Technical Appendix
(Posted Online)

In this appendix, we provide the proof of results in the Extensions part. In TA1, we focus on the case that the manufacturer also has the option of acquiring targetability with a fixed cost of F_t, but the manufacturer doesn't have the option to open a direct channel. In TA2, we extend TA1 by allowing the manufacturer to embrace both targetability and a direct channel. In TA3, we examine our basic model results in the context of retail competition.

TA1: Upstream or Downstream Personalized Pricing?

We first examine the case that both the manufacturer and the retailer have the option of acquiring targetability. Since the retailer decides whether to acquire targetability U or P, and the manufacturer also decides U_m or P_m, we have altogether 4 subgames (UU_m, PU_m, UP_m, and PP_m). UU_m and PU_m are the same as cases in the basic model where the manufacturer doesn't open a direct channel. We focus only on the two unique subgames.

Retailer Uniform Pricing and Manufacturer Personalized Pricing (UP_m)

Since the manufacturer targets end consumers with customized prices, the manufacturer can increase the wholesale price to the reservation price. In equilibrium, both the wholesale price and retail prices are equal to the consumers' reservation price. The manufacturer appropriates all consumer surplus and we have $\Pi = V - \frac{t}{2} - F_t$. The channel is fully coordinated with the manufacturer's personalized pricing as in Gerstner and Hess(1995).

Both Retailer and Manufacturer Personalized Pricing (PP_m)

With the manufacturer's personalized pricing, all consumers now have the same effective reservation price. Therefore, if the retailer also uses personalized pricing, it can only lead to a profit loss due to the cost of acquiring targetability. Once again, the wholesale price and retailing prices are equal to the reservation price. The retailer is now even worse off with targetability, or $\pi = -F_r < 0$.

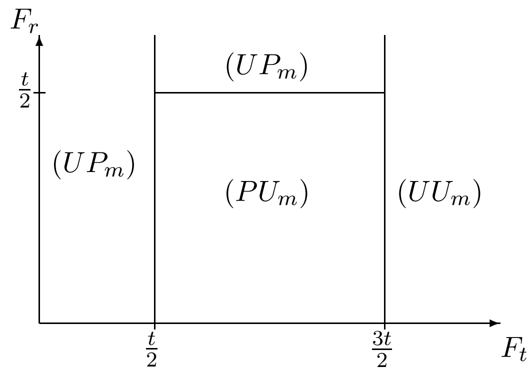
Equilibrium Manufacturer Strategies

Comparing the manufacturer's payoffs of UP_m and UU_m, we can easily see that when the cost of acquiring targetability is sufficiently high $F_t > \frac{3t}{2}$, the manufacturer never acquires targetability. Similarly, the manufacturer will acquire targetability when F_t is sufficiently small ($F_t < \frac{t}{2}$). When $\frac{t}{2} < F_t < \frac{3t}{2}$, whether the manufacturer should acquire targetability depends on the targetability acquisition decision made by the retailer.

Deterrence of Personalized Pricing by Retailer

When the retailer doesn't acquire targetability and use only a uniform price, the profit gain that the manufacturer can secure from personalized pricing is $\Delta\Pi^U = \frac{3}{2}t - F_t$. When the retailer acquires targetability, the profit gain is $\Delta\Pi^P = \frac{5}{12}t - F_t$. The manufacturer has a lower incentive to acquire targetability when the retailer acquires targetability. Therefore, the retailer can strategically invest in targetability to deter the manufacturer from acquiring targetability. This happens when the

Figure 2: Equilibrium Downstream and Upstream Personalized Pricing



retailer's targeting cost is sufficiently low or $F_r < \frac{t}{2}$. For the retailer, although personalized pricing alleviates double marginalization and hurts the retailer, it is still better than the case that the manufacturer acquires targetability. All possible equilibria are listed in Figure 2.

As we can see in Figure 2, either upstream or downstream personalized pricing may occur, but not both, even when costs permit ($\frac{t}{2} < F_t < \frac{3t}{2}$ and $F_r < \frac{t}{2}$).

