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Flirting with the enemy: online competitor referral and entry-deterrence

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Abstract Internet retailers often compete fiercely for consumers through expensive marketing efforts like search engine advertising, online coupons and a variety of special deals. Against this background, it is somewhat puzzling that many online retailers have recently begun referring their website visitors to their direct competitors. In this paper, using an analytical model, we examine this counterintuitive practice and posit that an entry deterrence motive can potentially explain this marketplace puzzle. Specifically, we develop a model where two incumbents compete for consumers' business while facing a potential entrant who is deciding whether to enter the market. In addition to setting the price, each incumbent firm could potentially display a referral link to its direct competitor. Our analysis reveals that when confronted with a potential entry, an incumbent may refer consumers to its competitor, intensifying the market competition that could result in shutting off the entrant. Furthermore, we show that when referral efficiency is exogenous, it is possible that in equilibrium only *one* incumbent refers its customers to competitor (i.e., one-way referral) or *both* incumbents refer their customers to each other (i.e, two-way referral). When referral efficiency is endogenous, the ex-ante symmetric incumbents may choose *asymmetric*

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referral efficiencies ex-post. We extend the model in a number of directions including making the entrant share endogenous and allowing incumbents to be asymmetric. Overall, our results indicate that firms may be motivated by entry deterrence to *voluntarily* refer consumers to their direct competitors even when they are paid nothing for the referral.

Keywords Online referral · Competitor referral · Entry-deterrence · Game theory

JEL Classification D4 · L1 · M3

1 Introduction

Online retailers often devote considerable financial resources to acquire new customers either organically or through competitive poaching. Online brokerages like E*Trade and TD Ameritrade offer cash offers as high as USD 600 to customers to open a new IRA accounts (Tergesen 2015). To induce switching, cellular companies like T-Mobile and Sprint prominently advertise on their websites their willingness to pay for early termination fees and the payments remaining on the phone obtained through competing service providers (Bonnington 2014). Such significant investments towards acquisition of new customers are not surprising given that marketers have often advocated firms to invest into upfront marketing activities with an eye on customer lifetime value. In other words, even when a firm might be seen losing money in the short term while acquiring a customer, long term future income streams from this customer might add up and be profitable (Gupta et al. 2004; Shin and Sudhir 2010). This logic rings especially true when consumers might face switching costs when moving to competition.

Against this background, a curious new phenomenon has emerged recently whereby many online retailers have started displaying content for their customers and visitors that allows them to find price and other information for a similar product at a competing retailer's website. This phenomenon — which we call "online competitor referral" — refers to the practice wherein firms refer consumers to their direct competitors on their websites. For example, Progressive Direct, a major online player in insurance industry, on its website provides visitors the readily available quotes of its major competitors (e.g., MetLife and Esurance) along with its own quote (see Fig. 1). Progressive Direct's competitor, Esurance.com, an online insurance company, also follows a similar practice that keeps its consumers informed of real-time comparison quotes by providing links to competitors' websites where a customer could buy a competitor's policy (See Fig. 2). A couple of points are noteworthy about these examples: As seen in Fig. 1, the practice is not merely a form of advertising highlighting that Progressive's price is the cheapest (there are significantly cheaper options available among the displayed prices). Second, these twin examples show that such referrals could come in many forms: Progressive Direct showing the quotes of the competitors directly while Esurance providing links to its competitors that take consumers to their webpages and check the prices (Fig. 2). This practice is observed in many other online contexts ranging from vitamin supplements, cars and retail

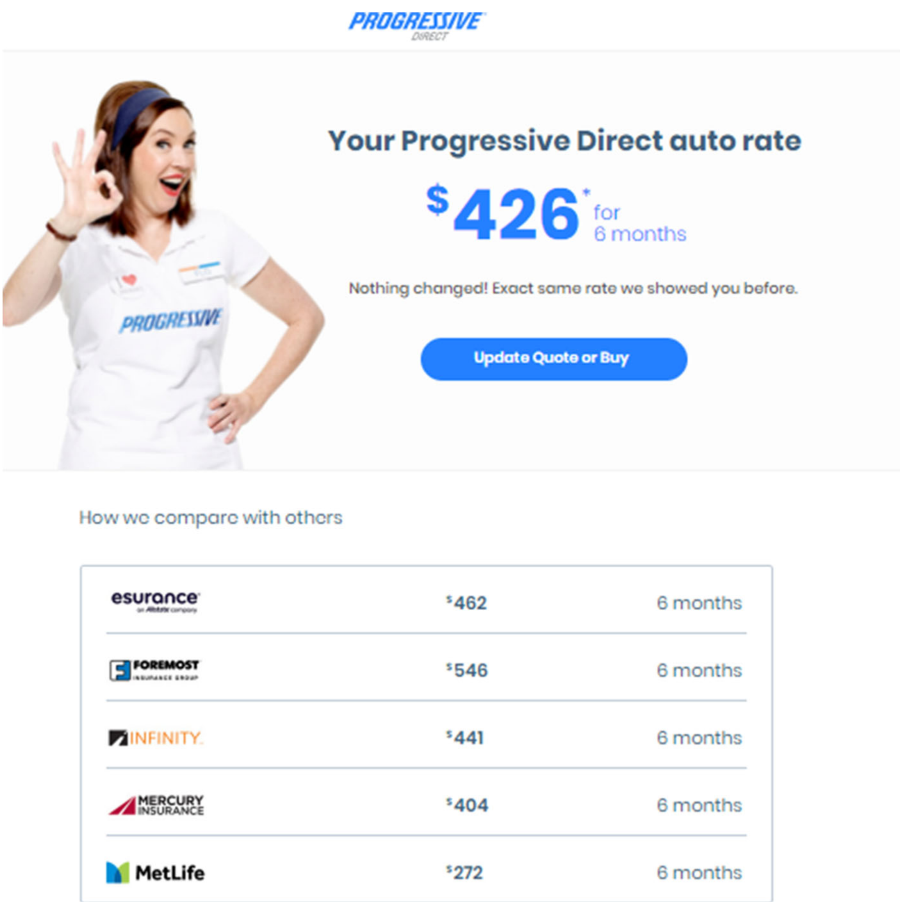

Fig. 1 Competitive Referral of Automobile Insurance Rates at Progressive.com (accessed on 08/22/2017)

products (See more examples in Figs. 3 and 4 for CD rates and mortgage rates provided by Ally Bank). As another prominent example, Zappos.com is well known for acting on behalf of consumers' best interests and referring them to its competitors (Zappos.com 2008).

This practice seems puzzling at a first glance because in industries like insurance and financial services where firms compete fiercely for consumers' business for the products that are largely homogeneous and consumers are very likely to purchase from a retailer that offers the lowest price. Consider a Progressive Insurance consumer who is looking to renew her car insurance policy. This consumer might already have all the required personal information on Progressive Direct and can seamlessly buy a policy there. By referring this consumer to competition, however, Progressive is lowering her search costs and possibly providing incentives for her to make the purchase elsewhere (if this consumer can find a sufficiently attractive price). While such referrals appear to be getting ubiquitous, there is little academic research

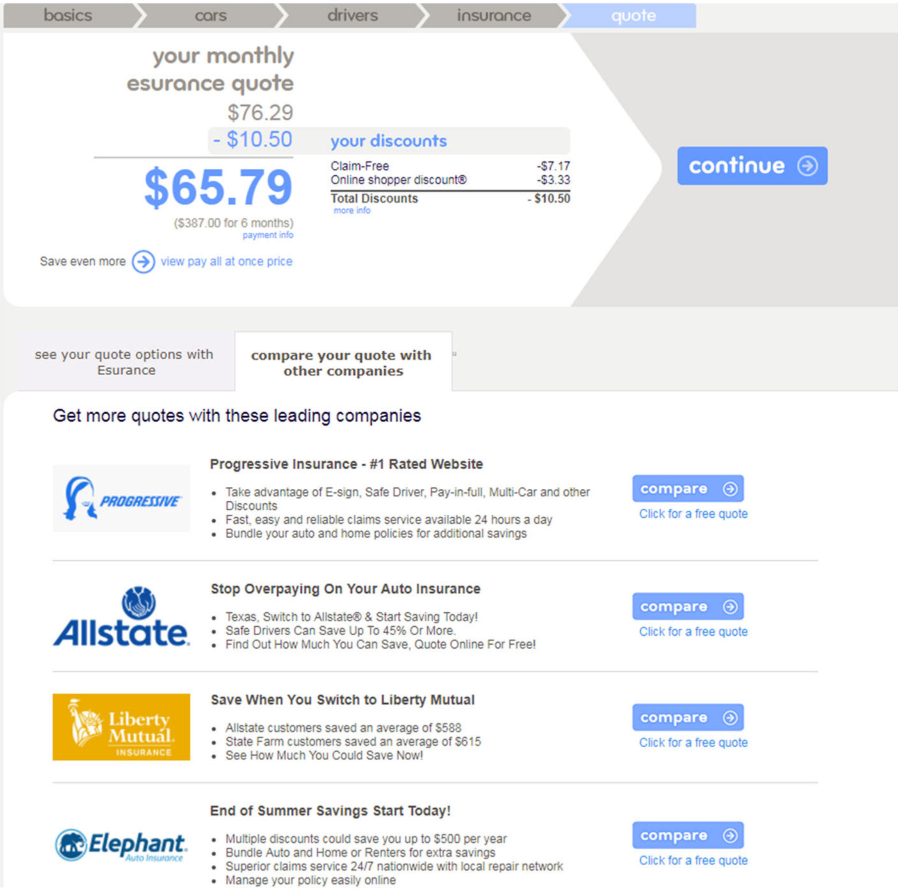

Fig. 2 Competitive Referral of Automobile Insurance Rates at Esurance.com (accessed on 08/22/2017)

investigating the mechanisms for firms *voluntarily* referring competitors online. We seek to address this gap in the present paper. Specifically, in this paper we examine the following questions:

- What is the rationale behind competitor referrals? Why do firms refer consumers to their competitors even though they are apparently worse off by doing so?
- Under what conditions would firms refer each other and under what conditions would one firm refer the other firm(s) but not be referred?

As mentioned earlier, these questions are especially intriguing when we consider that the practice of referring competitors seems common in markets where firms compete intensively for business. At a broader level, there is an increasing interest in firms' online practices since the share of online sales is steadily increasing surpassing a figure of USD 300 billion for the first time in the year 2015. Our paper speaks to the pricing issues in the domain of online markets (Baye et al. 2006) that are receiving increasing attention from policy makers and managers.

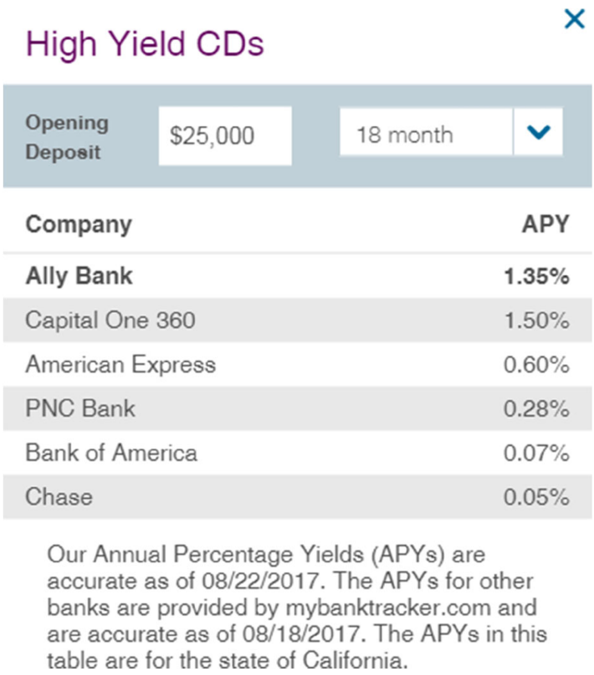

Fig. 3 Competitive Referral of CD Rates at Ally Bank (accessed on 08/22/2017)

In this paper, we develop a model of competition with three players: two incumbents selling a homogeneous product and a potential entrant looking to enter this market. Each incumbent seller has a fraction of customers who are *loyal* to it and only visit the incumbent's website when making a purchase. The remaining fraction is composed of *switchers* who visit the websites of both the sellers and buy from the seller who offers the lower price. Each incumbent seller confronts two decisions: What price to charge and whether to engage in a competitor referral which

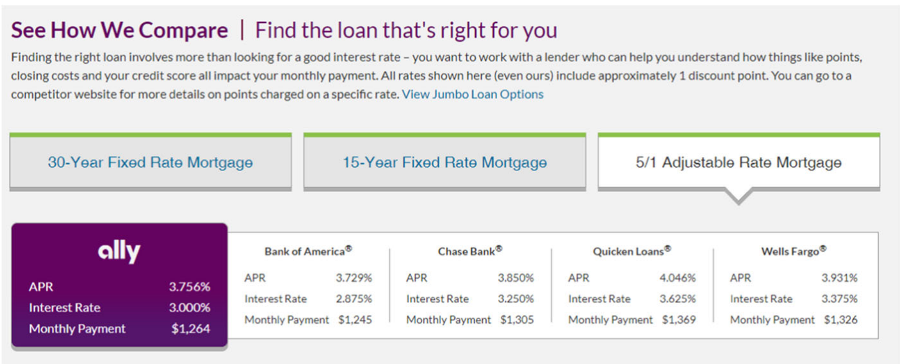

Fig. 4 Competitive Referral of Mortgage Rates at Ally Bank (accessed on 08/22/2017)

makes it easier for its visitors to do comparison shopping. Note that switchers are always comparing the prices across sellers but in the presence of competitor referral, a seller's loyal customer might also be swayed towards the other seller and could end up switching if she finds a favorable price. The pricing and the referral decisions of the incumbents and the entry decision (and pricing, if entry happens) are modeled as a three-person simultaneous move game.

Our analysis yields a rich set of equilibrium outcomes. There are conditions under which the third player never enters the market because the entry cost is too high, or always enters the market irrespective of incumbent actions if the entry cost is too low. Interestingly, under moderate levels of entry costs, we show that an incumbent may refer consumers to its competitor, intensifying the market competition that could shut the potential entrant from the market. Under some conditions, only *one* incumbent refers its competitor (i.e., one-way referral) while under others, *both* the incumbents refer each other (i.e, two-way referral). When one-way referral is not effective enough to deter entry, a two-way referral may be preferred. As long as a one-way referral can deter entry, a two-way referral is always sub-optimal. Our analysis also reveals that when the referral efficiency is endogenous, i.e., the incumbents' choice is not a binary decision (whether to apply referral or not) but a continuous variable that represents how easy it is for consumers to price shop, ex-ante symmetric incumbents may choose asymmetric referral strategies ex-post. These sets of analyses show that if the incumbents make simultaneous referral decisions, the outcome involves multiple equilibria. One the other hand, if the incumbents make referral decisions sequentially in a leader-follower fashion, one-way referral, two-way referral, or asymmetric referrals each could emerge as a unique equilibrium. Our analysis also shows that when the entrant's market share is endogenously determined, even if the entrant could increase market share costlessly, it might not pick up the highest possible market share. Overall, our results indicate that firms may be motivated by entry-deterrence to voluntarily refer consumers to their direct competitors completely *for free*.

In much of the existing research (reviewed in the next section), both the direct and the third-party referrals include a revenue-sharing contract that drives the retailers' referrals to their competitors. In contrast, we consider the context where a seller refers its competitor online for free. Our research shows that even when a firm does not earn any revenue by referring a consumer to competitor, it might willingly do so from the perspective of entry-deterrence. At the same time, we wish to be very clear that this paper is not providing entry-deterrence as "the" explanation for referrals and we readily concede that there could be other factors that in practice might lead a firm to refer its visitors to competition including a) an incentive to earn commissions by aggregating offers from different sellers (e.g., at a platform like Amazon); (b) stopping consumers from going to other firms' websites, (c) signaling confidence that its price is the lowest and, (d) targeting consumers with differentiated offers. At the same time, the presence of online firm referral (without explicit monetary incentives) in industries with homogeneous goods and fierce competition is intriguing and we posit that the entry deterrence might provide a plausible explanation in such contexts. Our stylized analytical model identifies conditions under which online referrals can act as entry deterrents and our focus is upon understanding this motive in depth. We do consider this motive to be a "first order" effect and our hope is that future empirical work should illuminate the importance of different forces across various contexts.

