Competitive Mobile Targeting

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Abstract

We investigate in a duopoly setting the consequences of competitive mobile targeting, the practice of firms’ setting prices based on consumers’ real-time locations. A distinct market feature of mobile targeting is that a consumer could travel across different locations for an offer that minimizes his total cost of buying. This cherry-picking opportunity imposes constraints on firms to carefully balance prices across locations, which in turn weakens their competition at each location. As a result, a firm’s profit can be either higher or lower under mobile targeting than under uniform pricing, a result that is different from typical results in prior literature on competitive targeting. Extending the main model, we also discuss how the profitability of mobile targeting may change with the fraction of consumers who are mobile accessible to the firms, the distribution of consumers across locations, the popularity of the targeted center location and the possibility of tracing down a consumer’s base location and restricting him to offers at that location. Our findings have important managerial implications for marketers who are interested in optimizing their mobile targeting strategies.
Introduction

People are spending more time with their mobile devices: U.S. adults, for example, are estimated to spend an average of 2 hours 51 minutes per day with mobile devices in 2014 (eMarketer 2014a). Smartphones, in particular, have replaced tablets as the leading device for researching retail items, with a 110% growth in usage from 2013 to 2014 (eMarketer 2014b). According to a survey of 1,511 randomly selected mobile users conducted by research firm Ninth Decimal in 2014, 55% of consumers have purchased a retail product as a result of seeing a mobile ad (NinthDecimal 2014) and marketers are quick to follow the eyeballs: global mobile ad spending more than doubled from 2013 to 2014, and is projected to reach $94 billion in 2018 (eMarketer 2014b).

The fast growth of mobile ad spending has triggered an increasing body of empirical research on the topic. Ghose, Goldfarb and Han (2013), for example, are among the first to show that search costs may be higher on mobile phones due to the small screen size and stores located in close proximity to a user’s home are much more likely to be clicked on mobile phones. Luo et al. (2014) investigate the optimal configuration of mobile targeting by simultaneously varying the location and timing of the offers and find that it can be profitable for firms to allow more time (e.g., one-day before vs. same-day) when targeting non-proximal consumers. Fong, Fang and Luo (2014) examine the effectiveness of real-time mobile geo-conquering promotions, promotions that target consumers located near a competitor’s store, and find that firms may benefit from such promotions and the optimal discount depth in these promotions can be different from those when targeting consumers that are located near a firm’s own store. Besides location and timing, other factors that have been shown to have an impact on the effectiveness of
mobile marketing include the product category (Bart, Stephen and Sarvary 2014) and contextual factors such as crowdedness (Andrews et al. 2014) and shoppers’ in-store path (Hui et al. 2013).

While marketers keep increasing their investment in mobile targeting and empirical research quickly accumulates, little research is done in the theoretical domain on this topic. We aim to fill the gap in this paper as theoretical insights into mobile targeting can provide guidance on how firms can optimize mobile targeting in a competitive environment. As existing research often utilizes field experiments to gauge causal effects of mobile targeting and it is extremely difficult to get two competing firms to participate in the same experiment, a theoretical framework can be effective in this regard. In particular, it can help us understand whether competing firms would have an incentive to adopt the mobile targeting technology and the conditions under which the technology would indeed increase their equilibrium profit.

To achieve these goals, we focus on two important features of mobile targeting that distinguish it from traditional targeting. First, mobile targeting is often based on consumers’ real-time location. Geo-targeting, the method of pinpointing an audience based on their location, is particularly powerful with mobile as it has the unique ability to target an audience at a far more granular level than any other marketing medium, enabling deeper, hyper-local, or even latitude-longitude targeting. Second, firms can deliver personalized offers through mobile devices in a private manner as consumers are individually addressable. In fact, when mobile users are asked what information they are most likely to respond to in a retail-related mobile ad, the highest ranked answer is Discounts/Sales, topping other answers such as product reviews or giveaways (NinthDecimal 2014). These two features of mobile technology create a unique opportunity for firms to engage in a new form of price discrimination: charging consumers different prices based on their real-time location.
As with other forms of price discrimination, the ability to vary prices based on location allows a firm to divide up the whole market and maximize profit for each local market. The increased flexibility in pricing could reduce deadweight loss and raise equilibrium profit in the absence of competition. When competition is present, however, one can show that such benefit can be dominated by the intensified price competition at each location and the firms may end up in a prisoner’s dilemma in which the net effect of targeting is simply the cost of distribution plus the discount given to redeemers (Shaffer and Zhang 1995).

A critical difference between mobile targeting and traditional targeting (e.g. mailed coupons) is that under mobile targeting, the final price is determined by real-time location, and consumers could potentially travel to different regions to obtain different offers. For example, if a firm decides to offer deeper discount near the competitor’s store than near its own store (a particular form of geo-conquering), then consumers may find it optimal to travel to the competitor’s store to obtain the better price and then come back to the focal store to purchase the product. The possibility for consumers to cherry pick an offer across locations, as it turns out, has profound implications for competing firms’ pricing strategies and the consequent market outcomes.

Intuitively, the cherry-picking opportunity leads firms to carefully balance their prices across locations. In particular, firms often find it profitable to balance the prices in a way so that consumers would not travel for better deals, since the firms could then profit from the consumers’ saved transportation cost. As a result, prices cannot be too different across locations, which in turn effectively limits price competition at each of the locations. Given the additional constraints on pricing, we show in this paper that different from findings in the prior literature, mobile targeting with real-time locations can often increase firm profit.
More specifically, we consider a duopoly setting in which each firm has consumers at its home base and there are also some consumers located in the middle of the two firms. We focus on the scenario in which the uniform-pricing firms would remain local monopolies and sell only to consumers at their home bases. It fits the type of non-necessity products, such as movie tickets (Luo et al. 2014) and snacks (Danaher et al. 2011) studied in the prior empirical research on mobile coupons.

We first show that firms would have an incentive to adopt mobile targeting when the technology is available, as the technology would enable them to increase demand at further-away locations without eroding profits at their home base. Under mobile targeting, each firm charges a price at its home base that is just low enough to keep the competitor out of the location. As the competitor can now charge a very low price at the focal firm’s home base, the new equilibrium home-base prices are lower than the previous uniform price. Besides poaching the other firm’s local customers, a firm now also has an incentive to use a discounted price to reach out to consumers who are located in the middle of the market. It needs to be careful, however, in setting this discounted price to ensure that its home-base consumers do not travel to the middle to get a better deal.

As a result, in the competitive mobile targeting equilibrium, price decreases at all locations when compared to uniform-pricing. On the other hand, demand increases for each firm and a firm’s profit can be either higher or lower than under uniform pricing. Consumers are always better off under mobile targeting, and therefore there exist situations in which firms and consumers both benefit from mobile targeting.

We examine several extensions of the model to generate more managerial insights. First, we show that when only a fraction of consumers are mobile accessible to the firms, our previous
results remain to hold. The firms essentially would treat the two types of consumers (non-accessible and accessible) as two different submarkets in which they practice uniform pricing and mobile targeting respectively. We next examine the scenario in which there can be fewer or more consumers located in the middle of the two firms. We show in this case that as demand expansion occurs mostly with the middle consumers, having more consumers in the middle increases the relative profitability of mobile targeting. In particular, when the mass of middle consumers exceeds a certain threshold, firms’ profit under mobile targeting exceeds their profit under uniform pricing. On the other hand, if the total market size is fixed, firms’ mobile targeting profit decreases with the proportion of the consumers located in the middle, because home consumers yield a higher margin.