TA2. Strategic Focus: Upstream Personalized Pricing or Direct Entry?

In TA1, the manufacturer doesn't have the option of opening a direct channel. Here we extend TA1 such that the manufacturer can both acquire targetability and open a direct channel. Once again, we focus only on the unique subgames, namely those where the manufacturer embraces both a direct channel and personalized pricing, denoted by UEP_m and PEP_m.

Retailer Uniform Pricing(UEP_m)

In this subgame, the manufacturer sells through two channels and also targets end consumers. We have:

$$p_m = V, p_d = V - s, \pi = 0, \Pi = V - s + \frac{s^2}{2t} - F_m - F_t. \tag{TA2.1}$$

The above results also hold for subgame PEP_m except that the retailer's profit is $\pi = -F_r$. Therefore, for the retailer, acquiring targetability is strictly dominated by no targetability at all. Therefore, PEP_m is never an equilibrium. For the same reason, $P\bar{E}P_m$ cannot be an equilibrium either. The possible equilibria when the manufacturer can embrace both a direct channel and personalized pricing are the following: $U\bar{E}U_m$, $U\bar{E}P_m$, UEU_m, UEP_m, $P\bar{E}U_m$, and PEU_m, none of them involves both upstream and downstream personalized pricing. Next we derive the manufacturer's strategy and examine how the manufacturer's strategy is affected by the retailer's targetability decision.

Manufacturer Strategy with Retailer Uniform Pricing

We derive the equilibrium here by comparing the manufacturer's payoffs associated with its different strategies. It is straightforward to show that when both targetability cost and entry cost are high ($F_m > \frac{(4t-s)^2}{8t}$ and $F_t > \frac{3}{2}t$), the manufacturer will neither enter the market nor acquire targetability. The manufacturer acquires targetability, but does not enter the market if $F_t < F_m + s - \frac{s^2}{8t} - \frac{t}{2}$, $F_t < \frac{3}{2}t$, and $F_m > \frac{t}{2} - s + \frac{s^2}{4t}$. The manufacturer will enter the market, but does not acquire targetability if $F_t > F_m + s - \frac{s^2}{8t} - \frac{t}{2}$, $F_t > \frac{3s^2}{8t}$, and $F_m < \frac{(4t-s)^2}{8t}$. If $F_m < \frac{t}{2} - s + \frac{s^2}{4t}$ and $F_t < \frac{3s^2}{8t}$, the manufacturer both opens a direct channel and acquire targetability, given that the direct channel shopping cost is sufficiently small $s < (2 - \sqrt{2})t$. However, when $s > (2 - \sqrt{2})t$, the manufacturer will never pursue both a direct channel and personalized pricing.

Manufacturer Strategy with Retailer Personalized Pricing

Similarly, the manufacturer will neither open a direct channel nor acquire targetability if $F_m > \frac{(2t-s)^2}{4t}$ and $F_t > \frac{t}{2}$. The manufacturer will both open a direct channel and acquire targetability if $F_m < \frac{t}{2} - s + \frac{s^2}{4t}$ and $F_t < \frac{s^2}{4t}$. The manufacturer acquires targetability, but doesn't enter the market if $F_t < F_m + s - \frac{t}{2} - \frac{s^2}{4t}$, $F_m > \frac{t}{2} - s + \frac{s^2}{4t}$, and $F_t < \frac{t}{2}$. The manufacturer opens a direct channel, but does not acquire targetability if $F_t > F_m + s - \frac{t}{2} - \frac{s^2}{4t}$, $F_t > \frac{s^2}{4t}$, and $F_m < \frac{(2t-s)^2}{4t}$.