The rest of this paper is organized as follows. We discuss the literature relevant to our paper in Section 2 followed by a description of the base model and its underlying assumptions (in Section 3). Section 4 presents the analysis where two competing incumbents make referral and pricing decisions while one entrant is contemplating whether to enter the market. Section 5 presents the model wherein the incumbents endogenously decide upon the referral efficiency and consider two versions of this model: one, where incumbents make simultaneous decisions while in another version we allow the incumbents to make sequential decisions. Section 6 models the endogenous market share of the entrant via informative advertising. Finally, we present two extensions of our main model in Section 7 where we relax a number of assumptions made in the main model including full market coverage and symmetry of the incumbents. Section 8 concludes the paper with a summary of our findings and possible extensions. To improve the readability of the paper, we relegate the derivations of subgame equilibria and proofs of the main propositions to Appendices A and B, respectively.

2 Related literature

Our study is closely linked to the academic literature researching referral programs. Previous research has studied three types of referrals. The first is *customer referral*, in which firms reward existing customers for bringing in new customers (Schmitt et al. 2011). This type of referral is an example of firms encouraging its consumers to practice word-of-mouth marketing. The second is *in-store referral* where a firm refers specific consumers to competitors who visit its store but do not find products that match their needs (Garicano and Santos 2004; Arbatskaya and Konishi 2012). In essence, it is a practice of ex-post offline referral wherein the firms first observe consumer preferences and then decide whom to provide referrals to. The third is *infomediary referral*, where independent infomediaries provide consumers with relevant information about enrolled firms. This stream of literature focuses on how infomediaries refer participating firms instead of on how an infomediary refers other infomediaries (Chen et al. 2002; Ghose et al. 2007). As an example, internet telephone company Vonage paying its customers to refer its services to other consumers is an example of customer referral. A law firm that specializes in trademark and copyright infringement issues referring one of its customer to another law firm for Maritime law is practising a form of in-store referral. Finally, an online infomediary like Expedia providing price and product information from enrolled hotels and airlines in lieu of commissions from the resulting sales is practising a form of infomediary referral. In contrast to these referral practices, in this paper, we are interested in online referrals where firms voluntarily provide information about competition carrying close substitute products (without any exchange of money) and decide upon their referral strategies prior to the realization of consumer preferences.

Related to our work, Cai and Chen (2011) study competitor referral, wherein one retailer could display links to a competing retailer directly (e.g., direct referral) or indirectly through an advertising agency (e.g., third-party referral). However, direct referral in their context is essentially platform selling: a large platform owner, such as Amazon.com, acts both as a retailer and as a host for many small retailers and makes money by charging commission for sales on the platform. Jiang et al. (2011) suggest an alternative explanation for such a platform selling — platform owner can learn from independent sellers the products that are suitable for direct selling. Finally, the study by Kuksov et al. (2017) is closely related to our paper, which allows two firms to host advertisements for their direct competitors. The authors demonstrate that if the ad commission fee is high enough, advertising for the competitor can mitigate competition and could result in an outcome that boosts profits of both the firms.

Broadly speaking, our paper is also closely related to two extensive literatures in marketing and economics studying: (a) implications of consumer search and, (b) firms' entry and deterrence strategies. Salop and Stiglitz (1977) show that when some consumers are partially informed about the full set of prices in a market, some firms might sell at competitive prices while the others might sell at higher price levels, rationalizing the spatial price dispersion observed across firms in the homogeneous goods markets. Varian (1980) shows in a similar set-up where some consumers are partially informed about the prices, the resulting prices could exhibit temporal price dispersion. The former paper rationalizes the simultaneous existence of the discount and the high-price stores for homogenous goods while the latter paper rationalizes the existence of sales wherein firms charge different prices over time for the same good. Extending these models, Baye and Morgan (2001) construct an information clearinghouse model that allows consumers to (endogenously) access a whole range of prices listed by the firms on a clearinghouse. They show that firms mix between listing and not listing and conditional upon listing, the model produces a price dispersion within and across firms, even when consumers are ex-ante homogeneous. Our model shares some similarities with these studies in that it produces price dispersion (via mixed strategy) but unlike these models it does not impose the zero-profit free entry condition. Furthermore, our aim lies in studying in depth a tool that brings price transparency and thus reduces search costs in a market and yet it could end up helping firms in preserving their market power. The empirical marketing literature has provided validation for these models by showing that search costs are indeed significant barrier to price discovery and that these costs decrease via interventions like in-store displays, advertising and presence on popular platforms like Amazon (Mehta et al. 2003). The competitor referral modeled in our paper can also be thought of a search cost reduction device albeit of a different kind in the sense that it reduces not own but the competitors' search costs.

Past literature has extensively studied the tools that incumbent firms have deployed for entry-deterrence. Early literature focused upon the role of irreversible investments like installed capacity (e.g., Dixit (1980)) whereby an incumbent firm via early investments in capacity could decrease its marginal costs and credibly convey to a potential entrant that its entry could be unprofitable. Other entry-deterrence strategies analyzed in the literature include brand proliferation (Schmalensee 1978), bundling (Nalebuff 2004), switching costs (Klemperer 1987) and limit pricing (Milgrom and Roberts 1982). In marketing, recently (He et al. 2017) have explored the role of free in-network pricing as entry deterrence tool while (Gao et al. 2016) explore how incumbent firms could use the high quality as a tool to deter the entry of copycat brands.

In the existing work on the entry-deterrence literature, the "irreversible" nature of the investments like capacity could provide the barrier that shuts off a potential entrant. In the context of online retailing, firms typically do not have such tools at disposal since by the very nature of these businesses, large upfront investments do not necessarily translate into a cost advantage. We identify competitor referral as a feasible tool that might aid firms in creating entry barriers. An obvious question to ask is how "credible" an online referral is as a deterrent tool if it does not seem like an obvious irreversible investment? In other words, if incumbents use competitive referral as an entry-deterrence tool but if an entry occurs and since referrals hurt incumbents' profits post-entry, could incumbents stop referrals post-entry? If that could happen then the referrals would not serve as entry-deterrence tools in the first place. Note however that: (a) In our set-up, a referral acts as a tool for information provision for a segment of population that does not have access to the full range of prices, and hence once the referral is applied the market becomes permanently competitive. Thus, within our framework where there is no new customer entry, there is no logical inconsistency in online referrals acting as deterrent tools. (b) Beyond our model, institutional practices show that firms are often able to commit to fair and transparent pricing via public pronouncements without signing any formal contracts with consumers. As an example, Progressive Insurance spent over 600 million dollars in the year 2013 (insurancebusinessmag.com 2015), a significant fraction of which went into highlighting the pricing transparency (e.g., in the well-advertised "The Name Your Own Price Tool" campaign). If a firm makes significant investments into making such a policy highlighted, then clearly it carries the risk of antagonizing a significant fraction of the population if it back off from the policy after promising it to the customers. (c) Finally, one could think of the entrants as fringe players who make quick entry and exit decisions over a relatively shorter horizon. In fact, there is some stylized evidence from empirical entry literature which suggests that entrants have significantly lower survival rate (Geroski 1995) relative to entrenched incumbents. These entrants could look at a market that is too competitive over a shorter horizon (perhaps because of referrals) and make a decision not to enter. Again, referrals could act as the entry-deterrent tools to ward off the entry of such fringe players.[1]

Our paper is also related to the recently burgeoning literature on marketing and economics of search engine marketing (Eliaz and Spiegler 2011; Athey and Ellison 2011; Jerath et al. 2011). When consumers use a search engine for a keyword search related to a product or service, it returns a large number of results sorted often in the order of relevance. However, for both the organic and sponsored alternatives that search engines make available (some of which might be quite irrelevant to search), the customer still to go through multiple links to find a relevant product. In other words, the consumers still face significant search hurdles in obtaining product information via a search engine query. We posit that online referrals provide a distinct

[1]We are grateful to the review team for bringing forth this important point and for suggesting the conceptual arguments to address it.

channel of information for consumers. A unique feature of this channel is that unlike search engines where an intermediary (search engine) provides the information and (sometimes) charges sellers for making this information available, firms practicing online referral provide accessible and relevant information about their rivals for free. Furthermore, the institutional features of search engines marketing are quite different from our context including pricing that occurs via an auction, among other features (Varian 2009).

3 Model setup

Consider a market for a homogeneous product served by two incumbent online sellers, denoted by seller 1 and seller 2 respectively. On the demand side, there is a unit mass of consumers who desire at most one unit of good with a common reservation price v.

Some consumers may be familiar with one seller's website but not familiar with the other's, so each platform has a proportion of "loyalists" who visit only the website they are familiar with every time they want to make a purchase. As described earlier, there is also a proportion of "switchers" who are familiar with both the websites and always make a price comparison across websites. Equivalently, the loyalists can be viewed as the customers with high search cost. While shopping, these customers first visit their familiar website but face significant search hurdles to explore further. The switchers, on the other hand, can be thought of as consumers with low search costs. They are not aversive to extensive search to find the best deal on the product. Any of these reasons– unfamiliarity, search costs or brand loyalty– or a combination of these, could be the possible drivers of less intensive search by loyalists. All that matters in our context is the presence of such consumers, and an extensive empirical and theoretical literature indeed suggests so (Varian 1980). We assume that each incumbent has a fraction $\alpha \in \left(0, \frac{1}{2}\right)$ of loyalists and the remaining fraction $1 - 2\alpha$ are switchers. Loyalists purchase a good from their familiar seller as long as the price is below v; while switchers compare prices between the two sellers and buy the cheapest product if its price is below v.

Online competitor referral could aid loyalists in comparing prices across the websites. For example, if Esurance provides a referral link to Progressive on its webpage or provides pricing information, customers who used to visit only esurance.com now become aware of the product information on progressive.com, maybe through "one-click." Thus, we assume that if seller i displays seller j's referral link on its own website ($i, j = 1, 2$ and $i \neq j$), some of seller i's visitors will click the referral link to visit seller j and make a comparison between the two offerings. We do not want to suggest that this is the only purpose of providing a referral link but it reflects one essential use of an online competitor referral — making suggestion to the visitors to consider products provided by the competitor. A similar assumption is also found in Kuksov et al. (2017).

Referrals are unlikely to be perfect. Some consumers may stick to a website like Progressive or Esurance because of switching costs, inattention or brand loyalty and not comparison shop even when they are provided with an easy access to competitive prices. In addition, sellers implement online competitor referral with varying details on their websites. For instance, businesses like Diet-To-Go and Progressive Direct provide business names, services and prices of its competitors, but do not display a link to their websites. In contrast, a business like Esurance displays links to their competitor's website (Fig. 2), which may lead to greater facilitation for consumers to visit other sellers. Accordingly, we assume that when a seller i refers seller j, a proportion $\varphi_i \in [0, 1]$ of seller i's visitors will do comparison shopping at the two sellers. The remaining fraction $1 - \varphi_i$ ignores the referral and stays loyal to seller i. φ_i is an indicator of seller i's referral efficiency. With the increase of φ_i, seller i becomes more efficient in guiding its online visitors to its competitor's website. In the main model, we will consider referral efficiency as an exogenous variable and set $\varphi_1 = \varphi_2 \equiv \varphi$. By doing so, we can focus on the effect of competitor referral on entry deterrence. In Section 5, we will relax this assumption and allow each incumbent to endogenously decide its referral efficiency.

A third player, denoted by seller 3, is considering entering the same market to compete with the two incumbents. The entry cost (e.g., the cost of opening an online store, making consumers aware of its existence via advertising, etc.) is $G > 0$. We assume that if seller 3 enters the market, it attracts a fraction $\beta \in (0, 1)$ of consumers to its website, and that this fraction of consumers is distributed uniformly through the market.

The sequence of the game proceeds as follows: In the first stage, the two incumbents simultaneously decide whether to display a referral link to their competitor. We denote seller i's referral and non-referral strategy by R_i and $\bar{R}_i$, respectively. We refer to the case when seller i chooses R_i while seller j chooses $\bar{R}_j$ as "one-way referral," and the case when both the incumbents apply referral as "two-way referral." The cost of online referral is normalized to zero. In the second stage, the potential entrant decides whether or not to enter the market, denoted as strategy E and $\bar{E}$ respectively. In the third stage, the two firms (if no entry occurs) or the three firms (if entry occurs) set prices simultaneously. Denote seller k's price as p_k, where $k = 1, 2, 3$. Given these prices, consumers decide whether and where to purchase.[2]

4 Main model: analysis and results

We start the analysis with the case when the referral efficiency is exogenous. It provides a clean case that allows us to interpret the impact of competitor referral. We use backward induction to arrive at equilibrium starting with the pricing game in the third stage. There are 2×2×2 subgames we need to analyze: no referral and no entry ($\bar{R}_1\bar{R}_2\bar{E}$), one-way referral and no entry ($\bar{R}_1 R_2\bar{E}$, $R_1\bar{R}_2\bar{E}$), two-way referral

[2] As we will see that an equilibrium in the pure strategies does not exist, so the firms randomize prices in our set-up. Randomized prices are consistent with the price variation observed in the actual homogeneous goods markets and it suggests that the price changes are typically a lot more frequent than changes in a policy like competitive referral. This provides a rationale for why prices follow and respond to the referral decision in the model timeline and not the vice-versa.

and no entry ($R_1 R_2 \bar{E}$), entry without referral ($\bar{R}_1 \bar{R}_2 E$), entry with one-way referral ($\bar{R}_1 R_2 E$, $R_1 \bar{R}_2 E$), and entry with two-way referral ($R_1 R_2 E$).

4.1 Benchmark: no referral and no entry

First, consider the case where there is no potential entry or referral ($\bar{R}_1 \bar{R}_2 \bar{E}$). The two incumbents serve their loyalists while competing for switchers. Under this setup, analogous to the arguments made in Varian (1980) and Narasimhan (1988), it can be readily shown that no price equilibrium in pure strategies exists, and only a mixed strategy Nash equilibrium is feasible (see Appendix A for a recap of these arguments).

Denote the CDF of p_i as $F_i(p)$, which is the probability that seller i charges a price no higher than p. Define $\bar{F}_i(p) = 1 - F_i(p)$, the probability that player i charges a price higher than p. When seller i chooses price p while seller j uses a mixed strategy, the expected profit of seller i is

$$\pi_i = p[\alpha + (1 - 2\alpha)\bar{F}_j(p)]. \tag{1}$$

Sellers 1 and 2 simultaneously set prices to maximize individual profits. Solving the firms' optimization problem, we obtain the equilibrium prices as below (see Appendix A for the derivation of subgame equilibria):

$$F_1(p) = F_2(p) = \begin{cases} 0 & if\ p < \frac{\alpha}{1-\alpha} v, \\ \frac{1-\alpha}{1-2\alpha}\left(1 - \frac{\alpha}{1-\alpha}\frac{v}{p}\right) & if\ \frac{\alpha}{1-\alpha} v \le p \le v, \\ 1 & if\ p > v. \end{cases}$$

The equilibrium profit of each seller is equal to the profit when the two sellers charge the maximum price $p = v$ and serve only their monopoly segment, i.e.,

$$\pi_1^{\bar{R}_1 \bar{R}_2 \bar{E}} = \pi_2^{\bar{R}_1 \bar{R}_2 \bar{E}} = \alpha v, \tag{2}$$

where the superscript denotes the corresponding subgame equilibrium. In other words, the profits that each incumbent can realize depend on the size of its loyal segment — the higher the number of loyalists, the higher the profits realized by each incumbent in equilibrium.