In the third extension, we investigate the natural question of whether it would be profitable for firms to target a frequently visited, popular location at the middle of the two firms, such as a park, to reduce consumers’ travel costs to receive coupons from this location. Interestingly, such practices turn out to weaken the benefit of mobile targeting and essentially bring firms back to the equilibrium outcomes under uniform pricing. Intuitively, when consumers at the home base can freely switch between different price offers, firms lose the ability to price discriminate based on location.

Finally, we consider the possibility for firms to trace down consumers’ base locations and restrict consumers to obtain only their base-location offers. In reality, new technologies such as Placed and JiWire can be used to identify where consumers spend the bulk of their time and create audience profiles based on their location histories.¹ When firms adopt such technologies, they can base pricing offers on a consumer’s usual (base) location rather than his real-time

¹ See, for example, [http://marketingland.com/how-location-evolved-into-audiences-for-mobile-ad-targeting-59126](http://marketingland.com/how-location-evolved-into-audiences-for-mobile-ad-targeting-59126).
location. If firms do this, we show that their profit always decreases in equilibrium. The intuition is consistent with prior literature on competitive targeting: without the possibility of consumer cherry-picking and the firms’ subsequent need to balance prices across locations, price competition at each location would be so fierce that the firms’ overall profit goes down.

Our paper contributes to the literature of competitive targeting, behavior-based price discrimination, and mobile marketing. The first literature often finds that while the ability to target different consumers with different prices appears to be a superior marketing strategy, it often tends to backfire as price competition intensifies within each segment of the market (e.g., Shaffer and Zhang 1995). In particular, Shaffer and Zhang (2002) show that even one-to-one promotions have the potential to either increase or decrease a firm’s equilibrium profit, depending on, for example, whether the firm has a larger market share than its competitor. We highlight that mobile targeting differs from traditional targeting techniques in that price is determined by a consumer’s real-time location and consumers have the ability to travel across locations for the best offer. The cherry-picking opportunity helps limit price competition in equilibrium by forcing firms to balance their prices across different locations, enhancing both firms’ equilibrium profit. As a result, our results differ significantly from prior literature, suggesting that mobile targeting can enhance profit for even perfectly symmetric firms.

Behavior-based price discrimination refers to the practice of pricing consumers differently based on their behavior. Early works in this literature argue that price discrimination based on past purchase behavior can lead to a prison’s dilemma that ultimately lowers profits for competing firms (Fudenberg and Tirole 2000; Villas-Boas 1999). Zhang (2011) further argues that as forward-looking firms try to attenuate this intensified competition by altering product design in early periods, products turn out to be less differentiated, causing even stronger
competition and lower profits for firms. Recent studies have also suggested different situations where behavior-based price discrimination might benefit firms, for example, when one firm is significantly more advantaged in its capability to add benefits to previous customers (Pazgal and Soberman 2008), and when customers differ in purchase quantity or when their preferences over different firms change over time (Shin and Sudhir 2010). Other than previous purchase behavior, studies have also investigated the consequences of pricing on other variables such as information related to customer cost (Shin, Sudhir and Yoon 2012; Subramanian, Raju and Zhang 2014). Our paper contributes to the literature of behavior-based pricing by adding another aspect of consumer behavior that firms can price on: a consumer’s real-time location. Our results suggest that the possibility of consumers’ cherry-picking across different locations provides another force to limit competition and hence allows firms to benefit from price discrimination. In this regard, our study also differ from those of location-based pricing (Thisse and Vives 1988) in which consumers are not mobile to obtain prices offered at other locations and competition leads to Prisoners' Dilemma as a consequence.

The literature of mobile targeting has been growing quickly in the past few years and provides empirical evidence that is consistent with our model assumptions and results. Luo et al. (2014), for example, find that it can be profitable for firms to allow more time when targeting non-proximal consumers, which is consistent with our assumption that consumers need to incur substantial travel cost to visit the store when they receive a mobile offer from far away. Consistent with our result that firms would offer a lower price to consumers who are located further away, Fong, Fang and Luo (2014) find that the optimal discount is deeper at locations near the competitor’s store than at locations near one’s own store. As we make the first attempt
to model competitive mobile targeting in a game-theoretical framework, our results yield interesting predictions for future empirical work in this domain.

The remainder of the paper proceeds as follows. In the next section, we introduce the main model of competitive mobile targeting. We then present the four extensions. Finally, we conclude with a discussion of managerial implications and directions for future research.

**A Model of Competitive Mobile Targeting**

In this section, we present a spatial model of competitive mobile targeting. Consider two competing firms located at the two ends of a unit line respectively. Firm 1 is located at 0 and Firm 2 is located at 1. The production cost of the products is normalized to zero without loss of generality.

There are three groups of consumers, each with a mass of one. Group 1 resides at 0, Group 2 resides at 1 and Group 3 resides at the middle of the unit line, \( \frac{1}{2} \). Therefore, each firm has a unit mass of home-base consumers, while another unit mass of consumers reside at an equal distance away from both firms. A consumer incurs a transportation cost, \( c = tx \), for traveling along the line with distance \( x \), where \( t \) is the unit transportation cost. Each consumer has a reservation price of \( V \) to the product category.

Consumers at each location also have heterogeneous preferences towards the two firms. At each location, they are distributed uniformly on a unit line in the preference dimension with utility \( V - tx_1 - sy \) for firm 1 and utility \( V - tx_2 - s(1-y) \) for firm 2, where \( x_i, i \in \{1,2\} \), is the distance the consumer has to travel in order to buy from firm \( i \) and \( y \) is uniformly distributed between \([0,1]\). Note that \( s \) is the marginal disutility on the preference dimension, and reflects the
notion that consumers residing at the same location can have heterogeneous preferences toward the two firms. Also, since we model travel explicitly in this paper, we consider consumers’ cost of both traveling to and traveling back from a firm. For example, for a consumer located at 0 to buy from the firm located at 1, the total travel distance is 2 and he incurs a travel cost of 2t. A consumer purchases at most one unit of the product and gets zero utility without a purchase.

To ensure that the practice of consumers’ cherry-picking on offers across locations has an effect on firm pricing under mobile targeting, we assume $2s < t$. This assumption implies that location mismatch is more costly to consumers than preference mismatch. To ensure that a pure-strategy equilibrium exists under mobile targeting, we also assume that $t < 4s$, meaning that while $s$ is small, it cannot be negligible. Putting the two assumptions together, we require $2s < t < 4s$.

Our model hence applies to settings in which there exists a distribution of different tastes among consumers at each location, while location still plays a dominant role in determining the match between a firm and a consumer. Restaurants, movie theatres, and spas can be good examples of such a setting as they tend to be frequented by local customers while tastes differ even in a given neighborhood.

To ensure that firms remain local monopolies under uniform pricing, we also assume $V < 2t + s$, meaning that consumers’ willingness to pay for the product category is not too high and we are focusing on non-necessity services and products such as movie tickets (Luo et al. 2014). Finally, to ensure that geo-conquesting is possible, i.e., it is possible for a fraction of consumers located at the competitor’s home base to buy the focal firm’s product, we also assume $V > 2t$.