Deterrence of Personalized Pricing by Retailer

The manufacturer's incentives to enter a direct channel or acquire targetability are lower when the retailer acquires targetability and pursues personalized pricing. Therefore, the retailer can strategically acquire targetability to deter the manufacturer's either direct entry or targetability acquisition. When $\frac{(2t-s)^2}{4t} < F_m < \frac{(4t-s)^2}{8t}$ and $F_t > F_m + s - \frac{s^2}{8t} - \frac{t}{2}$, if the retailer doesn't acquire targetability and uses only a uniform price, the manufacturer will enter the market; however, if the retailer acquires targetability, the manufacturer will not enter the market. When the retailer's personalized cost is sufficiently low $F_r < \frac{t}{2} - \frac{s^2}{16t}$, the retailer will strategically acquire targetability to deter the manufacturer's entry. When $F_t < F_m + s - \frac{s^2}{8t} - \frac{t}{2}$, $\frac{t}{2} < F_t < \frac{3}{2}t$, and $F_m > \frac{(2t-s)^2}{4t}$, the manufacturer will acquire targetability if the retailer does not acquire it; however, the manufacturer will not invest in targetability if the retailer acquires targetability. Therefore, the retailer can profitably acquire targetability to preempt the manufacturer's personalized pricing efforts when the targetability cost is sufficiently low $F_r < \frac{t}{2}$. When $F_m < \frac{t}{2} - s + \frac{s^2}{4t}$ and $\frac{s^2}{4t} < F_t < \frac{3s^2}{8t}$, the manufacturer will both open a direct channel and acquire targetability if the retailer doesn't pursue personalized pricing; however, the manufacturer will only enter the market and does not invest in targetability if the retailer acquires targetability. Therefore, the retailer can strategically acquire targetability to preempt the manufacturer's targetability acquisition when $F_r < \frac{s^2}{8t}$. When $F_t - s + \frac{s^2}{8t} + \frac{t}{2} < F_m < F_t - s + \frac{s^2}{4t} + \frac{t}{2}$ and $\frac{t}{2} - s + \frac{s^2}{4t} < F_m < \frac{(2t-s)^2}{4t}$, the manufacturer acquires targetability, but does not open a direct channel if the retailer doesn't acquire targetability; however, the manufacturer will only open a direct channel, but doesn't invest in targetability if the retailer acquires targetability. Therefore, the retailer can profitably acquire targetability to preempt the manufacturer's personalized pricing but allow the manufacturer to open a direct channel when $F_r < \frac{s^2}{8t}$.

TA3. Retail Competition

In the basic model, the retailer is a monopolist. Here we extend our basic model and examine our main results in the context of retail competition. We allow two retailers located at either ends of the Hotelling line. Both retailers can deicide independently whether to acquire targetability. Again, the manufacturer decides whether to open a direct channel. Altogether, we have 8 subgames, denoted by 3 letters.

Both Retailers Uniform Pricing without Manufacturer Entry ($UU\bar{E}$)

In this subgame, neither retailers acquire targetability and the manufacturer doesn't open a direct channel. Given V is sufficiently large ($V > 2t$), the manufacturer always induces the full market coverage. Since the manufacturer's profit is proportional to the wholesale price when the market is covered, it will set its wholesale price such that the retailers just cover the market with each sharing one half of the market. Thus, we can simplify our exposition by focusing on the equilibrium where the marginal consumers located at $\frac{1}{2}$ derive zero surplus from their purchases. In this equilibrium, we necessarily have $p_{r1} = p_{r2} = V - \frac{t}{2}$ where p_{r1} and p_{r2} are retail prices.

To derive the sufficient conditions for this equilibrium, we now examine a retailer's incentive to deviate from this proposed equilibrium price, while its rival stays put. Consider first that Retailer 1 deviates from $V - \frac{t}{2}$ by lowering its price by $\epsilon > 0$. This lower price will increase the retailer's market share by $\frac{\epsilon}{2t}$ so as to produce a total incremental gain of $\frac{\epsilon}{2t}(V - \frac{t}{2} - p_m - \epsilon)$. This price decrease also implies that each of the previous customers pays ϵ less, producing a total incremental loss of $\frac{\epsilon}{2}$. Such a deviation is unprofitable for Retailer 1 if the total incremental loss is larger than the total incremental gain, or $p_m \geq V - \frac{3}{2}t$.