4.2 One-way referral without entry

We now consider a scenario where each firm, in addition to setting prices, could potentially refer its visitors to the competitor's website. As discussed earlier, the referral is imperfect and we impose symmetric referral efficiency, i.e., $\varphi = \varphi_1 = \varphi_2$. We consider the subgame when seller 1 unilaterally refers seller 2, this is without the loss of generality as the retailers are symmetric. We denote this subgame as $R_1 \bar{R}_2 \bar{E}$. In this case, a fraction φ of seller 1's loyalists now become switchers as they can easily do comparison shopping (e.g., using a single click to a link). Therefore, a fraction $\alpha(1 - \varphi)$ of consumers remain loyal to seller 1, a fraction α of consumers remain loyal to seller 2, and the remaining fraction $1-\alpha(2-\varphi)$ become the comparison shoppers. The expected profits of the two sellers (at price p) are:

$$\pi_1 = p[\alpha(1-\varphi) + (1-2\alpha+\alpha\varphi)\bar{F}_2(p)], \tag{3}$$

$$\pi_2 = p[\alpha + (1-2\alpha+\alpha\varphi)\bar{F}_1(p)]. \tag{4}$$

We obtain the asymmetric mixed pricing strategies as follows:

$$F_1(p) = \begin{cases} 0 & if\ \ p < \frac{\alpha}{1-\alpha+\alpha\varphi}v, \\ \frac{1-\alpha+\alpha\varphi}{1-2\alpha+\alpha\varphi}\left(1-\frac{\alpha}{1-\alpha+\alpha\varphi}\frac{v}{p}\right) & if\ \ \frac{\alpha}{1-\alpha+\alpha\varphi}v \le p \le v, \\ 1 & if\ \ p > v, \end{cases}$$

$$F_2(p) = \begin{cases} 0 & if\ \ p < \frac{\alpha}{1-\alpha+\alpha\varphi}v, \\ \frac{1-\alpha}{1-2\alpha+\alpha\varphi}\left(1-\frac{\alpha}{1-\alpha+\alpha\varphi}\frac{v}{p}\right) & if\ \ \frac{\alpha}{1-\alpha+\alpha\varphi}v \le p \le v, \\ 1 & if\ \ p > v, \end{cases}$$

where seller 2 has a mass $\frac{\alpha\varphi}{1-\alpha+\alpha\varphi}$ at $p=v$. The equilibrium price density functions $F_1(p)$ and $F_2(p)$ have several commonalities to those in Narasimhan (1988): the upper bound of the price support is the monopoly price, v; the lower bound is the price at which the larger seller is indifferent between serving only its captive segment at the monopoly price and serving all of the customers who know of it at the lower bound, i.e., $\frac{\alpha}{1-\alpha+\alpha\varphi}v$; and all firms randomize over a common set of prices except that the larger (smaller) seller has a mass point (zero density) at the upper bound.

The equilibrium profit of seller 2 (who has a larger base of loyalists) is equal to the profit when it serves only its monopoly segment by setting the maximum price $p=v$. In contrast, the equilibrium profit of seller 1 (who has a smaller base of loyalists) equals the profit when it charges the minimum price $p=\frac{\alpha}{1-\alpha+\alpha\varphi}v$ and poaches all of the consumers who are not loyal to seller 2; that is,

$$\pi_1^{R_1\bar{R}_2\bar{E}} = \frac{\alpha(1-\alpha)v}{1-\alpha+\alpha\varphi}, \quad \pi_2^{R_1\bar{R}_2\bar{E}} = \alpha v. \tag{5}$$

By comparing subgames $\bar{R}_1\bar{R}_2\bar{E}$ and $R_1\bar{R}_2\bar{E}$, we obtain the following lemma.

Lemma 1 *One-way referral makes the referring firm worse off but does not affect the profit of the referred firm. Without the threat of a potential entry, an incumbent would never unilaterally refer its customers to a competitor.*

Lemma 1 shows that one-way referral makes the referring firm worse off, i.e., $\pi_1^{R_1\bar{R}_2\bar{E}} < \pi_1^{\bar{R}_1\bar{R}_2\bar{E}}$, which conforms to the intuition that no firm should be unilaterally willing to undercut its monopoly power by providing its consumers with an easy access to its competitor. Somewhat surprisingly, one-way referral does not help the referred firm, seeing $\pi_2^{R_1\bar{R}_2\bar{E}} = \pi_2^{\bar{R}_1\bar{R}_2\bar{E}}$. This result is due to the fact that seller 2 cannot benefit from a larger customer base without discounting its price. As long as the size of its loyal segment remains unchanged, seller 2 always has to trade off attracting switchers with a lower price against serving loyalists at a higher price.

Figure 5 presents the mixed prices under $\bar{R}_1\bar{R}_2\bar{E}$ and $R_1\bar{R}_2\bar{E}$ (by fixing $v=1$, $\alpha=\frac{1}{4}$ and $\varphi=1$). It shows that seller 1 charges a lower price on average when

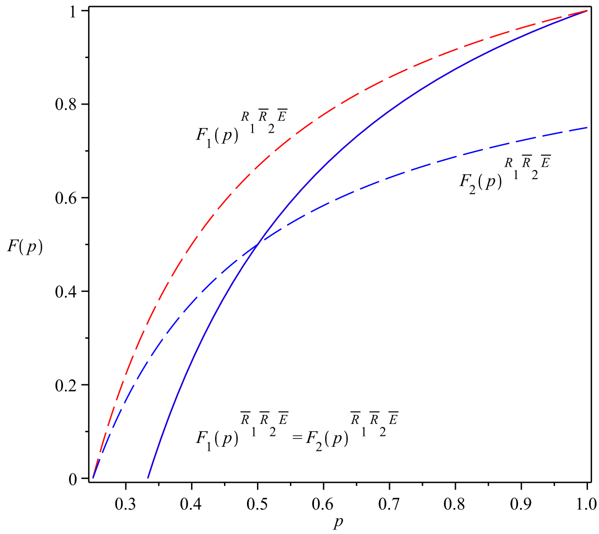

Fig. 5 Equilibrium Prices under $\bar{R}_1 \bar{R}_2 \bar{E}$ and $R_1 \bar{R}_2 \bar{E}$

referring its competitor, implying that seller 1 loses its monopoly power because of referral. However, seller 2 may raise or cut its price on average in response to seller 1's referral. One way to think about this price mixing by incumbents is that seller 1 has more "sales" events when it refers consumers to its competitors (Varian 1980).

4.3 Entry without referral

This section analyses a scenario where in addition to the two incumbent players, there is a third player (player 3) looking to enter the market. As noted before, if seller 3 enters the market a fraction β of consumers will become aware of it. We assume that the consumers who become familiar with seller 3 are drawn from all the existing segments of the loyalists and switchers. If the entry indeed happens, the subgame ($\bar{R}_1 \bar{R}_2 E$) involves three players and six market segments as shown in Table 1. Relying on the arguments made in Varian (1980), Vives (2001) and Xu et al. (2011), it can be shown that the pure pricing strategies do not exist. We follow oligopoly pricing techniques to arrive at the equilibrium outcomes.

Table 1 Market Segmentation for $\bar{R}_1 \bar{R}_2 E$

Segment	Fraction of consumers	Notation
Loyal to 1	$\alpha(1-\beta)$	n_1
Loyal to 2	$\alpha(1-\beta)$	n_2
Switch between 1 and 3	$\alpha\beta$	s_{13}
Switch between 2 and 3	$\alpha\beta$	s_{23}
Switch between 1 and 2	$(1-2\alpha)(1-\beta)$	s_{12}
Switch among 1, 2 and 3	$(1-2\alpha)\beta$	s_{123}

Denote the fraction of customers who are loyal to seller i as n_i, the fraction of switchers between sellers i and j as s_{ij}, and let s_{123} be the fraction of customers who switch among the three sellers. The values of n_i, s_{ij} and s_{123} as functions of model parameters are listed in Table 1. The expected profits of sellers 1, 2 and 3 (at price p) are given by, respectively,

$$\pi_1 = p[n_1 + s_{12}\bar{F}_2(p) + s_{13}\bar{F}_3(p) + s_{123}\bar{F}_2(p)\bar{F}_3(p)], \tag{6}$$

$$\pi_2 = p[n_2 + s_{12}\bar{F}_1(p) + s_{23}\bar{F}_3(p) + s_{123}\bar{F}_1(p)\bar{F}_3(p)], \tag{7}$$

$$\pi_3 = p[s_{13}\bar{F}_1(p) + s_{23}\bar{F}_2(p) + s_{123}\bar{F}_1(p)\bar{F}_2(p)] - G, \tag{8}$$

where seller 3 has an entry cost of G. The three sellers simultaneously pick their prices to maximize own profits. The equilibrium price strategies are

$$F_1(p) = F_2(p) = \begin{cases} 0 & if\ p < p_{\min}, \\ \frac{1-\alpha}{1-2\alpha}\left(1 - \frac{\alpha}{1-\alpha}\frac{h(p)}{p}\right) & if\ p_{\min} \le p \le p_{\max}, \\ \frac{1-\alpha}{1-2\alpha}\left(1 - \frac{\alpha}{1-\alpha}\frac{v}{p}\right) & if\ p_{\max} \le p \le v, \\ 1 & if\ p > v, \end{cases}$$

$$F_3(p) = \begin{cases} 0 & if\ p < p_{\min}, \\ \frac{1}{\beta} - \frac{1-\beta}{\beta}\frac{v}{h(p)} & if\ p_{\min} \le p \le p_{\max}, \\ 1 & if\ p > p_{\max}, \end{cases}$$

where we define $p_{\min} = \frac{\alpha(1-\beta)}{1-\alpha}v$, $p_{\max} = \frac{\sqrt{(1-\beta)^2(1-2\alpha)^2+4\alpha^2(1-\alpha)^2}-(1-\beta)(1-2\alpha)}{2\alpha(1-\alpha)}v$, and $h(p) = \sqrt{p^2 + \frac{(1-\beta)(1-2\alpha)v}{\alpha(1-\alpha)}p}$. The expressions of $F_1(p)$, $F_2(p)$ and $F_3(p)$ indicate that sellers 1 and 2 set prices over the entire interval $[p_{\min}, v]$ whereas seller 3 sets the upper bound $p_{\max}$ lower than v. The rationale is that seller 3 has the smallest (zero) loyal segment and hence the weakest power in setting price. The mixed pricing strategy of the three-player game is similar to that in Koçaş and Bohlmann (2008) and Xu et al. (2011). We show in Appendix A that when β approaches zero, $F_1(p)$ and $F_2(p)$ reduce to the expressions derived under $\bar{R}_1\bar{R}_2\bar{E}$.

The equilibrium profits of the three sellers are

$$\pi_1^{\bar{R}_1\bar{R}_2E} = \pi_2^{\bar{R}_1\bar{R}_2E} = \alpha(1-\beta)v, \quad \pi_3^{\bar{R}_1\bar{R}_2E} = \frac{\alpha\beta(1-\beta)}{1-\alpha}v - G. \tag{9}$$

Similarly, the equilibrium profits of sellers 1 and 2 also approach those under $\bar{R}_1\bar{R}_2\bar{E}$ when $\beta \to 0$. Comparing subgames $\bar{R}_1\bar{R}_2\bar{E}$ and $\bar{R}_1\bar{R}_2E$, we have $\pi_1^{\bar{R}_1\bar{R}_2E} < \pi_1^{\bar{R}_1\bar{R}_2\bar{E}}$ and $\pi_2^{\bar{R}_1\bar{R}_2E} < \pi_2^{\bar{R}_1\bar{R}_2\bar{E}}$. This makes intuitive sense since the entry of a third player now reduces the pricing power of the incumbents and makes them worse off. This outcome is formally presented in the following lemma.

Lemma 2 *Absent online referral, seller 3 enters the market as long as* $G \le \frac{\alpha\beta(1-\beta)}{1-\alpha}v$. *The entry of the third player makes the two incumbents worse off.*

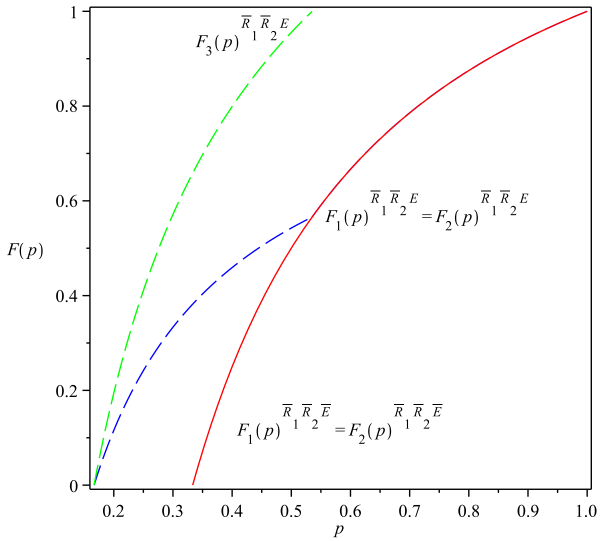

Fig. 6 Equilibrium Prices under $\bar{R}_1\bar{R}_2\bar{E}$ and $\bar{R}_1\bar{R}_2E$

Lemma 2 is quite intuitive because no incumbent wants higher competition in the market. Figure 6 illustrates the mixed prices under $\bar{R}_1\bar{R}_2\bar{E}$ and $\bar{R}_1\bar{R}_2E$ by fixing $v = 1$, $\alpha = \frac{1}{4}$ and $\beta = \frac{1}{2}$. When seller 3 enters the market, both sellers 1 and 2 discount prices more heavily. In other words, the new entry intensifies the market competition making the incumbents worse off. This finding is akin to saying that post-entry, the incumbents have more sales events as in Varian (1980).

4.4 One-way referral with entry

Now we consider the case where a competitor referral is a possibility, and begin with the analysis of one-way referral. In the subgame $R_1\bar{R}_2E$ where seller 3 enters the market and seller 1 refers seller 2, the market is segmented as follows: $n_1 = \alpha(1-\varphi)(1-\beta)$, $n_2 = \alpha(1-\beta)$, $s_{12} = (1-2\alpha+\alpha\varphi)(1-\beta)$, $s_{13} = \alpha(1-\varphi)\beta$, $s_{23} = \alpha\beta$ and $s_{123} = (1-2\alpha+\alpha\varphi)\beta$.

The profit functions are still given by Eqs. 6, 7 and 8. The pattern of mixed prices is similar to that under $\bar{R}_1\bar{R}_2E$: Two sellers set high prices on average and they set prices over the entire interval, while one seller may set the upper bound lower than other two. Employing the techniques used in the previous subgame, we obtain the price CDFs as below:

$$F_1(p) = \begin{cases} 0 & if\ p < p'_{\min}, \\ \frac{1-\alpha+\alpha\varphi}{1-2\alpha+\alpha\varphi}\left(1 - \frac{\alpha}{1-\alpha+\alpha\varphi}\frac{l(p)}{p}\right) & if\ p'_{\min} \le p \le p'_{\max}, \\ \frac{1-\alpha+\alpha\varphi}{1-2\alpha+\alpha\varphi}\left(1 - \frac{\alpha}{1-\alpha+\alpha\varphi}\frac{v}{p}\right) & if\ p'_{\max} \le p \le v, \\ 1 & if\ p > v, \end{cases}$$

$$F_2(p) = \begin{cases} 0 & if\ p < p'_{\min}, \\ \frac{1-\alpha}{1-2\alpha+\alpha\varphi}\left(1 - \frac{\alpha}{1-\alpha+\alpha\varphi}\frac{l(p)}{p}\right) & if\ p'_{\min} \le p \le p'_{\max}, \\ \frac{1-\alpha}{1-2\alpha+\alpha\varphi}\left(1 - \frac{\alpha}{1-\alpha+\alpha\varphi}\frac{v}{p}\right) & if\ p'_{\max} \le p \le v, \\ 1 & if\ p > v, \end{cases}$$

$$F_3(p) = \begin{cases} 0 & if\ p < p'_{\min}, \\ \frac{1}{\beta} - \frac{1-\beta}{\beta}\frac{v}{l(p)} & if\ p'_{\min} \le p \le p'_{\max}, \\ 1 & if\ p > p'_{\max}, \end{cases}$$

where seller 2 has a mass $\frac{\alpha\varphi}{1-\alpha+\alpha\varphi}$ at $p = v$, $l(p) = \sqrt{\frac{\alpha(1-\varphi)-\alpha^2(1-\varphi)^2}{\alpha-\alpha^2}p^2 + \frac{(1-\beta)(1-2\alpha+\alpha\varphi)v}{\alpha-\alpha^2}p}$, $p'_{\max} = \frac{\sqrt{(1-\beta)^2(1-2\alpha+\alpha\varphi)^2+4(\alpha-\alpha^2)[\alpha(1-\varphi)-\alpha^2(1-\varphi)^2]}-(1-\beta)(1-2\alpha+\alpha\varphi)}{2[\alpha(1-\varphi)-\alpha^2(1-\varphi)^2]}v$, and $p'_{\min} = \frac{\alpha(1-\beta)}{1-\alpha+\alpha\varphi}v$.