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2 When $t < 2s$, firms’ optimal prices at different locations, even without considering consumer cherry-picking, are already able to completely prevent cherry-picking, and as a result, mobile targeting degenerates to traditional coupon targeting. To focus on the interesting scenario where cherry-picking has a real impact, we assume $t > 2s$.

3 Our conclusions in the main model remain qualitatively unchanged when $4s < t < 11s/2$. We choose to focus on the region $t < 4s$ to simplify the presentation of proofs. When $t > 11s/2$, no pure-strategy equilibrium exists under mobile targeting as firms will have an incentive to deviate to uniform pricing.
Putting the two assumptions together, we require $2t < V < 2t+s$: consumers’ willingness to pay for the category is intermediate, so firms can either charge a high price and remain local monopolies, or they can price aggressively to poach the competitor’s home-base consumers.

Consider first the benchmark scenario in which mobile technology is not available and each firm charges a uniform price to all its consumers. Suppose that firms simultaneously choose their prices before consumers decide whether to buy one unit of the product, and if so, from which firm. We now solve for the subgame perfect equilibrium of this game.\(^4\)

**Proposition 1:** Under uniform pricing, the firms remain local monopolies and sell to all local consumers. Their optimal price and equilibrium profit is $V-s$.

Proposition 1 suggests that firms would set the prices such that all local consumers (i.e., those that have the same location as the firm) would buy the product, while other consumers do not buy the product. Our earlier assumptions on $V$ and $t$ ensure this outcome as it is more profitable for firms to focus on their home base given the intermediate level of willingness-to-pay for the product category and consumers’ significant transportation costs.

Suppose now that mobile targeting technology becomes available to both firms, which enables them to set prices based on the location of the consumer. Consider now the new pricing game in which the two firms simultaneously choose one of the following. First, to adopt uniform pricing with a set price for all consumers. Second, to adopt mobile targeting with a separate price for each location. As consumers obtain pricing offers on their mobile devices, they can travel

\(^4\) Proofs of all propositions, lemmas and corollaries are in the appendix.
across different locations to minimize the total cost of buying. As a tie-breaking rule, we assume that consumers do not travel when they are indifferent.

To keep the analysis tractable, we focus throughout the paper on symmetric equilibria in which the two firms adopt the same strategy in both technology and pricing. As a first step, we show that mobile targeting would indeed disrupt the uniform pricing equilibrium.

**Lemma 1**: When mobile targeting is available, there does not exist a symmetric equilibrium with uniform pricing.

Intuitively, the ability to charge different prices at different locations gives a firm increased flexibility when competing with the other firm. For example, it could enable a firm to expand market demand at distance \(\frac{1}{2}\) without decreasing its home-base profit. As a result, a firm often finds it attractive to get on the mobile platform once location-based targeting becomes available.

Since uniform pricing can no longer be part of the equilibrium, we now consider whether an equilibrium in which both firms adopt mobile targeting can be sustained. To characterize firms’ pricing strategies under mobile targeting, consider first consumers’ total cost of buying as summarized below, with \(\{p_0, p_{1/2}, p_1\}\) denoting a firm’s prices for consumers located at distance \(\{0, \frac{1}{2}, 1\}\).

**Table 1**: Consumers’ Total Cost of Buying under Mobile Targeting

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<th>Consumers at 0</th>
<th>Consumers at (\frac{1}{2})</th>
<th>Consumers at 1</th>
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<tr>
<td>Firm 1’s price:</td>
<td>(p_0)</td>
<td>(p_{1/2})</td>
<td>(p_1)</td>
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<tr>
<td>Cost of buying from Firm 1</td>
<td>(p_0, p_{1/2}+t, p_1+2t)</td>
<td>(p_0+t, p_{1/2}+t, p_1+2t)</td>
<td>(p_0+2t, p_{1/2}+2t, p_1+2t)</td>
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<tr>
<td>Firm 2’s price:</td>
<td>Cost of buying from Firm 2</td>
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<td>$p_0, p_{1/2} + t, p_1 + 2t$</td>
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Note: The cost of buying reflects all three buying scenarios. E.g., for top cell #1, it is $p_0$ if the consumer simply buys from firm 1 at location 0; $p_{1/2} + t$ if he travels to location $1/2$ to get the coupon and then comes back to buy from firm 1; and $p_1 + 2t$ if he travels to location 1 to get the coupon and then comes back to buy from firm 1.

Based on the consumers’ total cost of buying in Table 1, we make the following observations.

**Lemma 2:** An equilibrium with mobile targeting must satisfy the following properties: a) a consumer located at distance 0 has non-decreasing cost of buying when traveling to distance $1/2$ or distance 1, i.e., $p_0 \leq \min(p_{1/2} + t, p_1 + 2t)$, b) a consumer located at distance $1/2$ has non-decreasing cost of buying when travelling to distance 1, i.e., $p_{1/2} \leq p_1 + t$, and c) demand at distance 1 is 0 for both firms, i.e., $p_1 + 2t - p_0 \geq s$.

Intuitively, Lemma 2 highlights that by preventing consumers from travelling, firms could convert the consumers’ travel costs into their own profit. As firms coordinate their prices across the three locations to prevent consumers from cherry-picking for a better deal, we formalize below their optimal pricing strategy under mobile targeting.

**Proposition 2:** In the highest-profit mobile targeting equilibrium, each firm charges prices $(2t-s, t-s, 0)$ to consumers located at distance $\{0, 1/2, 1\}$. The profit for each firm is $5t/2 - 3s/2$ and all consumers are served in equilibrium.
The firms’ equilibrium prices in the proposition are driven by competition and conditions that prevent consumers from cherry picking. The intuition is as follows. Realize first that a positive price at the competitor’s home base cannot be sustained as the two firms would fight a price war until the poaching firm is driven out of the home base at price zero. As a result, a consumer located at 0 or 1 can always pay zero price and travel to the opposite end of the line to buy the product with a total cost of 2t. In order to keep all its local consumers, a firm has to charge a price that is not higher than 2t-s, which turns out to be the equilibrium local price for local customers. Finally, to prevent local consumers from travelling to the middle location for a better deal, the price at the middle needs to be at least t-s, which is higher than what the firms would charge at \( \frac{1}{2} \) if the consumers cannot cherry pick across locations and therefore can be sustained as the optimal price under mobile targeting. These optimal prices, when put together, yield the following comparative statics on firm profit.

**Corollary 1**: The price and profit in the highest-profit (mobile targeting) equilibrium increase with \( t \) and decrease with \( s \).

The corollary follows directly from Proposition 2. Essentially, when \( t \) increases, it is harder for consumers to cherry pick an offer across locations, and firms can hence increase equilibrium prices. When \( s \) increases, however, firms have to lower their home-base prices in order to keep all local customers, obtaining a lower profit in equilibrium.