If Retailer 1 deviates by increasing its price by $\epsilon > 0$, the market will become uncovered and Retailer 1's market share will be reduced by $\frac{\epsilon}{t}$. The total incremental gain for the retailer comes from a smaller number of customers each paying a higher price, amounting to $(\frac{1}{2} - \frac{\epsilon}{t})\epsilon$. The incremental loss comes from the customers who decide to forgo a purchase due to the higher price, totaling $\frac{\epsilon}{t}(V - \frac{t}{2} - p_m)$. Then, this deviation is unprofitable if $p_m \leq V - t$. The analysis for Retailer 2 is symmetrical. Thus, given $V - \frac{3}{2}t \leq p_m \leq V - t$, the equilibrium is characterized by $p_{r1} = p_{r2} = V - \frac{t}{2}$. Then, in this subgame, we must have

$$\Pi_1 = V - t, \quad \pi_1^1 = \pi_1^2 = \frac{t}{4} \tag{TA3.1}$$

where the superscript denotes retailers 1 and 2.

Both Retailers Uniform Pricing with Manufacturer Entry (UUE)

In this subgame, neither retailers acquire targetability and the manufacturer opens a direct channel. Once again, consumers incur a cost s shopping from the direct channel. To rule out the uninteresting case that the manufacturer never opens a direct channel, we assume $s < t$. If the manufacturer sets the wholesale price $p_m \geq V$, no consumers will buy from retailers. The manufacturer sells only through its direct channel. The optimal direct price will be $p_d = V - s$ and the manufacturer's profit is $\Pi = V - s - F_m$. Next we consider the case that $p_m < V$. The locations of consumers who are indifferent between shopping from retailers and the direct channel are at $x_1 = \frac{p_d+s-p_{r1}}{t}$ and $x_2 = \frac{p_d+s-p_{r2}}{t}$. Profit functions of retailers and the manufacturer are:

$$\pi^1 = (p_{r1} - p_m)x_1, \pi^2 = (p_{r2} - p_m)x_2, \Pi = p_m(x_1 + x_2) + p_d(1 - x_1 - x_2) - F_m \tag{TA3.2}$$

The equilibrium is as follows:

$$p_{r1} = p_{r2} = p_m + \frac{2s+t}{6}, p_d = p_m + \frac{t-s}{3}, x_1 = x_2 = \frac{2s+t}{6t} \tag{TA3.3}$$

$$\pi^1 = \pi^2 = \frac{(2s+t)^2}{36t}, \Pi = p_m + \frac{2(s-t)^2}{9t} - F_m. \tag{TA3.4}$$

Since we must have $p_d \leq V - s$ to guarantee consumer surplus from the direct channel is non-negative, we must have $p_m \leq V - \frac{2s+t}{3}$. Next we show when $p_m > V - \frac{2s+t}{3}$, the manufacturer will set the direct price optimally at $p_d = V - s$. Given any price in the direct channel, independent retailers set their prices optimally at $p_{r1} = p_{r2} = \frac{p_m+p_d+s}{2}$. The market shares of retailers and the direct channel are $x_1 = x_2 = \frac{p_d+s-p_m}{2t}$ and $x_d = 1 - \frac{p_d+s-p_m}{t}$. The necessary condition that all stores get non-negative market shares is $p_m - s \leq p_d \leq p_m - s + t$.