Seller 2, who has n_2 fraction of loyalists, always earns the profit equal to $n_2 v$; while sellers 1 and 3, both of whom have smaller share of loyalists, earn profits equal to $(s_{12}+s_{13}+s_{123})p_{\min}$ and $(s_{13}+s_{23}+s_{123})p_{\min} - G$, respectively. Thus,

$$\pi_1^{R_1\bar{R}_2E} = \frac{\alpha(1-\alpha)(1-\beta)}{1-\alpha+\alpha\varphi}v,\ \ \pi_2^{R_1\bar{R}_2E} = \alpha(1-\beta)v,\ \ \pi_3^{R_1\bar{R}_2E} = \frac{\alpha\beta(1-\beta)}{1-\alpha+\alpha\varphi}v - G. \tag{10}$$

When $\beta \to 0$, the equilibrium prices and profits of $R_1\bar{R}_2E$ approach the form under $R_1\bar{R}_2\bar{E}$.

Next lemma is obtained by comparing the results from $R_1\bar{R}_2E$ and $\bar{R}_1\bar{R}_2E$.

Lemma 3 *When seller 1 employs online competitor referral, then seller 3 enters the market as long as* $G \le \frac{\alpha\beta(1-\beta)}{1-\alpha+\alpha\varphi}v$. *The referral strategy makes seller 1 and seller 3 worse off without affecting seller 2's profit.*

Online referral is detrimental to the referring firm, i.e., $\pi_1^{R_1\bar{R}_2E} < \pi_1^{\bar{R}_1\bar{R}_2E}$. Therefore, no incumbent has an incentive to refer its competitor *conditional* on the entry of the third player. In addition, online referral does not influence the profit of the referred firm, i.e., $\pi_2^{R_1\bar{R}_2E} = \pi_2^{\bar{R}_1\bar{R}_2E}$. These results are consistent with the case with no entry.

It is noteworthy that $\pi_3^{R_1\bar{R}_2E} < \pi_3^{\bar{R}_1\bar{R}_2E}$. Thus, seller 3 is also hurt by seller 1's referral strategy because of the intensified competition. This finding suggests that seller 3, who could originally earn positive profits through entry, may be blocked out of the market when an incumbent refers its customers to the incumbent competitor. This key insight explains why seller 1 could refer its competitor even when its profit is attenuated, as will be shown later.

Figure 7 illustrates the equilibrium prices under $\bar{R}_1\bar{R}_2E$ and $R_1\bar{R}_2E$ by fixing $v = 1$, $\alpha = \frac{1}{3}$, $\beta = \frac{1}{4}$ and $\varphi = 1$, which shows the influence of online referral on prices under new entry.

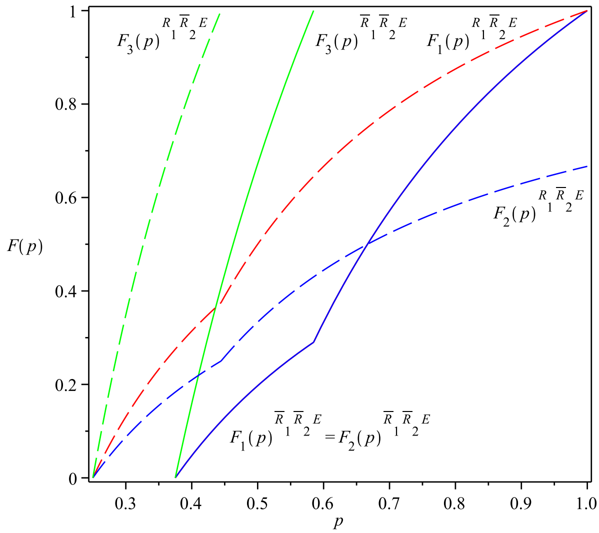

Fig. 7 Equilibrium Prices under $\bar{R}_1\bar{R}_2E$ and $R_1\bar{R}_2E$

4.5 Two-way referral

In this section, we briefly describe the analysis of two-way referrals (wherein each incumbent refers its customers to the other) without and with the entry. These remaining two subgames $R_1R_2\bar{E}$ and R_1R_2E are easily obtained by comparing them with $\bar{R}_1\bar{R}_2\bar{E}$ and $\bar{R}_1\bar{R}_2E$, respectively. Under $R_1R_2\bar{E}$, the size of each market segment is $n_1 = n_2 = \alpha(1-\varphi)$ and $s_{12} = 1 - 2\alpha(1-\varphi)$. The profits of the incumbents are

$$\pi_1^{R_1R_2\bar{E}} = \pi_2^{R_1R_2\bar{E}} = \alpha(1-\varphi)v. \tag{11}$$

Under R_1R_2E, the market segmentation is given by $n_1 = n_2 = \alpha(1-\varphi)(1-\beta)$, $s_{12} = [1-2\alpha(1-\varphi)](1-\beta)$, $s_{13} = s_{23} = \alpha(1-\varphi)\beta$ and $s_{123} = [1-2\alpha(1-\varphi)]\beta$, with the same form as in Table 1. Replacing α in Eq. 9 with $\alpha(1-\varphi)$, we can obtain the profits under R_1R_2E, i.e.,

$$\pi_1^{R_1R_2E} = \pi_2^{R_1R_2E} = \alpha(1-\varphi)(1-\beta)v, \;\; \pi_3^{R_1R_2E} = \frac{\alpha\beta(1-\beta)(1-\varphi)}{1-\alpha(1-\varphi)}v - G. \tag{12}$$

Two-way referral has similar properties with one-way referral, as shown in Lemmas 1–3, and we do not repeat these arguments here to save the space.

4.6 Equilibrium referral strategy

We are now ready to derive the equilibrium referral strategy for incumbents. In Sections 4.1–4.5, we have derived the subgame equilibria of the pricing strategy (i.e., the third stage) of the three-stage game, as shown in Eqs. 2, 5, 9–12. From Eqs. 9, 10 and 12, we can easily get the subgame equilibrium of the second stage of the game.

We formally state this in the following lemma, where we define $G_1 = \frac{\alpha\beta(1-\beta)v}{1-\alpha}$, $G_2 = \frac{\alpha\beta(1-\beta)v}{1-\alpha(1-\varphi)}$ and $G_3 = \frac{\alpha\beta(1-\beta)(1-\varphi)v}{1-\alpha(1-\varphi)}$.

Lemma 4 *Seller 3 enters the market if (a) $G < G_1$ when no online referrals are applied, (b) $G < G_2$ when one-way referral is applied, and (c) $G < G_3$ when two-way referrals are applied.*

Lemma 4 indicates that competitor referral could deter entry. Since $G_1 > G_2 > G_3$ for any $\varphi > 0$, two-way referral is more effective than one-way referral in entry-deterrence. This is not surprising because the market competition gets more fierce as the referral format changes from no referral to one-way referral and then to two-way referral. In other words, when no referrals are applied, a potential entrants needs to face a higher entry cost (G_1) to deter it from entry while in the presence of referrals, it could be deterred from entering the market at relatively lower costs (G_2 and G_3).

Based on the subgame equilibria shown in Eqs. 2, 5, 9–12) and in Lemma 4, we can obtain the foundational result of our base model that describes the equilibrium referral strategy. This is stated formally in the next proposition, where we define $\beta_1 = \varphi$ and $\beta_2 = \frac{\alpha\varphi}{1-\alpha(1-\varphi)}$.

Proposition 1 *For a given referral efficiency φ, the equilibrium referral and entry strategies are as follows:*

(i) *If $G > G_1$, no incumbent practices referral, and seller 3 does not enter the market;*
(ii) *If $G_2 < G \leq G_1$ and $\beta > \beta_2$, one incumbent seller refers its consumers to the other incumbent while the other does not reciprocate, and seller 3 does not enter the market;*
(iii) *If $G_3 < G \leq G_2$ and $\beta > \beta_1$, both the incumbents apply referrals, and seller 3 does not enter the market; (iv) If $G \leq G_3$, or $G_3 < G \leq G_2$ and $\beta \leq \beta_1$, or $G_2 < G \leq G_1$ and $\beta \leq \beta_2$, there is no referral by incumbents and seller 3 enters the market.*

Figure 8 provides a graphical partition of the parameter space for the equilibrium referral and entry strategies laid out in Proposition 1. A potential player's decision to enter a market is driven by two key forces: Entry cost (G) and the attractiveness of the market, which is proxied by β, the fraction of market that becomes aware of its existence upon entry. The figure is divided by G and β into four regions: If the entry cost is small, seller 3 always enters the market regardless of the referral decisions of the two incumbents. In this case, online competitor referral plays no other role besides intensifying the competition. Thus, neither incumbent has an incentive to refer its customers to the competitor. On the other hand, if the fraction of customers who are easily poached by the entrant is small (relatively low β) , incumbents can tolerate the influence of the new entry and therefore do not refer practice referral. However, if the entry cost is too high (higher than G_1), seller 3 never enters the market, which is independent of referral decisions of the two incumbents. In this case too, incumbents have no incentive to engage in referrals. These two regions are stated by part (i) and

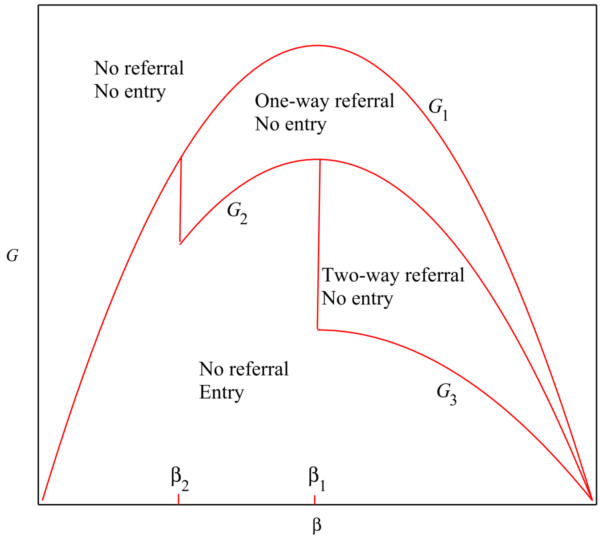

Fig. 8 Equilibrium under Main Model

part (iv) of Proposition 1 and are labeled as "No referral No entry" and "No referral Entry" regions respectively in Fig. 8.

Part (ii) of Proposition 1 is the core insight gleaned from our analysis. It shows that if G is medium and β is large, counter-intuitively, one-way referral occurs in equilibrium even though it makes the referring firm worse off $\left(\pi_1^{R_1\bar{R}_2\bar{E}} < \pi_1^{\bar{R}_1\bar{R}_2\bar{E}}\right)$. Why does this seller might self-cut its profit by referring its competitor? The rationale lies in the entry-deterrence motive. In a market where competition is weak, a potential entrant has high incentives to enter to grab a share of the pie. In contrast, if firms compete intensely, the entrant would rather stay outside of the market. Therefore, online competitor referral can serve as an entry-deterrence strategy via intensifying the competition. Although the referral hurts the referring firm, it is the lesser of two evils and can discourage the entrant from entry, a more severe threat to the incumbents $\left(\pi_1^{R_1\bar{R}_2\bar{E}} > \pi_1^{\bar{R}_1\bar{R}_2 E} \Leftrightarrow \beta > \beta_2\right)$.

Part (ii) of the proposition also indicates that there exist two Nash equilibria: seller 1 refers seller 2, or seller 2 refers seller 1. When it comes to the problem of who should shoulder the cost of referral (the act hurts the referring firm itself) to enjoy the fruits of entry-deterrence? Each one prefers the other to do the referral, in order to avoid incurring the cost and thus get a "free ride." Our analysis so far is silent on this issue. All we can say is that, a one-way referral leads to an outcome that is preferable to both the incumbents relative to the one where an entrant enters the market, and they would arrive at such an arrangement. Possibly, to alleviate the burden of such a responsibility falling upon a single player, the incumbents could use a mixed referral strategy whereby in equilibrium each seller will apply referral with probability τ and does not apply referral with probability $1-\tau$, where $\tau = \frac{\beta(1-\alpha)-(1-\beta)\alpha\varphi}{\beta(1-\alpha+\alpha\varphi)+\varphi(1-2\alpha+\alpha\varphi)}$

(see Appendix B for detailed derivation). Irrespective of whether firms used pure or mixed strategies, the key insight is that the referral will emerge as a voluntary practice under certain conditions even when firms are not being paid for rendering this service. Additionally, if the incumbents use a sequential leader-follower game to pick up referral strategy then we can get unique pure strategy equilibrium in referral choices. We explore this in detail in Section 5.2.

Part (iii) of Proposition 1 carries the intuition similar to part (ii) but also brings forth additional nuances. First, a two-way referral implies more intense competition relative to one-way referral, so as long as one-way referral can deter entry, two-way referral will be sub-optimal (note one-way referral occurs within the region $G_2 < G \leq G_1$ and $\beta > \beta_2$). Second, a two-way referral may be preferred over one-way referral. In particular, within the region $G_3 < G \leq G_2$ and $\beta > \beta_1$, a two-way referral can discourage entry while a one-way referral is no longer effective. This provides an intuition of the situations in which the two-way referral might be more effective than a one-way referral — a two-way referral is more effective under a lower range of fixed cost (G) and under the presence of a stronger entrant (higher β) relative to the region where one-way referral works. In other words, when the threat of an entrant is higher for incumbents (due to lower fixed cost of entry and a higher potential of the entrant luring existing customers), a one-way referral might not suffice and incumbents will need to resort to two-way referrals to intensify the competition and shut off the entrant.[3]

5 Endogenous referral efficiency

An online seller's referral implementation could take many forms. At one end of the spectrum, a seller might simply provide the names of its competitors and ask its consumers to check their offerings, while at the other end, it might display the prices charged by competitors and provide direct links to the competition for making purchases at these price. In the main model considered so far, we consider the referral efficiency as exogenously given. In this section, we relax this assumption and allow the incumbents to endogenously decide upon their referral efficiency φ_i. We consider two cases: (i) when firms make simultaneous referral decisions, and (ii) when firms make sequential referral decisions.