Comparing the mobile targeting equilibrium to uniform pricing, one can see that the availability of mobile targeting lowers market price at all locations and increases overall market
coverage. As with traditional forms of targeting, the ability for firms to price discriminate against different consumers allows them to expand their consumer base, although it comes with the cost of intensified price competition in each submarket. Different from traditional forms of targeting, however, the firms’ need to balance the three prices to prevent consumer cherry-picking under mobile targeting helps limit price competition, and as a result, firm profit may be either higher than under uniform pricing.

**Proposition 3:** Mobile targeting increases firms’ equilibrium profit from uniform pricing iff \( V < (5t - s)/2 \).

Proposition 3 suggests that mobile targeting enhances firm profitability if the consumers’ willingness-to-pay for the product category is relatively low, their travel cost is high and their preference regarding different firms is weak. The intuition of this result has to do with the increase in demand and decrease in price as firms move from uniform pricing to mobile targeting. While demand in our model always increases from 1 to 1.5, the decrease in price depends on the aforementioned parameters in the following way.

When travel cost \( t \) is high, the decrease in price is less significant as firms can charge higher prices to consumers under mobile targeting due to their decreased ability to travel. When the consumers’ preference parameter \( s \) is low, a firm can increase its margin at both distances 0 and \( 1/2 \) under mobile targeting, while the only relevant margin under uniform pricing is at distance 0 as the firms remain local monopolies. Finally, when the consumers have a lower willingness-to-pay for the product category, firms make less profit under uniform pricing as price needs to be lowered. Firm profit under mobile targeting, however, can remain unchanged as the
equilibrium prices are determined by balancing prices across locations rather than competing with non-purchase. Therefore, the decrease in price is less significant and mobile targeting enhances firm profit when the consumers’ travel cost is high, their preference for firms is low, and their willingness-to-pay for the product category is low.

As expected, as demand increases and price competition intensifies under mobile targeting, consumers are better off at all locations.

*Corollary 2: Consumers are strictly better off under mobile targeting than under uniform pricing.*

In sum, we have shown in the main model that once mobile targeting becomes available, a uniform-pricing equilibrium can no longer be sustained. While traditional targeting often lowers firm profit in a competitive setting, we show that mobile targeting can increase firm profit: while it generates demand expansion like traditional targeting, the associated price competition is less fierce as firms need to carefully balance their prices across. Consequently, there exist conditions under which both firms and consumers are strictly better off under mobile targeting than under uniform pricing.

**Extension I: A Fraction of Consumers Are Not Mobile Accessible**

While the adoption of mobile phones is becoming ubiquitous, consumers are still divided in their feelings about location sharing. According to a recent survey\(^5\), 71% mobile users opt into

location sharing, whereas 64% opt into push notifications and 64% opt into emails from brands. 63% of consumers who don’t use this feature simply don’t want to share their location. An additional 35% say they don’t want to participate because it decreases battery life. On the other hand, 76% of those who actually use location-sharing say it helps them receive more meaningful content, and 73% rate this feature as useful.

Based on these statistics, it is interesting to investigate what happens if only a fraction of consumers are accessible through mobile targeting. Suppose that a fraction $\alpha \in (0,1)$ of consumers at each location is accessible through their mobile devices and $\alpha$ is common knowledge. We can easily obtain that Proposition 1 remains to hold: firms would still have an incentive to adopt the technology as it would enable them to lower their price at location $\frac{1}{2}$ and make a higher overall profit.

Given that firms would adopt the mobile targeting technology, the market is essentially divided into two submarkets: consumers who are mobile accessible and consumers who are not. Since firms’ equilibrium prices under mobile targeting are always lower than those under uniform pricing, one can essentially treat these two submarkets as two different markets: consumers who receive offers on their mobile devices never have an incentive to buy at the (higher) uniform price instead. Consequently, the firms’ optimal prices for mobile accessible consumers remain the same as in Proposition 2: they charge $\{2t-s, t-s, 0\}$ at distances $\{0, \frac{1}{2}, 1\}$ and make profit $\alpha(5t/2-3s/2)$ in this submarket. On the other hand, they continue to charge $V-s$ to consumers who are not mobile accessible, and make a profit of $(1-\alpha)(V-s)$ in this submarket. One can verify that in this case the equilibrium can be sustained in that firms do not have an incentive to deviate to uniform pricing by getting off the mobile platform. As a result, the total profit of each firm in this case becomes $\alpha(5t/2-3s/2)+(1-\alpha)(V-s)$, which leads to the following result.
**Proposition 4:** Firms’ equilibrium profit increases with $\alpha$ if and only if $V < (5t-s)/2$.

Proposition 4 suggests that if mobile targeting increases firms’ profit from uniform pricing, then firms are better off when a larger fraction of consumers opt into mobile targeting. On the other hand, if the firms are in a prisoner’s dilemma and their profit under mobile targeting is lower than that under uniform pricing, then they are instead better off when a smaller fraction of consumers opt into mobile targeting. This latter case is more likely to occur when consumers have high willingness to pay for the product category, their transportation cost is small, and their preference for individual firms is strong.

**Extension II: Different Market Sizes across Locations**

As consumers in the real world are rarely evenly distributed, we investigate next how firms’ mobile targeting strategy would change when the size of consumer population is different across locations. In particular, we allow the mass of consumers at location $\frac{1}{2}$ to be $k$ ($k > 0$) and investigate the impact of $k$ on equilibrium outcomes.\(^6\)

To be consistent with our main model, we assume $k$ is small enough ($k < \frac{V-2s}{V-t}$) so that the firms remain local monopolies in the uniform pricing equilibrium. This condition automatically holds when $k \leq 1$ and it also implies that $k < \frac{3}{2}$ given $2s < t < 4s$ and $2t < V < 2t + s$. As shown in the

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\(^6\) Note that the results we obtain in this section remain qualitatively unchanged in the alternative model setup with a mass of $3\gamma$ consumers located at 0 and 1, and a mass of $3(1-2\gamma)$ consumers located at $\frac{1}{2}$: one can easily normalize the total mass of consumers to 3 in the current setup by dividing consumer populations by $(2+k)/3$ at all locations. We use the current setup as it minimizes notation and eases disposition.
main model, it is still profitable for firms to prevent consumers from travelling in a mobile targeting equilibrium. That is, Lemma 2 still holds, with the proof being the same as before. With this knowledge, we show next that the impact of k on the mobile targeting equilibrium.

**Lemma 3:** In the highest profit mobile targeting equilibrium, firms charge equilibrium prices \( \{2t-s, t-s, 0\} \) at distances \( \{0, \frac{1}{2}, 1\} \) when \( 2s < t < \left( \frac{2}{k} + 2 \right) s \), and their equilibrium profit is \( 2t - s + \frac{k}{2} (t - s) \).

Lemma 3 suggests that the firms’ equilibrium pricing strategies remain unchanged as long as \( 2s < t < \left( \frac{2}{k} + 2 \right) s \). Note that this condition is harder to satisfy as \( k \) increases. Intuitively, as a higher fraction of consumers are located in the middle, firms have a stronger incentive to lower their prices at this location. Therefore, to sustain the firms’ original equilibrium prices, \( k \) cannot be too large. Suppose that the original prices are sustained, we compare the firms’ profit under mobile targeting to that under uniform pricing below, assuming that the firms would enter the highest-profit equilibrium under mobile targeting.