In addition, $p_d < p_m - s$ can never happen in the equilibrium, otherwise no consumer will buy from retailers. Since the manufacturer's profit is proportional to the direct channel price, the manufacturer always has incentive to increase its p_d to improve its profit. Therefore, we must have $p_d > p_m - s = V - \frac{2s+t}{3} - s = V - \frac{5s+t}{3}$. The manufacturer's profit is given by:

$$\Pi = \frac{-p_m^2 + p_m s + p_d(p_d + s - t)}{t}. \tag{TA3.5}$$

The first order condition $\frac{d_\Pi}{d_{p_d}} = \frac{2p_d+s-t}{t}$ is always positive given $p_d \geq V - \frac{5s+t}{3}$ and $s < t < \frac{V}{2}$. The manufacturer's profit increases with p_d until $p_d = V - s$. However, since $p_m > V - \frac{2s+t}{3}$, the manufacturer can never be better off charging $p_d > V - s$. Otherwise the manufacturer can always lower p_d to cover the uncovered market by retailers and improve its profit. Therefore, when $p_m > V - \frac{2s+t}{3}$, the equilibrium is as follows:

$$p_{r1} = p_{r2} = \frac{V + p_m}{2}, p_d = V - s, x_1 = x_2 = \frac{V - p_m}{2t}, x_d = \frac{p_m + t - V}{t} \tag{TA3.6}$$

$$\pi^1 = \pi^2 = \frac{(V - p_m)^2}{4t}, \Pi = \frac{p_m(2V - s) - p_m^2 - (V - t)(V - s)}{t} - F_m. \tag{TA3.7}$$

Then, the manufacturer's profit can be written as:

$$\Pi = \begin{cases} V - s - F_m & \text{if } p_m \geq V \\ \frac{p_m(2V-s)-p_m^2-(V-t)(V-s)}{t} - F_m & \text{if } V - \frac{2s+t}{3} \leq p_m < V \\ p_m + \frac{2(s-t)^2}{9t} - F_m & \text{if } p_m < V - \frac{2s+t}{3}. \end{cases}.$$

The manufacturer achieves its optimal profit when it sets the wholesale price at $p_m = V - \frac{s}{2}$ which leads to $x_1 = x_2 = \frac{s}{4t}$. The final equilibrium profits in this subgame are as follows:

$$\pi_2^1 = \pi_2^2 = \frac{s^2}{16t}, \Pi_2 = V - s + \frac{s^2}{4t} - F_m. \tag{TA3.8}$$

One Retailer Personalized Pricing without Manufacturer Entry ($PU\bar{E}$)

Since two retailers are symmetric, we assume, without any loss of generality, that retailer 1 uses personalized pricing. we assume, *à la* Thisse and Vives (1988), that the retailer setting a uniform price moves first. This assumption is necessary to insure that a pure strategy equilibrium exists.

When $p_m > V - \frac{2}{3}t$, the market is not completely covered and both retailers are local monopolists. The manufacturer's profit is $\Pi = \frac{3p_m(u-p_m)}{2t}$. When $p_m \leq V - \frac{2}{3}t$, the market is always covered and the manufacturer's profit is proportional to the wholesale price. The manufacturer's profit in that case can be written as:

$$\Pi = \begin{cases} 0 & \text{if } p_m > u \\ \frac{3p_m(u-p_m)}{2t} & \text{if } u - \frac{2}{3}t < p_m \leq u \\ p_m & \text{if } p_m < V - \frac{2}{3}t. \end{cases}.$$

The manufacturer's profit is at the optimum when it sets $p_m = V - \frac{2}{3}t$ which leads to $p_{r2} = V - \frac{t}{3}$, $x_1 = \frac{2}{3}$, and $x_2 = \frac{1}{3}$. Then, in this subgame, we must have

$$\pi_3^1 = \frac{2t}{9} - F_r, \pi_3^2 = \frac{t}{9}, \Pi_3 = V - \frac{2}{3}t. \tag{TA3.9}$$

Compared to the benchmark case, both retailers are worse off and the manufacturer is better off when one retailer acquires targetability.