5.1 Simultaneous referrals

We use backward induction to arrive at the Nash equilibrium. In the third stage, there are two sellers (if seller 3 does not enter the market) or three sellers (if seller 3 enters the market) competing on prices. The pricing game follows the same logic as in the base model. Here, we only list the subgame equilibrium profits. Without loss of

[3] As shown in Appendix B, there also exists a "No referral Entry" equilibrium in the region denoted by "Two-way referral No entry," but it is Pareto-dominated by the latter.

generality, suppose that in the first stage seller 1 sets a higher referral efficiency than seller 2, i.e.,

$$\varphi_1 \geq \varphi_2. \tag{13}$$

If the seller 3 does not enter the market, the market will be segmented according to $n_1 = \alpha(1-\varphi_1)$, $n_2 = \alpha(1-\varphi_2)$ and $s_{12} = 1-\alpha(2-\varphi_1-\varphi_2)$. Since $n_1 \leq n_2$, seller 2 will earn the profit that it can realize by charging the maximum price and selling only to its loyalists, i.e., $\pi_2 = n_2 v$; whereas seller 1 earns the profit that it can realize by charging the minimum price and selling to both the loyal and the switch segments, i.e., $\pi_1 = \frac{n_2(n_1+s_{12})}{n_2+s_{12}} v$. By simple algebra,

$$\pi_2^{\bar{E}} = \alpha(1-\varphi_2)v. \tag{14}$$

$$\pi_1^{\bar{E}} = \frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)v}{1-\alpha+\alpha\varphi_1}. \tag{15}$$

If seller 3 enters the market, the market gets segmented as follows: $n_1 = \alpha(1-\varphi_1)(1-\beta)$, $n_2 = \alpha(1-\varphi_2)(1-\beta)$, $n_3 = 0$, $s_{13} = \alpha(1-\varphi_1)\beta$, $s_{23} = \alpha(1-\varphi_2)\beta$, $s_{12} = [1-\alpha(2-\varphi_1-\varphi_2)](1-\beta)$ and $s_{123} = [1-\alpha(2-\varphi_1-\varphi_2)]\beta$. Since $n_2 \geq n_1 \geq n_3$, seller 2 will be the most powerful firm who can earn the monopoly profit, i.e., $\pi_2 = n_2 v$; seller 1 will get the profit that it can realize by charging the minimum price, i.e., $\pi_1 = \frac{(1-n_2-s_{23})n_2 v}{1-n_1-s_{13}}$; and seller 3 has zero loyalist and earns the profit that it can realize by serving all the switchers who are aware of its existence, i.e., $\pi_3 = \frac{(s_{13}+s_{23}+s_{123})n_2 v}{1-n_1-s_{13}} - G$. By simple algebraic manipulations,

$$\pi_2^E = \alpha(1-\varphi_2)(1-\beta)v. \tag{16}$$

$$\pi_1^E = \frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)(1-\beta)v}{1-\alpha+\alpha\varphi_1}, \tag{17}$$

$$\pi_3^E = \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1} - G. \tag{18}$$

In the second stage, the potential entrant decides whether to enter the market given φ_1 and φ_2. From Eq. 18, we can easily obtain the condition under which seller 3 enters the market, i.e.,

$$\frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1} > G. \tag{19}$$

In the first stage, the two incumbents decide their referral strategies. Based on the subgame equilibrium profits Eqs. 14–18 and the condition for new entry shown in Eq. 19, we get the profits of the incumbents as below:

$$\pi_2 = \begin{cases} \alpha(1-\varphi_2)v & if\ G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}, \\ \alpha(1-\varphi_2)(1-\beta)v & if\ G < \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}, \end{cases} \tag{20}$$

$$\pi_1 = \begin{cases} \frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)v}{1-\alpha+\alpha\varphi_1} & if\ G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}, \\ \frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)(1-\beta)v}{1-\alpha+\alpha\varphi_1} & if\ G < \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}. \end{cases} \tag{21}$$

For all parameter values, we always have $\pi_2 > \pi_1$ as long as $\varphi_1 > \varphi_2$.

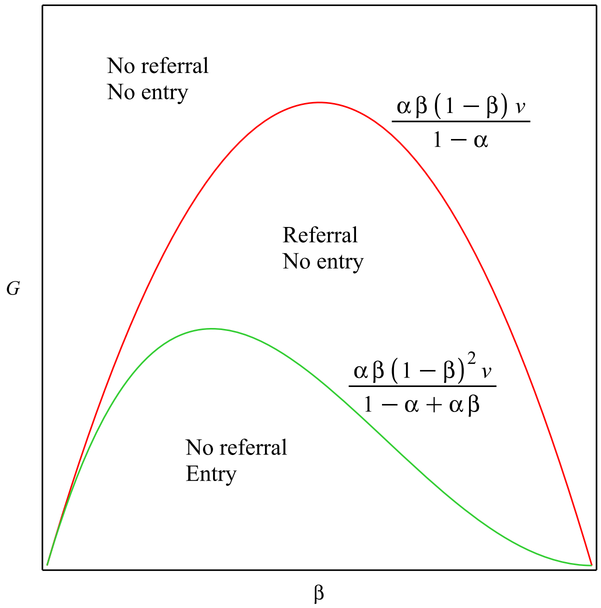

Fig. 9 Equilibrium with Endogenous Referral Efficiency

Then, we can model the decision process as a simultaneous, non-cooperative game and can show that there might exist multiple Nash equilibria. This leads to our next proposition (where we use the superscript $*$ to denote the Nash equilibrium) formally stated below:

Proposition 2 *Suppose that referral efficiencies are endogenously determined and* $\varphi_1 \geq \varphi_2$. *(i) When* $G > \frac{\alpha\beta(1-\beta)v}{1-\alpha}$, *neither incumbent applies referral, i.e.,* $\varphi_1^* = \varphi_2^* = 0$, *and seller 3 does not enter the market. Under this case,* $\pi_1^* = \pi_2^* = \alpha v$. *(ii) When* $\frac{\alpha\beta(1-\beta)v}{1-\alpha} \geq G > \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$, *seller 3 does not enter the market and there exist multiple equilibria where* φ_1^* *and* φ_2^* *are determined by*

$$\begin{cases} \frac{\alpha\beta(1-\beta)(1-\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*} = G, \\ \varphi_2^* < \beta, \\ \varphi_1^* < \frac{(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}. \end{cases} \tag{22}$$

Under this case, $\pi_2^* = \alpha(1-\varphi_2^*)v$ *and* $\pi_1^* = \frac{\alpha(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*}$. *(iii) When* $G \leq \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$, *neither incumbent applies referral, i.e.,* $\varphi_1^* = \varphi_2^* = 0$, *and seller 3 enters the market. Under this case,* $\pi_1^* = \pi_2^* = \alpha(1-\beta)v$ *and* $\pi_3^* = \frac{\alpha\beta(1-\beta)v}{1-\alpha} - G$.

Proposition 2 gives the equilibrium results when the two incumbents decide their referral efficiencies simultaneously and non-cooperatively. We can depict the equilibrium referral and entry decisions in Fig. 9.

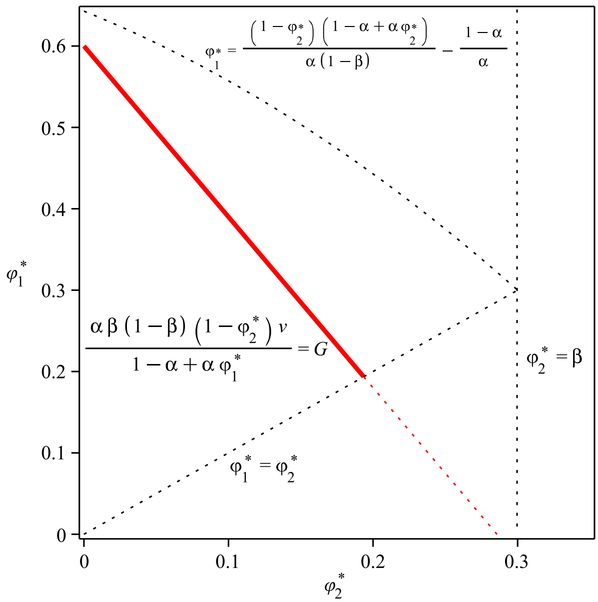

Fig. 10 Multiple Nash Equilibria with Endogenous Referral Efficiency

Part (i) and part (iii) of Proposition 2 coincide with our main model: If the entry cost is small, seller 3 always enters the market; and if the entry cost is too high, seller 3 never enters the market. In these cases, no incumbent would refer its competitor.

Part (ii) of Proposition 2 implies the possibility that the incumbents may use asymmetric referral efficiencies to deter entry. Figure 10 gives an example that shows the possible equilibria determined by Eq. 22 where the parameters are set as $\alpha = 0.4$, $\beta = 0.3$, $v = 10$ and $G = 1$. As shown in Fig. 10, any possible equilibrium must be constrained by the dotted curves $\varphi_2^* < \beta$ and $\varphi_1^* < \frac{(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}$ (by assumption we should also have $\varphi_1^* \geq \varphi_2^*$). These constraints ensure that φ_1^* and φ_2^* are not too large such that the incumbents suffer less from competitor referring than from new entry. Otherwise, the incumbents would rather let seller 3 enters the market. With these constraints, the incumbents should set φ_1^* and φ_2^* large enough such that the potential entrant can be blocked out of the market, i.e., $\frac{\alpha\beta(1-\beta)(1-\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*} = G$. Therefore, the solid line in Fig. 10 depicts all possible equilibrium referral efficiencies. That is to say, given any point on the solid line, neither incumbent has an incentive to increase or decrease the current referral efficiency (increasing efficiency would lose more loyalists while decreasing efficiency would not deter entry).

5.2 Sequential referrals

A further question needing discussion is the non-uniqueness of the first stage game outcome: when the incumbents apply referral to deter entry, how is the identity of the higher/lower efficiency incumbent selected? This is a problem that occurs in many games with symmetric competing firms but with asymmetric outcomes (Ireland 1993). The solution to the problem is usually sought in terms of leader-follower relationship between competitors.

In this section, we model the referral decision process as a sequential, non-cooperative game, with one incumbent (seller 1) as the leader and the other (seller 2) as the follower. In order to determine the Stackelberg equilibrium by backward induction, we first solve seller 2's optimal decision on φ_2 conditional on φ_1. Given φ_1, seller 2 may set φ_2 lower or higher than φ_1. If $\varphi_2 \leq \varphi_1$, seller 2 will be the relatively larger incumbent and its profit is given by

$$\pi_2 = \begin{cases} \alpha(1-\varphi_2)v & if\ G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}, \\ \alpha(1-\varphi_2)(1-\beta)v & if\ G < \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}. \end{cases} \tag{23}$$

If $\varphi_2 > \varphi_1$, seller 2 will be the relatively smaller incumbent; hence

$$\pi_2 = \begin{cases} \frac{\alpha(1-\varphi_1)(1-\alpha+\alpha\varphi_1)v}{1-\alpha+\alpha\varphi_2} & if\ G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_1)v}{1-\alpha+\alpha\varphi_2}, \\ \frac{\alpha(1-\varphi_1)(1-\alpha+\alpha\varphi_1)(1-\beta)v}{1-\alpha+\alpha\varphi_2} & if\ G < \frac{\alpha\beta(1-\beta)(1-\varphi_1)v}{1-\alpha+\alpha\varphi_2}. \end{cases} \tag{24}$$

Equations. 23–24 show that given G, φ_1 and φ_2, π_2 always decreases with φ_2. Thus, seller 2 has at most three choices: (a) $\varphi_2^* = 0$, the optimal decision when $G < \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}$ or $G < \frac{\alpha\beta(1-\beta)(1-\varphi_1)v}{1-\alpha+\alpha\varphi_2}$; (b) $\varphi_2^* = 1 - \frac{G(1-\alpha+\alpha\varphi_1)}{\alpha\beta(1-\beta)v}$, the optimal decision when $G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}$; and (c) $\varphi_2^* = \frac{\beta(1-\beta)(1-\varphi_1)v}{G} - \frac{1-\alpha}{\alpha}$, the optimal decision when $G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_1)v}{1-\alpha+\alpha\varphi_2}$. Under (a), seller 2 will earn a profit of

$$\pi_2 = \begin{cases} \alpha v & if\ G \geq \frac{\alpha\beta(1-\beta)v}{1-\alpha+\alpha\varphi_1}, \\ \alpha(1-\beta)v & if\ G < \frac{\alpha\beta(1-\beta)v}{1-\alpha+\alpha\varphi_1}. \end{cases} \tag{25}$$

Under (b) or (c), seller 2 earns the same profit:

$$\pi_2 = \frac{G(1-\alpha+\alpha\varphi_1)}{\beta(1-\beta)v}. \tag{26}$$

Comparing Eqs. 25–26 and assuming that seller 2 maximizes own profit, we can obtain seller 2's response conditional on φ_1, as shown in Lemma 5.

Lemma 5 *When the incumbents make referral decisions sequentially, the follower's (seller 2) response will be: (i) if* $G < \frac{\alpha\beta(1-\beta)^2v}{1-\alpha+\alpha\varphi_1}$ *or* $G \geq \frac{\alpha\beta(1-\beta)v}{1-\alpha}$, $\varphi_2^* = 0$*; and (ii) if* $\frac{\alpha\beta(1-\beta)^2v}{1-\alpha+\alpha\varphi_1} \leq G < \frac{\alpha\beta(1-\beta)v}{1-\alpha}$,

$$\varphi_2^* = \begin{cases} 1 - \frac{G(1-\alpha+\alpha\varphi_1)}{\alpha\beta(1-\beta)v} & if\ \varphi_1 > \frac{\alpha\beta(1-\beta)v-(1-\alpha)G}{\alpha\beta(1-\beta)v+\alpha G}, \\ \frac{\beta(1-\beta)(1-\varphi_1)v}{G} - \frac{1-\alpha}{\alpha} & if\ \varphi_1 \leq \frac{\alpha\beta(1-\beta)v-(1-\alpha)G}{\alpha\beta(1-\beta)v+\alpha G}. \end{cases} \tag{27}$$

Lemma 5 is consistent with what we find in Proposition 2: if the cost of entry is sufficiently low, referral cannot deter entry; and if entry is too expensive, there is no need to apply referral. Under these two extreme cases, the referral follower would never apply referral, i.e., $\varphi_2^* = 0$. On the other hand, if the entry cost is medium, the follower will set φ_2^* according to Eq. 27, which means that if the referral leader sets a high (low) level of referral efficiency, the follower will respond with a low (high) level.

As the Stackelberg leader, seller 1 takes into account the follower's response. If $G \geq \frac{\alpha\beta(1-\beta)v}{1-\alpha}$, no entry occurs and thus $\varphi_1^* = 0$. If $G < \frac{\alpha\beta(1-\beta)v}{1-\alpha}$, seller 1 has two options: let $G < \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\varphi_1}$ or $G \geq \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\varphi_1}$. When seller 1 sets φ_1 such that $G < \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\varphi_1}$, i.e., $\varphi_1 < \frac{\beta(1-\beta)^2 v}{G} - \frac{1-\alpha}{\alpha}$, the potential entrant will enter the market. Under this case, seller 1 optimally sets $\varphi_1^* = 0$ and earns $\pi_1 = \alpha(1-\beta)v$ profit. When seller 1 sets $\varphi_1 \geq \frac{\beta(1-\beta)^2 v}{G} - \frac{1-\alpha}{\alpha}$, the potential entrant will be blocked out. Under this case, seller 1 optimally sets $\varphi_1^* = \max\{\frac{\beta(1-\beta)^2 v}{G} - \frac{1-\alpha}{\alpha}, 0\}$ and earns a profit of $\pi_1 = \alpha(1-\varphi_1^*)v$ if $\varphi_1^* \leq \varphi_2^*$ or $\pi_1 = \frac{\alpha(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*}$ if $\varphi_1^* > \varphi_2^*$. The value of π_1 depends on whether $\max\{\frac{\beta(1-\beta)^2 v}{G} - \frac{1-\alpha}{\alpha}, 0\}$ exceeds $\frac{\alpha\beta(1-\beta)v-(1-\alpha)G}{\alpha\beta(1-\beta)v+\alpha G}$. By algebra, we can obtain seller 1's profit under each alternative. Seller 1's actions are determined by its profit maximization that yields the final equilibrium, as shown in the next proposition.

Proposition 3 *When the incumbents make referral decisions sequentially, the equilibrium referral strategies, entry decisions and profits are shown in* Table 2.

Proposition 3 and Table 2 give a unique outcome by imposing the assumption of sequential referral decisions. The core insight contained in Proposition 3 is consistent with that in Proposition 2. That is, when the cost of entry is not too large or too small, the incumbents may carefully introduce referral to deter any potential entry. Although the incumbents are hurt by their own referral, it is the lesser of two evils relative to new entry.

