Delta})\theta_1}{4(1-\alpha)}$. One can see that $\frac{(\Delta-\hat{\Delta})\theta_1}{4(1-\alpha)} < \frac{4\Delta\theta_1}{9(1-\alpha)}$.

This proves that in our model setup firm 2 would not prefer to launch a new product with quality $\hat{\Delta} < \Delta$ in the absence of concerns regarding NPP.

However, if firm 2 cannot develop a better product with quality higher than Δ then just to increase the reference quality in the first period and hence to increase its competitive advantage against firm 1 it may develop a new product with quality $\Delta - \varepsilon$ and preannounce this. Following NPP, the reference quality in the first period increases from $\frac{\Delta}{2}$ to $\frac{2\Delta-\varepsilon}{3}$. Firm 2 knows that no consumer would postpone his purchase and its profits in the second period will not suffer, but it will gain from NPP by raising the reference quality in the first period.

As a result, since firm 2 is not willing to develop a new product with quality $\hat{\Delta} < \frac{\Delta}{2}$ the result in Proposition 5 cannot be challenged.□