One Retailer Personalized Pricing with Manufacturer Entry (PUE)

If the manufacturer sets the wholesale price at $p_m > V$, consumers will never buy from any retailer. The optimal direct channel price in that case is $p_d = V - s$ and the manufacturer's profit is $\Pi = V - s - F_m$. If the manufacturer sets $p_m < V - \frac{2t+4s}{7}$, its direct channel competes with retailers. The manufacturer's profit is given by:

$$\Pi = \begin{cases} p_m + \frac{2(3s-2t)^2}{49t} - F_m & \text{if } p_m \leq V - \frac{2t+4s}{7} \\ \frac{-3p_m^2+3p_m(2V-s)+(3V-2t)(V-s)}{2t} - F_m & \text{if } V - \frac{2t+4s}{7} < p_m \leq V \\ V - s - F_m & \text{if } p_m > V. \end{cases}.$$

Then, the manufacturer's profit is optimal at $p_m = V - \frac{s}{2}$ which leads to $p_{r2} = V - \frac{s}{4}$, $x_1 = \frac{s}{2t}$, and $x_2 = \frac{s}{4t}$. Therefore, in this subgame, the profits are:

$$\pi_4^1 = \frac{s^2}{8t} - F_r, \pi_4^2 = \frac{s^2}{16t}, \Pi_4 = V - s + \frac{3s^2}{8t} - F_m. \tag{TA3.10}$$

Compared to the previous subgame ($PU\bar{E}$), the manufacturer's wholesale price increases and both retailers are worse off with the manufacturer's entry. The manufacturer's gain from its direct entry is $\Delta\Pi^{PU} = \frac{(3s-4t)^2}{24t} - F_m$ which is smaller than its gain when both retailers use uniform pricing $\Delta\Pi^{UU} = \frac{(2t-s)^2}{4t} - F_m$. Therefore, the manufacturer will have less incentive to enter the market if retailers acquire targetability.

Both Retailers Personalized Pricing without Manufacturer Entry ($PP\bar{E}$)

In this subgame, the manufacturer can charge a wholesale price p_m such that either $p_m \in [V - \frac{t}{2},\ V)$ or $p_m \leq V - \frac{t}{2}$. In the former case, the market is uncovered. The marginal consumers for a retailer are determined by setting $V - t\tilde{x}_i - p_m = 0$. Then, for all other consumers located at $x \leq \tilde{x}_i$, the retailer charges a location-specific price given by $p_{ri}(x) = V - tx$. Therefore, the retailer's profit is given by

$$\pi_i = \int_0^{\tilde{x}_i} [p_{ri}(x) - p_m]dx = \frac{(V - p_m)^2}{2t},$$

and the manufacturer's profit is given by $\Pi = 2p_m\tilde{x}_i$.

When $p_m \leq V - \frac{t}{2}$, the market is always covered so that the manufacturer's payoff is given by p_m. To derive a retailer's equilibrium profit, note that the location of marginal consumers $\tilde{x}$ that divides the two retailers' markets is determined by $V - t\tilde{x} - p_m = V - t(1 - \tilde{x}) - p_m$, which yields $\tilde{x} = \frac{1}{2}$. For all the inframarginal consumers located at $x_i \in [0,\ \frac{1}{2}]$, retailer i's price must satisfy two conditions: $V - tx_i - p_{ri} \geq V - t(1 - x_i) - p_m$ and $V - tx_i - p_{ri} \geq 0$, which implies $p_{ri} = \min\{V - tx_i,\ p_m + t - 2tx_i\}$. Thus, for $p_m \leq V - t$, a retailer charges $p_{ri} = p_m + t - 2tx_1$ for all x_i and its profit is given by $\frac{t}{4}$. For $V - t < p_m \leq V - \frac{t}{2}$, we define $\bar{x}$ such that $V - t\bar{x} = p_m + t - 2t\bar{x}$. Then a retailer's profit is given by

$$\pi^i = \int_0^{\bar{x}} (V - tx - p_m)dx + \int_{\bar{x}}^{\frac{1}{2}} (p_m + t - 2tx - p_m)dx.$$