Furthermore, Table 2 clearly show that under sequential referral decisions, either one-way referral, two-way referral, or asymmetric equilibrium referral decisions could be the unique Nash equilibrium (See the third and fourth columns of Table 2), The referral leader will set a (weakly) lower referral level and consequently earn a (weakly) higher profit than the follower, i.e., $\varphi_1^* \leq \varphi_2^*$ and $\pi_1^* \geq \pi_2^*$. At the extreme,

Table 2 Equilibrium Results for Sequential Referral Decisions

	$G < \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$	$\frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta} \leq G < \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha}$	$\frac{\alpha\beta(1-\beta)^2 v}{1-\alpha} \leq G < \frac{\alpha\beta(1-\beta)v}{1-\alpha}$	$G \geq \frac{\alpha\beta(1-\beta)v}{1-\alpha}$
φ_1^*	0	$\frac{\beta(1-\beta)^2 v}{G} - \frac{1-\alpha}{\alpha}$	0	0
φ_2^*	0	$\frac{\beta(1-\beta)v}{G}\left[\frac{1}{\alpha} - \frac{\beta(1-\beta)^2 v}{G}\right] - \frac{1-\alpha}{\alpha}$	$\frac{\beta(1-\beta)v}{G} - \frac{1-\alpha}{\alpha}$	0
E or $\bar{E}$	E	$\bar{E}$	$\bar{E}$	$\bar{E}$
π_1^*	$\alpha(1-\beta)v$	$\alpha v\left[\frac{1}{\alpha} - \frac{\beta(1-\beta)^2 v}{G}\right]$	αv	αv
π_2^*	$\alpha(1-\beta)v$	$\alpha(1-\beta)v$	$\frac{(1-\alpha)G}{\beta(1-\beta)}$	αv

it might result in an outcome such that $\varphi_1^* = 0$ and $\varphi_2^* = \frac{\beta(1-\beta)v}{G} - \frac{1-\alpha}{\alpha}$; that is, one incumbent refers its competitor while its competitor does not. This provides us with an explanation for a rich set of referral policies adopted by online sellers. To provide an example, Progressive usually refers its customers to its competition while a competitor like GEICO does not always return the favor.

6 Endogenous entrant share

So far, we have assumed that the entrant's market share is exogenously determined which is clearly a simplified assumption for the sake of restricting our focus upon understanding the role of referrals in a clean and transparent manner. Now we extend our model to the case where entrant can affect its market share through explicit actions, i.e., the entrant's market share β is endogenously determined. A simple way to incorporate this is to consider β as a consequence of entrant's investment in informative advertising. As in the literature of informative advertising (e.g., Grossman and Shapiro (1984) and Soberman (2004)), let β be the advertising intensity that can be interpreted as the fraction of consumers exposed to the entrant's ad. The cost of reaching fraction β of consumers is assumed to be $\frac{c}{2}\beta^2$, where $c > 0$ is the cost parameter.

We restrict our attention to simultaneous referrals. If we also let φ_i be endogenously decided, from Proposition 2 as well as Fig. 9, we get the condition under which seller 3 chooses to enter the market, i.e., $G < \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$. Seller 3's profit conditional on entry is $\pi_3 = \frac{\alpha\beta(1-\beta)v}{1-\alpha} - G - \frac{c}{2}\beta^2$. Therefore, the entrant's maximization problem is given by

$$\begin{cases} \max_\beta \ \pi_3 = \frac{\alpha\beta(1-\beta)v}{1-\alpha} - G - \frac{c}{2}\beta^2, \\ s.t. \quad \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta} > G. \end{cases} \tag{28}$$

The solution to this problem is provided in the Appendix and we collect the equilibrium in Proposition 4.

Proposition 4 *When β is endogenously determined, (i) if $G > \frac{\alpha\bar{\beta}(1-\bar{\beta})^2 v}{1-\alpha(1-\bar{\beta})}$, seller 3 would never enter the market; (ii) otherwise, seller 3 enters the market and optimally sets $\beta^* = \min\left\{\max\{\beta_l, \hat{\beta}\}, \beta_h\right\}$, where $\bar{\beta} = \frac{\sqrt{(1-\alpha)(9-\alpha)}-3(1-\alpha)}{4\alpha}$, $\hat{\beta} = \frac{\alpha v}{2\alpha v + c(1-\alpha)}$, and β_l and β_h ($\beta_l < \beta_h$) are the two roots of equation $G = \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$.*

Proposition 4 shows that our model can also incorporate the case of endogenous β. An additional implication we get from Proposition 4 is that the entrant may not set β as large as possible even if it is costless. As a numerical example, at $v = 10$, $\alpha = 0.4$, $G = 0.7$, we will have $\bar{\beta} = 0.29$, $\hat{\beta} = \frac{4}{8+0.6c}$, $\beta_l = 0.17$ and $\beta_h = 0.45$. The entrant's optimal decision is to set $\beta^* = \min\{\max\{\beta_l, \hat{\beta}\}, \beta_h\}$. There are two reasons for this equilibrium. First, with the increase of β, although the entrant tends to share larger market size, it also implies that the incumbents face more threats that potentially results in more fierce defense (price competition). Thus, even without the constraint shown in the maximization problem in Eq. 28, the entrant will set β^* only up to $\hat{\beta}$. Second, at the time of choosing β, the entrant should also ensure that the constraint in Eq. 28 is satisfied. This constraint, as shown in Proposition 2 and Fig. 9, is to guarantee that the incumbents would not apply referral strategy to deter entry. As such, the entrant should also concede on its potential market share to avoid the incumbents' entry deterrence motives. In particular, β^* should neither exceed β_h nor fall below β_l.

7 Extensions

In the base model, we made several assumptions that could be termed as "unrealistic." For example, we assume that switchers and loyalists are equally attracted by the new entrant and that the two incumbents are symmetric with respect to their market shares. These assumptions are made for tractability. In this section, we demonstrate the robustness of our model by relaxing the assumptions.

7.1 General consumer segments

In the base model, we assume that a new entrant attracts customers uniformly through the market and the new entrant cannot create any segment of loyalists. Now, we show the robustness of our model by relaxing these assumptions.

We now assume that besides the loyal segments of the incumbents (each with size α) and the switcher segment (with size $1 - 2\alpha - \gamma$), there is a "non-buyer" segment with size $\gamma \in (0, 1 - 2\alpha)$. This segment includes the consumers who are unaware of, or just do not like the incumbents and do not make a purchase. Conditional upon a new entry, each segment may contain a fraction of customers that could be attracted by the new entrant (because of the entrant's advertising or awareness through word-of-mouth). However, each segment may have a different attraction rate. Let β_o, β_s and β_b be the attraction rates of the loyalists, switchers, and non-buyers, respectively towards the new entrant. Intuitively, loyalists should be least likely to be attracted by the new entrant than the switchers, while the non-buyers should be most attracted to the new entrants (since by definition they do not like the incumbents). Thus, we assume that $\beta_o < \beta_s < \beta_b$. To keep the analysis tractable and to sharpen our focus on general consumer demand, we assume exogenous referral efficiencies and entrant market share and consider the case of symmetric incumbents by setting $\varphi_1 = \varphi_2 = 1$. The assumption of symmetric incumbents enables us to focus only upon the one-way referral case since two-way referral would result in zero profit for the incumbents under the assumption of 100% referral efficiency.

As seen in the Appendix, we can derive the equilibrium profit of each seller under each subgame (conditional on the referral strategy and entry decision). We use superscripts $\bar{R}$ and R to denote the corresponding equilibrium when one-way referral is applied or not. Then, we have the following proposition where the expressions of $\underline{G}$ and $\bar{G}$ are provided in the Appendix.

Proposition 5 *With general consumer segments characterized by parameters* α, γ, β_o, β_s, β_b *and* $\varphi_1 = \varphi_2 = 1$, *in equilibrium one-way referral will be applied to deter entry when* $\alpha < \beta_o(1-\gamma)$ *and* $\underline{G}(\alpha, \gamma, \beta_o, \beta_s, \beta_b, v) < G < \bar{G}(\alpha, \gamma, \beta_o, \beta_s, \beta_b, v)$.

We glean two intuitive but important implications from Proposition 5. First, for incumbents to use referral under equilibrium, the ratio $\frac{\alpha}{1-\gamma}$ should be less than β_o. Note that the term $\frac{\alpha}{1-\gamma}$ reflects the incumbent's ability to profit from its loyalists and β_o characterizes the incumbent's potential loss upon the threat of new entry. Only when the potential loss due to new entry exceeds the guaranteed profit earned from the loyalists, will the incumbent resort to referral as a defense against the threat. Second, the use of referral requires $\underline{G}(\alpha, \gamma, \beta_o, \beta_s, \beta_b, v) < G < \bar{G}(\alpha, \gamma, \beta_o, \beta_s, \beta_b, v)$; that is, the entrant will earn positive profit without competitor referral but earn negative profit in the presence of referral. Finally, we use a numerical example to show how Proposition 5 works. Let $v = 10$, $\alpha = 0.3$, $\gamma = 0.1$, $\beta_o = 0.4$, $\beta_s = 0.6$ and $\beta_b = 0.8$. Then, we have $\pi_1^{R\bar{E}} = 2 > \pi_1^{\bar{R}E} = 1.8$ (the condition $\alpha < \beta_o(1-\gamma)$ holds), $\pi_3^{\bar{R}E} = 1.5 - G$ and $\pi_3^{RE} = 1.12 - G$. Clearly, when $G \in (1.12, 1.5)$, seller 3 will be blocked out of the market by competitor referral and using referral to deter entry is worthwhile to the referring firm. Overall, our main results and intuitions for firms' provision of referral is preserved under this important extension.

7.2 Asymmetric incumbents

In this subsection, we extend the base model to examine the case where sellers 1 and 2 differ in their number of loyalists. This is an interesting case where we can show that the seller with relatively smaller loyal segment (i.e., the weak brand) may, even unilaterally, refer the seller with relatively larger loyal segment (i.e., the strong brand).

Suppose that seller i has a fraction α_i $(i = 1, 2)$ of loyal segment. Without loss of generality, label seller 1 (2) as the strong (weak) brand, i.e., $\alpha_1 > \alpha_2$. For simplicity, we keep $\varphi_1 = \varphi_2 = 1$ and $\beta_o = \beta_s = \beta_b = \beta$ which are all exogenously given.

Next proposition lists the conditions under which the strong-brand or the weak-brand uses referral strategy to deter entry, where we define $G_a = \frac{\alpha_1\beta(1-\beta)}{1-\alpha_2}v$, $G_b = \alpha_1\beta(1-\beta)v$, $G_c = \alpha_2\beta(1-\beta)v$, $\beta_a = 1 - \frac{\alpha_2(1-\alpha_2)}{\alpha_1}$, and $\beta_b = \alpha_2$.

Proposition 6 *When* $\alpha_1 > \alpha_2$, $\varphi_1 = \varphi_2 = 1$ *and* $\beta_o = \beta_s = \beta_b = \beta$, *in equilibrium one-way referral will be applied to deter entry when (i)* $G_c < G \leq G_b$ *and* $\beta > \beta_a$ *(strong-brand referral equilibrium), or (ii)* $G_b < G \leq G_a$ *and* $\beta_b < \beta \leq \beta_a$ *(weak-brand referral equilibrium), or (iii)* $G_b < G \leq G_a$ *and* $\beta > \beta_a$ *(strong- or weak-brand referral equilibrium).*

Proposition 6 is roughly sketched by Fig. 11. The main finding from Proposition 6 is that the weaker seller may refer the stronger seller even when the stronger seller does not do so, as shown in parts (ii) and (iii) of the proposition. It conforms to our intuition that the strong-brand referral format, as shown in part (i) and (iii) of the proposition, is more effective in entry-deterrence than the weak-brand referral

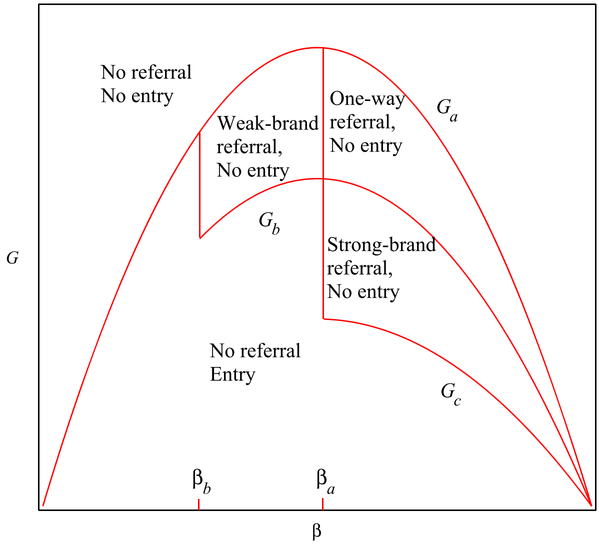

Fig. 11 Equilibrium under Asymmetric Incumbent Model

because the stronger seller earns more profits without entry and is hurt more when an entry occurs. Therefore, the stronger seller has a stronger incentive to block potential entry. It seems puzzling that weak-brand referral may become more effective under certain conditions. In fact, the stronger seller has to pay a higher price for referral than the weaker seller — referral hurts the stronger seller more since it loses more loyalists when referring competitor; on the contrary, the weaker seller who has fewer loyalists loses less. Therefore, the stronger (weaker) seller has a higher (lower) incentive to protect its share but under certain conditions the stronger (weaker) seller's referral may be less (more) efficient to deter entry.

8 Concluding remarks

In the present paper, we study the marketing practice of referring competitors online using a game-theoretical model where two competing incumbents decide whether to refer their competitor whereas an entrant decides whether to enter the market. In the main model, we assume that each incumbent has the same fraction of loyal consumers who visit only the incumbent. Once one incumbent refers the other, a fraction of the loyalists of this incumbent compare prices and buy from the seller offering the lowest price. After examining all the feasible subgames, we find that although competitor referral makes the referring firm worse off, under certain conditions, it could be the lesser of two evils relative to the threat of a potential entry. Therefore, the incumbents may apply referral strategy as a tool to deter entry. Furthermore, both one-way and two-way referrals may appear in the equilibrium. A two-way referral leads to more intense market competition than a one-way referral and might get used to deter entry when the entry costs are lower. However, as long as a one-way referral can deter entry, a two-way referral is always sub-optimal. We also analyze the scenario where the referral efficiency is modeled as an endogenous decision and find that the ex ante symmetric incumbents may choose asymmetric referral efficiencies ex post. Finally, we discuss the case when the incumbents make sequential referral decisions and show that either one-way referral, two-way referral or asymmetric referral decisions could constitute the unique equilibria.

In terms of theoretical contribution, our work complements the recent interest in research on practices that allow firms to earn rents even under competitive pressures. For example, use of little advertised add-on fees could be used to “obfuscate” the price information by service providers to earn higher markups even under intense competition (Gabaix and Laibson 2006; Shulman and Geng 2013). In contrast to this strand of literature, we show that even a practice like online referrals that is ostensibly designed to improve price transparency could be used to improve firm profits and potentially hurt consumers.[4]

In summary, our results indicate that firms may be motivated by entry deterrence to voluntarily refer consumers to their direct competitors for free. Our model is situated in conditions where firms compete intensely, and some of the firms that practice online referral, like the retail insurance markets, face similar competitive pressures. Future research could empirically explore the evidence in support of our key findings and also help researchers extend this model in fruitful directions that are grounded in better institutional contexts.

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Appendix A: Equilibrium results under main model

Our model analysis results in firms following no pure pricing strategies. We present a sketch for this finding following Varian (1980) and Narasimhan (1988). Take the no referral and no entry $\left(\bar{R}_1\bar{R}_2\bar{E}\right)$ subgame as an example. Suppose that there exists a pair of pure prices, denoted by (p_1^*, p_2^*), under which the incumbents receive the maximum profits. Assume that $p_1^* \leq p_2^*$ without loss of generality. By definition, if p_1^* is seller 1’s equilibrium price, there would not exist a price, denoted by p_1^ℓ, such that $\pi_1(p_1^\ell) > \pi_1(p_1^*)$.