**Proposition 5:** Firms’ equilibrium profit under mobile targeting increases with \( k \) and is higher than that under uniform pricing if \( k > \frac{2(V - 2t)}{t - s} \). If we fix the total market size, firms’ equilibrium profit under mobile targeting decreases with the proportion of consumers located at \( \frac{1}{2} \).

If the amount of middle consumers increases without affecting the amount of local consumers, firm profit under mobile targeting will increase because firms can serve more consumers in equilibrium. However, if we fix the total market size and change the distribution of
consumers across different locations, equilibrium firm profit under mobile targeting would in fact decrease with the proportion of middle consumers, because the firms can obtain a higher margin on their local consumers than consumers who are located further away.

**Extension III: Choosing Popular Locations for Mobile Targeting**

While we often observe firms’ targeting consumers at their own stores (geo-fencing) and those at their competitors’ stores (geo-conquering), it is much less obvious what kind of locations would be better for firms to target in between the two stores. It is natural to wonder, for example, whether it would be profitable for firms to choose destinations that are frequently visited by the general public, such as parks, as opposed to unpopular locations that are not visited on a regular basis. In this section, we analyze a variation of the model in which location $\frac{1}{2}$ is a very popular destination: consumers frequently go to and back from this location and thus can get mobile offers at this location without having to incur (additional) travel cost. Consumers’ total cost of buying under mobile targeting in this case can be updated as follows.

*Table 2: Consumers’ Total Cost of Buying when $\frac{1}{2}$ is a Popular Location*

<table>
<thead>
<tr>
<th></th>
<th>Consumers at 0</th>
<th>Consumers at $\frac{1}{2}$</th>
<th>Consumers at 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Firm 1’s price:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost of buying from Firm 1</strong></td>
<td>$p_0$</td>
<td>$p_{1/2}$</td>
<td>$p_1$</td>
</tr>
<tr>
<td></td>
<td>$p_0, p_{1/2}, p_1+2t$</td>
<td>$p_0+t, p_{1/2}+t, p_1+2t$</td>
<td>$p_0+2t, p_{1/2}+t, p_1+2t$</td>
</tr>
<tr>
<td><strong>Firm 2’s price:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost of buying from Firm 2</strong></td>
<td>$p_1$</td>
<td>$p_{1/2}$</td>
<td>$p_0$</td>
</tr>
<tr>
<td></td>
<td>$p_0+2t, p_{1/2}+t, p_1+2t$</td>
<td>$p_0+t, p_{1/2}+t, p_1+2t$</td>
<td>$p_0, p_{1/2}, p_1+2t$</td>
</tr>
</tbody>
</table>
As before, we characterize the highest-profit mobile targeting equilibrium in this scenario.

**Proposition 6:** When location $\frac{1}{2}$ is "popular" and frequently visited so that consumers can get the price at this location without travel cost, in the highest profit mobile targeting equilibrium, the firms charge $\{V-s, p_{1/2}, p_1\}$ at distance $\{0, \frac{1}{2}, 1\}$ with $p_{1/2} \geq V-s$ and $p_1 \geq V-2t$, or charge $\{p_0, V-s, p_1\}$ at distance $\{0, \frac{1}{2}, 1\}$ with $p_0 \geq V-s$ and $p_1 \geq V-2t$. The firms’ equilibrium profit is $V-s$.

From Proposition 6, we can easily see that the equilibrium is equivalent to a uniform pricing equilibrium with both firms charging $V-s$ at all locations.

**Corollary 3:** A uniform pricing equilibrium with both firms charging $V-s$ can be sustained if consumers can visit location $\frac{1}{2}$ without incurring travel cost.

In our main model, firms in the mobile targeting equilibrium can charge a higher price to local consumers than to consumers located further away. As the local consumers can now effortlessly obtain a lower price at $\frac{1}{2}$, firms essentially lose the power to price discriminate. As a result, we are back to the uniform pricing equilibrium outcomes. If firms have to incur a positive cost to use mobile targeting, they would rather not adopt the technology when the middle location can be visited by consumers without (additional) travel cost. In other words, in order for mobile targeting to be effective, travel costs need to be substantial and the targeted middle location has to be one that consumers do not visit on a regular basis.
Extension IV: Tracing Down Consumers’ Base Locations

Finally, we consider the possibility for firms to trace down consumers’ base locations and restricting consumers to pay their base-location prices. Suppose that the tracing technology costs $C > 0$ to the firm that adopts it. The technology can be either mobile based (e.g., Placed, JiWire) or paper based, in which case it simply means purchasing a mailing list and sending coupons to people’s homes. Once tracing is implemented, a consumer can no longer obtain a price that is not offered at his base location. Suppose now that the firms are in the highest-profit mobile targeting equilibrium. We first examine a firm’s incentive to adopt the tracing technology.

**Lemma 4:** Firms would implement tracing if $C < \frac{(t-2s)^2}{8s}$.

Essentially, firms would lower their prices at location $\frac{1}{2}$ to increase their demand when tracing is implemented, as they no longer have to worry about home consumers traveling to this location for a better deal. Consistent with this intuition, Lemma 4 suggests that firms are more likely to implement tracing when $t$ is higher and $s$ is lower, as there is more room for the firms to lower their prices at $\frac{1}{2}$ under mobile targeting. Suppose the condition in Lemma 4 above is satisfied, firms implement tracing, and the cost of tracing is sunk. We now investigate whether tracing can be sustained as part of an equilibrium.

**Proposition 7:** Tracing can be sustained in equilibrium. In this equilibrium, firms charge prices \{2t-s, s, 0\} to consumers at distance \{0, $\frac{1}{2}$, 1\}, and all consumers are served. The firms earn an equilibrium profit of $2t-s/2$ and are worse off than under mobile targeting without tracing.
Proposition 7 suggests that firms have to lower prices with the tracing technology and their profit is lower than under mobile targeting without tracing even if the tracing technology is costless. The reason for this is that since consumers can no longer cherry pick across locations, firms have stronger freedom to compete in prices. As a result, price competition intensifies and the firms’ profit decreases, which is consistent with results in the prior literature on competitive couponing (e.g., Shaffer and Zhang 1995).

Conclusion

In this paper, we show in a duopoly setting that targeting consumers based on their real time locations on a mobile platform is fundamentally different from traditional targeting strategies. In particular, the ability for consumers to travel across locations for better deals help curtail firms’ price competition at each location, possibly leading to higher overall profit. We show that this benefit of mobile targeting critically depends on the percentage of consumers whose locations are accessible through their mobile devices, the distribution of consumers across locations, and the popularity of the targeted center location. Finally, we show that while firms may have an incentive to trace down consumers’ base location to prevent them from cherry picking an offer across locations, such technologies typically make the firms worse off as they tend to intensify price competition.

Our results have important managerial implications for marketers who aim to optimize their mobile targeting strategies. Our results suggest, for example, that managers should carefully trade off the benefit (demand expansion) and cost (increased price competition) of mobile
targeting. Moreover, the ability for consumers to travel for a better deal may help enhance firms’ equilibrium profit and therefore should not be discouraged. If a company decides that mobile targeting is beneficial, it should encourage more consumers to become mobile accessible and target a middle location in the marketplace that consumers do not visit on a regular basis.