We can now summarize the manufacturer's profit in this subgame as

$$\Pi = \begin{cases} 0 & \text{if } p_m \geq V \\ \frac{2p_m(V-p_m)}{t} & \text{if } V - \frac{t}{2} \leq p_m < V \\ p_m & \text{if } p_m \leq V - \frac{t}{2}. \end{cases}$$

Since the left derivative of π_m at the point of $p_m = V - \frac{t}{2}$ is positive and the right derivative is negative, the optimal wholesale price must be given by $p_m = V - \frac{t}{2}$. Then, the payoffs for the retailers and the manufacturer in this subgame are given by

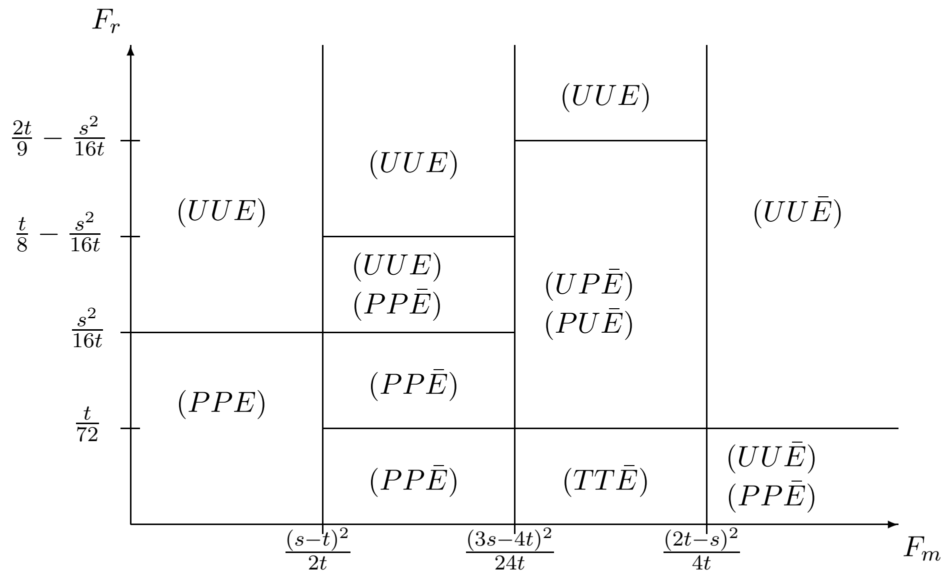
$$\pi_5^1 = \pi_5^2 = \frac{t}{8} - F_r, \Pi_5 = V - \frac{t}{2}. \quad \text{(TA3.11)}$$

Both Retailers Personalized Pricing with Manufacturer Entry (PPE)

Similarly, we have the following equilibrium:

$$\pi_6^1 = \pi_6^2 = \frac{s^2}{8t} - F_r, \Pi_6 = V - s + \frac{s^2}{2t} - F_m. \quad \text{(TA3.12)}$$

Figure 3: Equilibrium Channel and Pricing Structures With Competing Retailers



When the retailers all charge a uniform price, the manufacturer's gain from direct entry is given by $\Delta\Pi^{UU} = \Pi_2 - \Pi_1 = \frac{(2t-s)^2}{4t}$. Similarly, the corresponding gains for the manufacturer when one retailer uses personalized pricing or both retailers implement personalized pricing are $\Delta\Pi^{PU} = \Pi_4 - \Pi_3 = \frac{(3s-4t)^2}{24t}$ and $\Delta\Pi^{PP} = \Pi_6 - \Pi_5 = \frac{(t-s)^2}{2t}$. The manufacturer's gain is largest in the first case, *i.e.* $\Delta\Pi^{UU} > \Delta\Pi^{PU} > \Delta\Pi^{PP}$. Therefore, either one or both retailers may acquire targetability to deter the manufacturer's direct entry. When $\frac{(3s-4t)^2}{24t} < F_m < \frac{(2t-s)^2}{4t}$ and $\frac{t}{72} < F_r < \frac{2t}{9} - \frac{s^2}{16}$