When $p_1^* < p_2^*$, all the switchers purchase from seller 1 and we have $\pi_1(p_1^*) = p_1^*(1-\alpha)$. Let $p_1^\ell = p_1^* + \varepsilon < p_2^*$, where ε is infinitely small but positive. Then, all the switchers still purchase from seller 1 and we have $\pi_1(p_1^\ell) = (p_1^* + \varepsilon)(1-\alpha) > \pi_1(p_1^*)$. A contradiction.

[4]The results of the consumer welfare analyses are available from the authors upon request.

When $p_1^* = p_2^*$, the switchers randomly purchase from the incumbents. Assume that a fraction $\lambda_i \in (0, 1)$ of the switchers choose seller i, where $\sum_{i=1}^{2} \lambda_i = 1$, then we have $\pi_1(p_1^*) = p_1^*[\alpha + \lambda_1(1 - 2\alpha)]$. Let $p_1^\ell = p_1^* - \varepsilon < p_2^*$, where $\varepsilon > 0$. Then, all the switchers purchase from seller 1 and $\pi_1(p_1^\ell) = (p_1^* - \varepsilon)(1 - \alpha)$. Clearly, $\pi_1(p_1^\ell) > \pi_1(p_1^*) \Leftrightarrow \varepsilon < \frac{p_1^*(1-\lambda_1)(1-2\alpha)}{1-\alpha}$. The inequality holds as long as ε is sufficiently small. A contradiction.

The discussion above proves the non-existence of pure price strategies. The existence of mixed pricing strategies can be proved by construction, as shown in the following discussion.

No Referral and No Entry

Under $\bar{R}_1\bar{R}_2\bar{E}$, each incumbent has a fraction α of loyalists and the remaining fraction $1 - 2\alpha$ is composed of switchers. The expected profit of seller i equals

$$\pi_i = p[\alpha + (1 - 2\alpha)\bar{F}_j(p)]. \tag{A1}$$

Suppose that the two sellers set prices over the interval $[p_{\min}, v]$. Each seller should be indifferent between charging prices $p_{\min}$ and v. Since $\bar{F}_j(p_{\min}) = 1$ and $\bar{F}_j(v) = 0$, we have $p_{\min}(1 - \alpha) = \alpha v$, i.e., $p_{\min} = \frac{\alpha v}{1-\alpha}$. Furthermore, each seller must earn the same profit given any prices within $[p_{\min}, v]$. Thus, $p[\alpha + (1 - 2\alpha)\bar{F}_j(p)] = \alpha v$, from which we get $F_j(p) = 1 - \frac{\alpha(v-p)}{(1-2\alpha)p}$. Obviously, seller 1 and seller 2 are symmetric w.r.t. the equilibrium price and profit. Therefore, at the equilibrium $F_1(p) = F_2(p) = 1 - \frac{\alpha(v-p)}{(1-2\alpha)p}$ for $p \in [\frac{\alpha v}{1-\alpha}, v]$, and $\pi_1 = \pi_2 = \alpha v$.

One-way Referral without Entry

Under $R_1\bar{R}_2\bar{E}$, seller 1 has a fraction $n_1 = \alpha(1-\varphi)$ of loyalists, seller 2 has a fraction $n_2 = \alpha$ of loyal customers and the remaining fraction $s_{12} = 1 - \alpha(2 - \varphi)$ switches between the incumbents. Sellers 1 and 2 has an expected profit, respectively,

$$\pi_1 = p[\alpha(1 - \varphi) + (1 - 2\alpha + \alpha\varphi)\bar{F}_2(p)], \tag{A2}$$

$$\pi_2 = p[\alpha + (1 - 2\alpha + \alpha\varphi)\bar{F}_1(p)]. \tag{A3}$$

Following Narasimhan (1988), seller 2 (with a larger base of loyal segment) is indifferent between setting $p = v$ and $p = p_{\min}$, where $p_{\min}$ is the minimum possible price. Thus, $\pi_2 = n_2 v = (n_2 + s_{12})p_{\min}$, i.e., $p_{\min} = \frac{n_2 v}{n_2+s_{12}}$. By charging $p = p_{\min}$, the seller 1 obtains the profit $\pi_1 = \frac{n_2 v}{n_2+s_{12}}(n_1 + s_{12})$. Each seller must receive the same profit within the price support $[p_{\min}, v]$. Therefore, $n_2 v = pn_2 + ps_{12}\bar{F}_1(p)$ and $\frac{n_2 v}{n_2+s_{12}}(n_1 + s_{12}) = pn_1 + ps_{12}\bar{F}_2(p)$, from which we have

$$\begin{aligned} F_2(p) &= 1 - \frac{\frac{n_2(n_1+s_{12})}{n_2+s_{12}}v - n_1 p}{s_{12}p} \quad for \;\; p \in \left[\frac{n_2 v}{n_2+s_{12}}, v\right], \\ F_1(p) &= 1 - \frac{n_2(v-p)}{s_{12}p} \quad for \;\; p \in \left[\frac{n_2 v}{n_2+s_{12}}, v\right], \end{aligned} \tag{A4}$$

where seller 2 has a mass $\frac{n_2-n_1}{n_2+s_{12}}$ at price v. This is the well-known "Hi-Lo" price strategy. Finally, the equilibrium profits of sellers 1 and 2 are, respectively, $\pi_1 = \frac{n_2 v}{n_2+s_{12}}(n_1 + s_{12})$ and $\pi_2 = n_2 v$.

Entry without referral

The derivation of equilibria under $\bar{R}_1\bar{R}_2E$ directly follows Koçaş and Bohlmann (2008). First define the supports of each firm's CDF of price. Clearly, the upper bound of the feasible price set cannot exceed v. The minimum price for any firm is when it is indifferent between selling only to its loyal segment and quoting a lower price to capture the switchers. The minimum prices are $p_1^{\min} = \frac{n_1 v}{n_1+s_{12}+s_{13}+s_{123}} = \frac{\alpha(1-\beta)v}{1-\alpha}$ for seller 1, $p_2^{\min} = \frac{n_2 v}{n_2+s_{12}+s_{23}+s_{123}} = \frac{\alpha(1-\beta)v}{1-\alpha}$ for seller 2, and $p_3^{\min} = 0$ for seller 3. Clearly, $p_1^{\min} = p_2^{\min} > p_3^{\min}$.

Sellers 1 and 2 are symmetric w.r.t. their price strategies; hence they have the same price ranges. Seller 3 has the lowest minimum price; hence seller 3 shares the same lower bound as sellers 1 and 2. However, since sellers 1 and 2 have the same upper bound v and seller 3 has the weakest power in setting high price, it is possible that seller 3 sets the upper bound lower than v. Denote the common lower bound of the three sellers as $p_{\min}$, and denote the upper bound of seller 3 as $p_{\max}$.

Within the higher price region $[p_{\max}, v]$, sellers 1 and 2 compete with each other. Seller 1 is indifferent between setting $p = v$ and $p = p_{\max}$. Thus,

$$\pi_1 = n_1 v = n_1 p_{\max} + s_{12} p_{\max} \bar{F}_2(p_{\max}). \tag{A5}$$

Within the lower price region $[p_{\min}, p_{\max}]$, the three firms compete and they are indifferent among charging any prices. Thus,

$$\pi_1 = n_1 p_{\max} + s_{12} p_{\max} \bar{F}_2(p_{\max}) = (n_1 + s_{12} + s_{13} + s_{123}) p_{\min}, \tag{A6}$$

$$\begin{aligned}\pi_3 &= s_{13} p_{\max} \bar{F}_1(p_{\max}) + s_{23} p_{\max} \bar{F}_2(p_{\max}) + s_{123} p_{\max} \bar{F}_1(p_{\max}) \bar{F}_2(p_{\max}) - G \\ &= (s_{13} + s_{23} + s_{123}) p_{\min} - G.\end{aligned} \tag{A7}$$

Solving Eqs. A4, A5 and A6 and $F_1(p_{\max}) = F_2(p_{\max})$ simultaneously yields

$$p_{\min} = \frac{\alpha(1-\beta)}{1-\alpha} v, \tag{A8}$$

$$p_{\max} = \frac{\sqrt{(1-\beta)^2(1-2\alpha)^2 + 4\alpha^2(1-\alpha)^2} - (1-\beta)(1-2\alpha)}{2\alpha(1-\alpha)} v, \tag{A9}$$

$$F_1(p_{\max}) = F_2(p_{\max}) = 1 - \frac{(n_1 + s_{12} + s_{13} + s_{123}) p_{\min} - n_1 p_{\max}}{s_{12} p_{\max}}. \tag{A10}$$

To determine $F_1(p)$ and $F_2(p)$ within the interval $[p_{\max}, v]$, we should solve the equation $\pi_1 = n_1 v = n_1 p + s_{12} p \bar{F}_2(p)$, from which we have

$$F_1(p) = F_2(p) = \frac{1-\alpha}{1-2\alpha}\left[1 - \frac{\alpha v}{(1-\alpha)p}\right]. \tag{A11}$$

To determine $F_1(p)$, $F_2(p)$ and $F_3(p)$ within the interval $[p_{\min}, p_{\max}]$, we should solve the following equations ($F_1(p) = F_2(p)$):

$$\pi_1 = n_1 v = n_1 p + s_{12} p \bar{F}_2(p) + s_{13} p \bar{F}_3(p) + s_{123} p \bar{F}_2(p) \bar{F}_3(p), \tag{A12}$$

$$\pi_3 = (s_{13}+s_{23}+s_{123}) p_{\min} - G = s_{13} p \bar{F}_1(p) + s_{23} p \bar{F}_2(p) + s_{123} p \bar{F}_1(p) \bar{F}_2(p) - G. \tag{A13}$$

By algebra, we have

$$F_3(p) = \frac{1}{\beta} - \frac{1-\beta}{\beta} \frac{v}{h(p)}, \tag{A14}$$

$$F_1(p) = F_2(p) = \frac{1-\alpha}{1-2\alpha} \left[1 - \frac{\alpha v}{(1-\alpha)p} \cdot \frac{1-\beta}{1-\beta F_3(p)} \right], \tag{A15}$$

where we define $h(p) = \sqrt{p^2 + \frac{(1-\beta)(1-2\alpha)v}{\alpha(1-\alpha)} p}$. It is clearly shown that $F_1(p)$ and $F_2(p)$ will degenerate to the case where there is no entrance if $\beta = 0$. In case that $\beta > 0$, we can simplify $F_1(p)$ and $F_2(p)$ to, respectively,

$$F_1(p) = F_2(p) = \frac{1-\alpha}{1-2\alpha} \left[1 - \frac{\alpha}{1-\alpha} \frac{h(p)}{p} \right]. \tag{A16}$$

To sum up, we obtain the CDFs of the equilibrium mixed prices as shown in the base model. The equilibrium profits of sellers 1, 2 and 3 are, respectively, $\pi_1 = \pi_2 = n_1 v = \alpha(1-\beta)v$ and $\pi_3 = (s_{13} + s_{23} + s_{123}) p_{\min} - G = \frac{\alpha\beta(1-\beta)}{1-\alpha} v - G$.

One-way referral with entry

In the subgame $R_1 \bar{R}_2 E$, we have $n_1 = \alpha(1-\varphi)(1-\beta)$, $n_2 = \alpha(1-\beta)$, $s_{12} = (1-2\alpha+\alpha\varphi)(1-\beta)$, $s_{13} = \alpha(1-\varphi)\beta$, $s_{23} = \alpha\beta$ and $s_{123} = (1-2\alpha+\alpha\varphi)\beta$. The pattern of mixed prices is similar to that under $\bar{R}_1 \bar{R}_2 E$ and thus we omit the derivation process.

Two-way referral

The subgames $R_1 R_2 \bar{E}$ is similar with $\bar{R}_1 \bar{R}_2 \bar{E}$. The subgame $R_1 R_2 E$ is similar with $\bar{R}_1 \bar{R}_2 E$. The derivation process of these two subgames is analogue to previous subgames and thus we omit the derivation process.

Appendix B: Proof of Propositions

Proof of Proposition 1

When $G \le \frac{\alpha\beta(1-\beta)(1-\varphi)}{1-\alpha(1-\varphi)} v$, seller 3 always enters the market under no referral or one-way referral or two-way referral. The payoffs of sellers 1 and 2 under different referral strategies are listed in Fig. 12. It is easily seen from Fig. 12 that $\bar{R}_1 \bar{R}_2$ is the unique Nash equilibrium.

When $G > \frac{\alpha\beta(1-\beta)}{1-\alpha} v$, seller 3 never enters the market under no referral or one-way referral or two-way referral. The payoffs of sellers 1 and 2 under different referral

		Seller 2	
		R_2	$\bar{R}_2$
Seller 1	R_1	$\alpha(1-\beta)(1-\varphi)v,\ \alpha(1-\beta)(1-\varphi)v$	$\frac{\alpha(1-\alpha)(1-\beta)}{1-\alpha(1-\varphi)}v,\ \alpha(1-\beta)v$
	$\bar{R}_1$	$\alpha(1-\beta)v,\ \frac{\alpha(1-\alpha)(1-\beta)}{1-\alpha(1-\varphi)}v$	$\alpha(1-\beta)v,\ \alpha(1-\beta)v$

Fig. 12 Firm Payoffs when $G \le \frac{\alpha\beta(1-\beta)(1-\varphi)}{1-\alpha(1-\varphi)}v$

strategies are listed in Fig. 13. It is easily seen from Fig. 13 that $\bar{R}_1\bar{R}_2$ is the unique Nash equilibrium.

When $\frac{\alpha\beta(1-\beta)(1-\varphi)}{1-\alpha(1-\varphi)}v < G \le \frac{\alpha\beta(1-\beta)}{1-\alpha(1-\varphi)}v$, seller 3 is blocked out of the market only if the incumbents simultaneously offer referrals. The payoffs of sellers 1 and 2 under different referral strategies are listed in Fig. 14.

As shown in Fig. 14, $\bar{R}_1\bar{R}_2$ is a Nash equilibrium. However, there may exist another one Nash equilibrium depending on the value of β. If $\beta \le \varphi$, there is no other Nash equilibrium. If $\beta > \varphi$, R_1R_2 is the other Nash equilibrium. It is clear that R_1R_2 is a Parato-dominating strategy relative to $\bar{R}_1\bar{R}_2$. Thus, R_1R_2 will be the unique equilibrium over the long run.

When $\frac{\alpha\beta(1-\beta)}{1-\alpha(1-\varphi)}v < G \le \frac{\alpha\beta(1-\beta)}{1-\alpha}v$, seller 3 can be blocked out of the market under one-way referral or two-way referral. The payoffs of sellers 1 and 2 under different referral strategies are listed in Fig. 15. As shown in Fig. 15, $\bar{R}_1\bar{R}_2$ is the unique Nash equilibrium if $\beta \le \frac{\alpha\varphi}{1-\alpha+\alpha\varphi}$. If $\beta > \frac{\alpha\varphi}{1-\alpha+\alpha\varphi}$, there exist two Nash equilibria: $R_1\bar{R}_2$ and $\bar{R}_1R_2$. In this case, assume that each seller applies referral with probability τ and does not apply referral with probability $1-\tau$. Under the mixed referral strategy, each seller earns the same expected profit between applying referral and not applying. Thus, $\tau\cdot\alpha(1-\varphi)v + (1-\tau)\cdot\frac{\alpha(1-\alpha)}{1-\alpha(1-\varphi)}v = \tau\cdot\alpha v + (1-\tau)\cdot\alpha(1-\beta)v \Leftrightarrow \tau = \frac{\beta(1-\alpha)-(1-\beta)\alpha\varphi}{\beta(1-\alpha+\alpha\varphi)+\varphi(1-2\alpha+\alpha\varphi)}$.

Proof of Proposition 2

Equations 20–21 imply that the simultaneous referral decisions may result in multiple Nash equilibria.