There are many interesting directions for future research. For example, many companies have been thinking about how to connect multiple devices of a user and build an integrated profile based on his purchase history, location history, demographics and browsing habits. It would be useful to see how these elements would interact with each other in shaping a user’s purchase intent and correspondingly, the optimal way to target different users. We have also focused on the case in which consumers need to incur physical travel costs to visit the store in order to purchase the product, and as mobile payment matures, one can imagine situations in which consumers would make a purchase directly online. In that case, the relevant cost would be shipping, which may or may not be lower to the local consumers than to consumers who are located further away. Therefore, we expect mobile commerce, and e-commerce in general, to have a significant impact on the effectiveness of mobile targeting, as the elimination of the differences in transportation cost when the consumers purchase from different sellers may once again prevent firms to price discriminate across different locations. Finally, it may be worthwhile to investigate how asymmetry between firms may affect the consequences of mobile targeting. In particular, it would be nice to know if there exist conditions under which mobile targeting would benefit one firm while hurting the other.
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Appendix

**Proof of Proposition 1**: If firms only serve the local consumers, \( \pi=p(V-p)/s \), where \( V-s<p<V \).

Under F.O.C., the profit maximizing price is \( V/2 \). Because \( V/2<V-s \), the optimal price is \( V-s \), and so the optimal profit is \( V-s \). Given \( s<t/2 \), the middle segment is not served because the utility of buying from either firm is \( V-t-(V-s)<0 \). To make sure that neither firm has incentive to deviate to lowering its price to serve the middle consumers, i.e., \( V-s>\max_{0<\lambda<1} (V-t-\lambda s)(1+\lambda) \), we need \( V<s+2t \). Under this condition, neither firm has incentive to deviate to lowering its price to serve the competitor’s local consumers either, i.e., \( V-s>\max_{0<\lambda<1} (V-2t-2\lambda s)(2+\lambda) \). Q.E.D.

**Proof of Lemma 1**: Consider the different ranges of prices that firms can charge in a symmetric uniform pricing equilibrium. First, suppose \( p>V-s \). In this case we know from Proposition 1 that a firm can increase its profit by lowering price to \( p=V-s \). Second, suppose \( V-t\leq p\leq V-s \) so that firms remain local monopolies, in this case a firm can profitably deviate to charging a different price at location \( 1/2 \), \( p_{1/2}=V-t-s \), which will enable the firm to generate positive profit at this location without decreasing its profit from local consumers. Third, suppose \( s<p<V-t \), in this case a firm can profit from lowering \( p_{1/2} \) by a small number \( \epsilon>0 \) as the unconstrained optimal price at location \( 1/2 \) is \( s \). Finally, suppose that \( p\leq s \), a firm then can profitably deviate to charging \( t+s \) at its base location. Q.E.D.

**Proof of Lemma 2**: To show a), realize that if \( p_0>\min\{p_{1/2}+t, p_1+2t\} \), no one buys at \( p_0 \). Then a firm can increase profit by lowering \( p_0 \) to \( \min\{p_{1/2}+t, p_1+2t\} \). When the firm does this, consumers at distance 0 will switch from buying at \( p_{1/2} \) or \( p_1 \) to buying at \( p_0 \), and the firm can
gain an additional profit of $t$ or $2t$ from these consumers without affecting consumers at other locations.

To show b), realize that if $p_{1/2} > p_1 + t$, then no one buys at $p_{1/2}$. In this case, there are three possibilities. First, if $p_0 + 2t < p_1 + 2t$, then a firm can deviate profitably by lowering both $p_1$ and $p_{1/2}$ to the current $p_0$ and then increasing $p_0$. By doing so, it can increase profit from distance 0 without affecting profit from distance $1/2$ or 1. Second, if $p_0 + t \leq p_1 + 2t \leq p_0 + 2t$, then a firm can deviate profitably by lowering $p_{1/2}$ to the current $p_0$ and then increasing $p_0$ because by doing so, it can increase profit at distance 0 without affecting profit from distance $1/2$ or 1. Third, if $p_1 + 2t < p_0 + t$, then a firm can deviate profitably by lowering $p_{1/2}$ to $p_1 + t$. In this deviation, consumers at distance 0 are not affected because of a) and consumers at distance 1 are not affected because $p_{1/2} + 2t$ won’t be the lowest price, while at least some consumers at location $1/2$ will switch from buying at $p_1$ to buying at $p_{1/2}$, and the firm will hence make an additional profit of $t$ on these consumers without changing the demand. Note that here, both firms have positive demand at location $1/2$ in equilibrium, otherwise a firm will have an incentive to lower $p_{1/2}$ to $p_0 - t$ to increase the firm’s profit at $1/2$, without affecting profit at other prices.

To show c), suppose without loss of generality that Firm 2’s demand at location 0 is not zero. We show below that it is profitable for Firm 1 in this case to lower $p_0$. Given a) and b), we have $p_0 \leq p_{1/2} + t \leq p_1 + 2t$. Therefore, a consumer located at 0 would either buy from Firm 1 at $p_0$, or buy from Firm 2. The only possible scenario in which demand for Firm 2 is positive is when the consumer buys from Firm 2 at price $p_1$ and $p_1 + 2t - s \leq p_0$, as the consumers’ total cost of buying from Firm 2 at the other two prices are at least higher than $p_0$ by $t$ ($t > s$). Firm 1’s demand at location 0 is thus determined by $V - p_0 - sy > V - (p_1 + 2t) - s(1 - y)$, i.e., $y < (p_1 - p_0 + s + 2t) / (2s)$. Firm 1’s profit at location 0 is hence $p_0 (p_1 - p_0 + s + 2t) / (2s)$ and it is optimal for the firm to decrease its price.
as long as $p_0 > (p_1 + s + 2t)/2$. Given $p_1 + 2t - s > (p_1 + s + 2t)/2$ whenever $p_1 > 0$, and a decrease in $p_0$ for Firm 1 would not affect its profit at other locations as long as $p_0 > p_1 + t$ (implied by $p_0 > p_1 + 2t - s > p_1 + t$), Firm 1 finds it profitable to decrease its price. Q.E.D.

**Proof of Proposition 2:** Given Lemma 2c, we must have $p_0 \leq 2t - s + p_1$, so that consumers at locations 0 or 1 will all buy from the firm with distance 0. Given Lemma 2a and 2b, we must have $p_0 \leq p_{1/2} + t$ and $p_{1/2} \leq p_1 + t$, with at most one condition binding given $p_0 \leq 2t - s + p_1$.

A) If $p_{1/2} \leq p_1 + t$ is binding, i.e., $p_{1/2} = p_1 + t$, we have $p_0 < p_{1/2} + t$ and $p_0 \leq 2t - s + p_1$. Since $p_1 \geq 0$, $p_{1/2} \geq t$. Since $t > s$ (s is the unconstrained optimal price at $\frac{1}{2}$ for two competing firms), both firms will have incentives to lower price to get more consumers from location $\frac{1}{2}$; this can be done without affecting consumers at distance 0 or 1 (because $p_0 < p_{1/2} + t$ is not binding). So this cannot be equilibrium.

B) If $p_0 \leq p_{1/2} + t$ is binding, i.e., $p_0 = p_{1/2} + t$, we have $p_{1/2} < p_1 + t$ and $p_0 \leq 2t - s + p_1$. If $p_0 < 2t - s + p_1$, a firm could make more profit by increasing $p_0$ until the constraint is binding and keeping $p_{1/2} = p_0 - t$. Therefore, in the highest profit equilibrium, $p_0 = 2t - s + p_1$.

Since $p_{1/2} < p_1 + t$ is not binding, if $p_1 > 0$ and the competitor is charging a local price that is just low enough to keep the focal firm’s demand to be zero at distance 1, the focal firm would have an incentive to lower $p_1$ to get more consumers at distance 1 without affecting consumers at distance 0 or $\frac{1}{2}$. So in equilibrium, we must have $p_1 = 0$. Then $p_0 = 2t - s$ and $p_{1/2} = t - s$. In this equilibrium, all consumers buy at the price at their home location.

Below we check the firm’s incentives to deviate from these prices.
First, the firm has no incentive to lower \( p_0 \) because it will lead to lower profit from distance 0 without affecting the profit from distance \( \frac{1}{2} \) or 1 or even decreasing the profit from distance \( \frac{1}{2} \) (if \( p_0 < p_{1/2} \)). The firm also has no incentive to raise \( p_0 \) because it will lead to a loss of \( t \) from distance 0 without getting additional profit from distance \( \frac{1}{2} \) or 1.

Second, the firm has no incentive to raise \( p_{1/2} \) because it will deviate further from the optimal price \( s \) when consumers cannot obtain prices out of their home base and the firm will therefore lose profit from distance \( \frac{1}{2} \) without getting additional profit from 0 or 1.

Third, to check if the firm will have an incentive to lower price \( p_{1/2} \), we derive the deviation profit for the firm as follows.

If a firm deviates and lowers \( p_{1/2} \) to \( p_D \), it will get more consumers at \( \frac{1}{2} \), but lose profit \( t \) from consumers at distance 0 unless it lowers \( p_0 \) at the same time; in the latter case, it will lose profit \( p_{1/2} - p_D \) from consumers at distance 0. Because \( p_{1/2} - p_D < t \), the firm will find it profitable to lower \( p_0 \) as well if it deviates. So the firm maximizes \( p_D(p_{1/2} - p_D + s)/(2s) - (p_{1/2} - p_D) \), where \( p_D \leq p_{1/2} \).

From this maximization we get (1) \( p_D = p_{1/2} \) when \( p_{1/2} \leq 3s \), (2) \( p_D = (p_{1/2} + 3s)/2 \) when \( 3s < p_{1/2} < 5s \), and (3) \( p_D = p_{1/2} - s \) when \( p_{1/2} \geq 5s \). Under (2) and (3), deviation yields higher profit. Thus, as long as \( p_{1/2} \leq 3s \), the equilibrium holds. Since \( 3s > t - s \), the following equilibrium yields the highest profit: prices are \( \{2t-s, t-s, 0\} \) at distance \( \{0, \frac{1}{2}, 1\} \), and profit is \( \pi = \frac{5t}{2} - \frac{3s}{2} \).

C) If neither condition is binding, i.e., \( p_0 < p_{1/2} + t \) and \( p_{1/2} < p_1 + t \), then we can show that it cannot be an equilibrium. If consumers cannot travel to get a lower price (i.e., there are no constraints to keep the consumers from travelling), the optimal price at distance 0 is \( 2t-s \), and the optimal price at distance \( \frac{1}{2} \) is \( s \). Since \( 2t-s > s+t \), if \( p_0 \leq p_{1/2} + t \) is not binding, it
must be that at most one price is at its optimal price. Then the firm will have incentive to
move the other price closer to the optimal price. For example, if \( p_{1/2}=s \), then \( p_0<2t-s \) and
the firm will have incentive to raise \( p_0 \) to get more profit from distance 0 without
affecting its demand at distance \( 1/2 \). If \( p_{1/2}>s \), then the firm will have incentive to lower
\( p_{1/2} \) to get more profit from distance \( 1/2 \) without affecting its demand at distance 0 or 1. So
this cannot be equilibrium.

As a final step of the proof, we show that the equilibrium above would not break down due to
firms’ deviating to the uniform pricing strategy. Without loss of generality, check Firm 2’s
incentive to deviate. Given Firm 1’s equilibrium prices, the most profitable deviation in uniform
pricing for Firm 2 is to charge \( 2t-s \) and sell to every consumer at distance 0. The deviation profit
is \( 2t-s \), which is always lower than Firm 2’s equilibrium profit given \( s<t \). Q.E.D.

**Proof of Proposition 3:** Firms’ profit under uniform pricing is \( V-s \), and their profit under mobile
targeting is \( 5t/2-3s/2 \). Therefore, profit under mobile targeting is higher if \( 5t/2-3s/2>V-s \), which
can be reduced to \( V<5t/2-s/2 \). Q.E.D.

**Proof of Corollary 2:** Consider first consumers located at 0 (1). These consumers purchase from
Firm 1 (2) at the price \( V-s \) under uniform pricing and they purchase from Firm 1 (2) at the price
\( 2t-s \) (<\( V-s \)) under mobile targeting. Consider next consumers located at \( 1/2 \). They do not make a
purchase and have zero surplus under uniform pricing. With mobile targeting, they purchase
from either Firm 1 or Firm 2 at the price \( t-s \), deriving a utility of \( V-t-(t-s)-sd=V-2t+s(1-d)>0 \),
where \( d \) (between 0 and 1) is the consumer’s distance from his preferred firm. Q.E.D.
Proof of Proposition 4: The only thing we need to verify is that firms do not have an incentive to deviate to uniform pricing by getting off the mobile platform. This can be seen by noting that (1) for consumers who are mobile accessible, the highest profit a firm can make in a uniform-price deviation is $\alpha(2t-s)$, lower than what the firm makes in equilibrium, $\alpha(5t/2-3s/2)$, and (2) for consumers who are not mobile accessible, the highest profit a firm can make in a uniform-price deviation is $(1-\alpha)(V-s)$, the same as what it makes in equilibrium. Q.E.D.

Proof of Lemma 3: The proof is similar to that of Proposition 2 except for two major modifications. First, when checking if a firm has an incentive to lower the price at distance $\frac{1}{2}$ in scenario B), the deviating firm now maximizes $k \cdot p_D(p_{1/2}-p_D+s)/(2s)-(p_{1/2}-p_D)$, where $p_D \leq p_{1/2}$. To keep the firm from deviating, we need $p_{1/2} \leq (2/k+1)s$. Therefore, the equilibrium holds when $t-s<(2/k+1)s$, i.e., $t<\left(\frac{2}{k}+2\right)s$.

Second, when checking whether firms would want to deviate to uniform pricing from mobile targeting, the firm’s deviation profit is now maximized when he sells only to the home base consumers if $t<2s/k$, which is possible if $k<1$ and guaranteed if $k<1/2$. In this case, the deviation profit $2t-s$ is always lower than the firm’s profit in the highest-profit mobile targeting equilibrium, which is $2t-s+k/2(t-s)$. When $t \geq 2s/k$, which is possible only if $k>1/2$, the firm’s deviation profit is maximized by selling also to some of the consumers located at $\frac{1}{2}$. In particular, the maximum deviation profit, at deviation price $\frac{t}{2} + \frac{s}{k}$, is $\frac{k}{2s} \left(\frac{t}{2} + \frac{s}{k}\right) \left(\frac{t}{2} - \frac{s}{k}\right) + \frac{t}{2} + \frac{s}{k} \cdot \frac{t}{2}$, which is always lower than $2t-s$ (smaller than firms’ profit under mobile targeting) given $1/2<k<3/2$.

In sum, when $k<1/2$, firms deviate to selling to all home based consumers and make less profit. When $\frac{1}{2} \leq k < 1$, firms deviate to either selling to all home based consumers or selling also
to some consumers located at $\frac{1}{2}$. In either case, profit is lower than under mobile targeting. When $1<k<\frac{3}{2}$, firms deviate to selling to all home based consumers and some consumers located at $\frac{1}{2}$ and deviation profit is also lower than under mobile targeting. Therefore, there is no profitable deviation for any possible $0<k<\frac{3}{2}$. \textbf{Q.E.D.}

\textbf{Proof of Proposition 5:} It can be easily seen that the profit increases with $k$. To see what happens if we fix the total market size, we normalize the firms’ profit by the total mass of consumers $2+k$. The firm’s normalized profit can be written as \[ \frac{[(2t-s)+k(t-s)/2]/(2+k)}{(2+k)} \] and the first order derivative of this profit with respect to $k$ is negative. To see the second part of the proposition, note that the firms’ equilibrium profit under uniform pricing is $V-s$ and their equilibrium price under mobile targeting is $2t-s+k^2(t-s)$. The comparison of these two profits completes the proof. \textbf{Q.E.D.}

\textbf{Proof of Proposition 6:} First, note that $\min\{p_0, p_{1/2}\} \leq p_1+2t$, otherwise a firm can increase profit by lowering $p_0$ or $p_{1/2}$ to $p_1+2t$; by doing so, the firm can gain an additional profit of $2t$ from the consumers at distance 0 without affecting profit at other locations.

Now let’s first derive the equilibrium when $p_0 \leq p_{1/2}$. Consider two cases based on the relationship between $p_0$ and $p_1$. 1) If $p_0 \leq p_1+t$, then consumers at distance 0 or $\frac{1}{2}$ buy at $p_0$ (or a price equal to $p_0$), and the demand at distance 1 is zero because consumers’ total cost of buying from the firm at distance 1 is always bigger than their cost of buying from the local firm by more than $s$. Because the same price binds at distances 0 and $\frac{1}{2}$ and the firm does not have demand at distance 1, based on our calculations under uniform pricing, firms will set the binding price to be $V-s$ and serve only the local customers. So the equilibrium will be \{V-s, p_{1/2}, p_1\} for distance \{0,
½, 1} where \( p_{1/2} \geq V - s \) and \( p_1 \geq V - s - t \). 2) If \( p_0 + t < p_0 \leq p_1 + 2t \), then \( p_0 \) is binding for consumers at distance 0 and \( p_1 \) is binding for consumers at distance ½ or 1. In this case, similar to c) in Lemma 2, we can show that the demand at distance 1 is zero and \( p_0 = p_1 + 2t - s \). Thus the highest profit firms can get is \( p_1 + 2t - s + p_1 (V - p_1 - 2t) / s \), where \( 0 \leq (V - p_1 - 2t) / s \leq 1/2 \). We can show that firms will get the highest profit by only selling to the local consumers, i.e., by setting \( p_0 = V - s \) and \( p_1 \geq V - 2t \).

Combing 1) an 2), the equilibrium will be \{V - s, p_{1/2}, p_1\} for distance \{0, ½, 1\} where \( p_{1/2} \geq V - s \) and \( p_1 \geq V - 2t \).

If \( p_0 > p_{1/2} \), the proof is very similar, and we can show that the equilibrium will be \{\( p_0 \), V-s, \( p_1 \}\} for distance \{0, ½, 1\} where \( p_0 \geq V - s \) and \( p_1 \geq V - 2t \). **Q.E.D.**

**Proof of Lemma 4:** Without loss of generality, suppose Firm 2 is the deviating firm. In the most profitable deviation from the mobile targeting equilibrium, Firm 2 charges \( 2t - s \) to consumers at location 1 and sells to all these consumers, charges \( t/2 \) at location ½ and sells to \( t/(4s) \) consumers, and gets zero profit at location 0. Firm 2’s total profit in this deviation is \( t^2/(8s) + 2t - s - C \), and this is higher than its equilibrium profit in Proposition 2 iff \( C < \frac{(t - 2s)^2}{8s} \). **Q.E.D.**

**Proof of Proposition 7:** Consider first the firms’ optimal prices if both firms adopt the tracing technology. To find optimal prices at ½, we have \( V - t - sy - p_{f1} = V - t - s(1 - y) - p_{f2} \), which leads to \( y = (p_{f2} - p_{f1} + s) / (2s) \). Therefore, \( p_{f1} = (p_{f2} + s) / 2 \), \( p_{f2} = (p_{f1} + s) / 2 \), and \( p_{f1}^* = p_{f2}^* = s \). To make sure that consumers get positive utility in equilibrium, we need \( V > t + 3s / 2 \), which is true given our assumptions \( V > 2t \) and \( t > 2s \).

To find optimal prices at 0, we have \( V - sy - p_{f1} = V - s(1 - y) - 2t - p_{f2} \), which leads to \( y = (pf_{f2} - p_{f1} + s + 2t) / (2s) \). Therefore, \( p_{f1} = (p_{f2} + s + 2t) / 2 \), \( p_{f2} = (p_{f1} + s - 2t) / 2 \), and \( p_{f1}^* = s + 2t / 3 \), \( p_{f2}^* = s - 2t / 3 \). Given
s<\text{t}/2, p_{12}^*=0. \text{ So we have to set } p_{12}^*=0. \text{ Now if } p_{12}^*=0, \text{ it can be derived that Firm 1 finds it optimal to sell to all the consumers at 0. So } p_{11} \text{ is derived by } V-s-p_{11}=V-2t-0, \text{ which leads to } p_{11}^*=2t-s. \text{ Therefore, the equilibrium prices are } \{2t-s, s, 0\} \text{ and the profit for each firm is } 2t-s/2. \text{ Given } s<\text{t}/2, \text{ this profit is always lower than firms’ profit under mobile targeting, } 5t/2-3s/2.

As a final step, we show that such a tracing equilibrium can be sustained. Consider the maximum profit a firm could make by deviating back to mobile targeting from tracing. Given the other firm’s optimal prices with tracing, a firm can make at most 0 at distance 1, at most s/2 at distance 1/2 and at most 2t-s at distance 0 when deviating to mobile targeting even without having to balance prices. Therefore, the total deviation profit cannot be higher than the equilibrium profit with tracing. Consider now the maximum profit a firm could make by deviating back to uniform pricing from the tracing equilibrium. We know that a firm’s deviation profit in this case is \( p[1-p/(2s)] + p \) when \( 0 \leq p \leq 2s \) and \( p(2t+s-p)/(2s) \) when \( 2s < p \leq V-s \). Therefore, the maximum deviation profit is \( 2t-s \), which is lower than the firm’s profit in the tracing equilibrium. Q.E.D.