		Seller 2	
		R_2	$\bar{R}_2$
Seller 1	R_1	$\alpha(1-\varphi)v,\ \alpha(1-\varphi)v$	$\frac{\alpha(1-\alpha)}{1-\alpha(1-\varphi)}v,\ \alpha v$
	$\bar{R}_1$	$\alpha v,\ \frac{\alpha(1-\alpha)}{1-\alpha(1-\varphi)}v$	$\alpha v,\ \alpha v$

Fig. 13 Firm Payoffs when $G > \frac{\alpha\beta(1-\beta)}{1-\alpha}v$

		Seller 2	
		R_2	$\bar{R}_2$
Seller 1	R_1	$\alpha(1-\varphi)v,\ \alpha(1-\varphi)v$	$\frac{\alpha(1-\alpha)(1-\beta)}{1-\alpha(1-\varphi)}v,\ \alpha(1-\beta)v$
	$\bar{R}_1$	$\alpha(1-\beta)v,\ \frac{\alpha(1-\alpha)(1-\beta)}{1-\alpha(1-\varphi)}v$	$\alpha(1-\beta)v,\ \alpha(1-\beta)v$

Fig. 14 Firm Payoffs when $\frac{\alpha\beta(1-\beta)(1-\varphi)}{1-\alpha(1-\varphi)}v < G \leq \frac{\alpha\beta(1-\beta)}{1-\alpha(1-\varphi)}v$

(a) When φ_1 and φ_2 are sufficiently small such that $G < \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}$, seller 3 will enter the market. In this case, the profit of each incumbent decreases with their own referral efficiency, implying that neither incumbent should do referral, i.e., $\varphi_1 = \varphi_2 = 0$. As a consequence, $\pi_1 = \pi_2 = \alpha(1-\beta)v$ and $\pi_3 = \frac{\alpha\beta(1-\beta)v}{1-\alpha} - G$.

(b) When φ_1 and φ_2 are sufficiently large such that $G \geq \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}$, seller 3 will not enter the market. In this case, the profit of each incumbent also decreases with their own referral efficiency. Thus, as long as $G > \frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1}$, at least one incumbent could decrease its referral efficiency by $\varepsilon > 0$ to improve profit without affecting seller 3's entry decision. As such, another set of Nash equilibria is determined by $\frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1} = G$. This will block seller 3 out of the market; hence $\pi_2 = \alpha(1-\varphi_2)v$ and $\pi_1 = \frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)v}{1-\alpha+\alpha\varphi_1}$.

Comparing the two alternatives we can obtain the conditions under which (b) is the equilibrium. First, the larger incumbent should earn a higher profit by applying referral, i.e., $\alpha(1-\varphi_2)v > \alpha(1-\beta)v \Leftrightarrow \varphi_2 < \beta$. Similarly, the smaller incumbent should also earn a higher profit by applying referral, i.e., $\frac{\alpha(1-\varphi_2)(1-\alpha+\alpha\varphi_2)v}{1-\alpha+\alpha\varphi_1} > \alpha(1-\beta)v \Leftrightarrow \varphi_1 < \frac{(1-\varphi_2)(1-\alpha+\alpha\varphi_2)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}$. Thus, the conditions under which the incumbents set φ_2^* and φ_1^* according to alternative (b), i.e., $\frac{\alpha\beta(1-\beta)(1-\varphi_2)v}{1-\alpha+\alpha\varphi_1} = G$, are

$$\begin{cases} \varphi_1^* = \frac{\beta(1-\beta)(1-\varphi_2^*)v}{G} - \frac{1-\alpha}{\alpha}, \\ \varphi_2^* < \beta, \\ \varphi_1^* < \frac{(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}. \end{cases} \tag{B1}$$

		Seller 2	
		R_2	$\bar{R}_2$
Seller 1	R_1	$\alpha(1-\varphi)v,\ \alpha(1-\varphi)v$	$\frac{\alpha(1-\alpha)}{1-\alpha(1-\varphi)}v,\ \alpha v$
	$\bar{R}_1$	$\alpha v,\ \frac{\alpha(1-\alpha)}{1-\alpha(1-\varphi)}v$	$\alpha(1-\beta)v,\ \alpha(1-\beta)v$

Fig. 15 Firm Payoffs when $\frac{\alpha\beta(1-\beta)}{1-\alpha(1-\varphi)}v < G \leq \frac{\alpha\beta(1-\beta)}{1-\alpha}v$

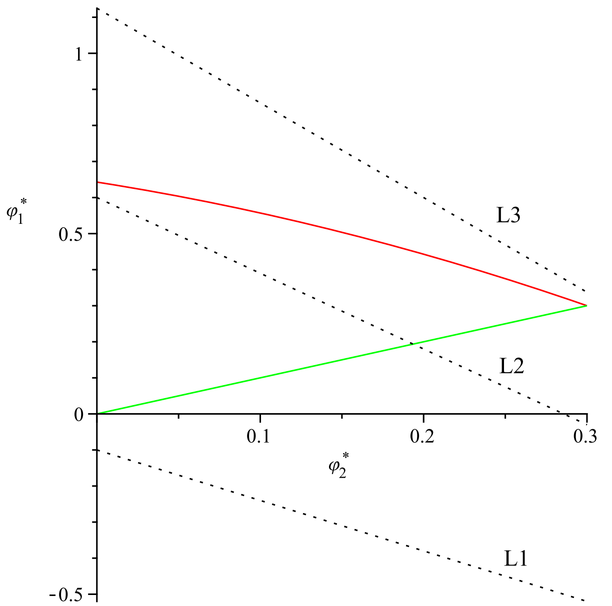

Fig. 16 Conditions Shown in Eq. B1

Now, we should derive the thresholds for parameters to ensure the possibility of conditions shown in Eq. B1. To this end, we make a numerical example by setting $\alpha = 0.4$, $\beta = 0.3$, $v = 10$ and $G = 0.8$ or 1 or 1.5, as shown in Fig. 16. The two solid curves depict the conditions $\varphi_2^* \leq \varphi_1^* < \frac{(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}$, so they cover the possible regions for $(\varphi_1^*, \varphi_2^*)$. The dotted line named L1 (L2, L3) depicts the condition $\varphi_1^* = \frac{\beta(1-\beta)(1-\varphi_2^*)v}{G} - \frac{1-\alpha}{\alpha}$ given $G = 1.5$ ($G = 1$, $G = 0.8$).

See first L1. This case implies that only if $\varphi_1^* < 0$ can the equation $\frac{\alpha\beta(1-\beta)(1-\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*} = G$ hold, even when $\varphi_2^* = 0$. Putting $\varphi_2^* = 0$ into $\varphi_1^* = \frac{\beta(1-\beta)(1-\varphi_2^*)v}{G} - \frac{1-\alpha}{\alpha} < 0$ we have $G > \frac{\alpha\beta(1-\beta)v}{1-\alpha}$. Under this case, $\frac{\alpha\beta(1-\beta)(1-\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*} < G$ given any φ_1^* and φ_2^*. Thus, seller 3 does not enter the market and $\varphi_1^* = \varphi_2^* = 0$.

See L2 then. This case implies that L2 and the solid curves have at least one crossing point. Solving $\varphi_1^* = \frac{\beta(1-\beta)(1-\varphi_2^*)v}{G} - \frac{1-\alpha}{\alpha}$ and $\varphi_1^* = \varphi_2^*$ yields $\varphi_2^* = \frac{\alpha\beta(1-\beta)v-(1-\alpha)G}{\alpha\beta(1-\beta)v+\alpha G}$. Solving $\varphi_1^* = \frac{\beta(1-\beta)(1-\varphi_2^*)v}{G} - \frac{1-\alpha}{\alpha}$ and $\varphi_1^* = \frac{(1-\varphi_2^*)(1-\alpha+\alpha\varphi_2^*)}{\alpha(1-\beta)} - \frac{1-\alpha}{\alpha}$ yields $\varphi_2^* = 1 - \frac{1}{\alpha} + \frac{\beta(1-\beta)^2 v}{G}$. Checking the two possible crossing points we have $\varphi_2^* = \frac{\alpha\beta(1-\beta)v-(1-\alpha)G}{\alpha\beta(1-\beta)v+\alpha G} < \beta \Leftrightarrow G > \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$ and $\varphi_2^* = 1 - \frac{1}{\alpha} + \frac{\beta(1-\beta)^2 v}{G} < \beta \Leftrightarrow G > \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$. Thus, when $\frac{\alpha\beta(1-\beta)v}{1-\alpha} \geq G > \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$, the equilibrium is characterized by Eq. B1.

The last case is L3 with $G \leq \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$. Under this case, $\frac{\alpha\beta(1-\beta)(1-\varphi_2^*)v}{1-\alpha+\alpha\varphi_1^*} > G$ given any φ_1^* and φ_2^* that can improve both incumbents' profits. Thus, seller 3 enters the market and $\varphi_1^* = \varphi_2^* = 0$.

Proof of Proposition 4

To solve the maximization problem Eq. 28, we should first derive the optimal β in the absence of the constraint, denoted by $\hat{\beta}$ (i.e., the inner solution of the maximization problem). We easily have $\hat{\beta} = \frac{\alpha v}{2\alpha v + c(1-\alpha)}$. Then, we should ensure that the constraint is satisfied. Since $\frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$ reaches its maximum value at $\beta = \frac{\sqrt{(1-\alpha)(9-\alpha)}-3(1-\alpha)}{4\alpha} \equiv \bar{\beta}$, we know that if $G > \frac{\alpha\bar{\beta}(1-\bar{\beta})^2 v}{1-\alpha(1-\bar{\beta})}$, the constraint cannot hold. In this case, seller 3 would not enter the market and earn zero profit.

Suppose now $G \leq \frac{\alpha\bar{\beta}(1-\bar{\beta})^2 v}{1-\alpha(1-\bar{\beta})}$. To derive the conditions under which the constraint holds, define $H(\beta) = \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$ which is a quasi-concave function with respect to β; that is, with the increase of β, $H(\beta)$ first increases and finally decreases. When $\beta = 0$ or $\beta = 1$, we have $H(\beta) = 0$. The properties of $H(\beta)$ implies that the equation $G = \frac{\alpha\beta(1-\beta)^2 v}{1-\alpha+\alpha\beta}$ has two solutions, denoted as β_l and β_h (i.e., the corner solutions of the maximization problem). Clearly, seller 3 has to set β within (β_l, β_h) to satisfy the constraint. As a result, if $\hat{\beta}$ is located within β_l and β_h, we have $\beta^* = \hat{\beta}$; if $\hat{\beta}$ is smaller than β_l, we have $\beta^* = \beta_l$; and if $\hat{\beta}$ is larger than β_h, we have $\beta^* = \beta_h$.

Proof of Proposition 5

The sketch of proof is as follows. In the absence of new entry or competitor referral, the equilibrium profit is the guaranteed profits are

$$\pi_1^{\bar{R}\bar{E}} = \pi_2^{\bar{R}\bar{E}} = \alpha v. \tag{B2}$$

If seller 1 applies referral and seller 3 does not enter, we have $n_1 = 0$, $n_2 = \alpha$ and $s_{12} = 1 - \alpha - \gamma$. The minimum prices each incumbent might charge are $p_{1\min} = \frac{n_1 v}{n_1 + s_{12}} = 0$ and $p_{2\min} = \frac{n_2 v}{n_2 + s_{12}} = \frac{\alpha v}{1-\gamma}$. Thus, the lower bound of the equilibrium mixed pricing is $p_{\min} = \max\{p_{1\min}, p_{2\min}\} = p_{2\min}$, resulting in the equilibrium profits

$$\pi_1^{R\bar{E}} = \frac{\alpha(1-\alpha-\gamma)v}{1-\gamma}, \ \pi_2^{R\bar{E}} = \alpha v. \tag{B3}$$

If seller 3 enters the market and neither incumbent applies referral, the market will be segmented as follows: $n_1 = n_2 = \alpha(1-\beta_o)$, $n_3 = \gamma\beta_b$, $s_{13} = s_{23} = \alpha\beta_o$, $s_{12} = (1-2\alpha-\gamma)(1-\beta_s)$ and $s_{123} = (1-2\alpha-\gamma)\beta_s$. The minimum prices each seller might set are $p_{1\min} = p_{2\min} = \frac{n_1 v}{n_1+s_{12}+s_{13}+s_{123}} = \frac{\alpha(1-\beta_o)v}{1-\alpha-\gamma}$ and $p_{3\min} = \frac{n_3 v}{n_3+s_{13}+s_{23}+s_{123}} = \frac{\gamma\beta_b v}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}$. Whether the system minimum price equals $p_{1\min}$ or $p_{3\min}$ depends on whether $\frac{\alpha(1-\beta_o)}{1-\alpha-\gamma}$ is larger or smaller than $\frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}$. When the parameters satisfy $\frac{\alpha(1-\beta_o)}{1-\alpha-\gamma} > \frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}$, we have $p_{\min} = p_{1\min}$, and therefore, $\pi_1^{\bar{R}E} = \pi_2^{\bar{R}E} = \alpha(1-\beta_o)v$ and $\pi_3^{\bar{R}E} = p_{1\min}(n_3 + s_{13} + s_{23} + s_{123})$.

Otherwise, we have $p_{\min} = p_{3\min}$, $\pi_1^{\bar{R}E} = \pi_2^{\bar{R}E} = p_{3\min}(n_1 + s_{12} + s_{13} + s_{123})$ and $\pi_3^{\bar{R}E} = \gamma\beta_b v - G$. To sum up, we have

$$\begin{cases} \pi_1^{\bar{R}E} = \pi_2^{\bar{R}E} = \alpha(1-\beta_o)v,\ \pi_3^{\bar{R}E} = \frac{\alpha(1-\beta_o)(2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b)v}{1-\alpha-\gamma} - G, \\ \qquad \text{if } \frac{\alpha(1-\beta_o)}{1-\alpha-\gamma} > \frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}, \\ \pi_1^{\bar{R}E} = \pi_2^{\bar{R}E} = \frac{\gamma\beta_b(1-\alpha-\gamma)v}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b},\ \pi_3^{\bar{R}E} = \gamma\beta_b v - G, \\ \qquad \text{if } \frac{\alpha(1-\beta_o)}{1-\alpha-\gamma} \le \frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}. \end{cases} \tag{B4}$$

If seller 3 enters the market and seller 1 applies referral, the sizes of each market segment are $n_1 = s_{13} = 0$, $n_2 = \alpha(1-\beta_o)$, $n_3 = \gamma\beta_b$, $s_{23} = \alpha\beta_o$, $s_{12} = (1-\alpha-\gamma)(1-\beta_s)$ and $s_{123} = (1-\alpha-\gamma)\beta_s$. The minimum prices each seller might charge are $p_{1\min} = 0$, $p_{2\min} = \frac{n_2 v}{n_2+s_{12}+s_{23}+s_{123}} = \frac{\alpha(1-\beta_o)v}{1-\gamma}$ and $p_{3\min} = \frac{n_3 v}{n_3+s_{23}+s_{123}} = \frac{\gamma\beta_b v}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b}$. Whether the system minimum price equals $p_{2\min}$ or $p_{3\min}$ depends on whether $\frac{\alpha(1-\beta_o)}{1-\gamma}$ is larger or smaller than $\frac{\gamma\beta_b}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b}$. When $\frac{\alpha(1-\beta_o)}{1-\gamma} > \frac{\gamma\beta_b}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b}$, we have $p_{\min} = p_{2\min}$, under which case $\pi_1 = p_{2\min}(s_{12} + s_{123})$, $\pi_2 = \alpha(1-\beta_o)v$, and $\pi_3 = p_{2\min}(n_3 + s_{23} + s_{123})$. Otherwise, we have $p_{\min} = p_{3\min}$, under which $\pi_1 = p_{3\min}(s_{12} + s_{123})$, $\pi_2 = p_{3\min}(n_2 + s_{12} + s_{23} + s_{123})$ and $\pi_3 = \gamma\beta_b v - G$. To sum up, we have

$$\begin{cases} \pi_1^{RE} = \frac{\alpha(1-\beta_o)(1-\alpha-\gamma)v}{1-\gamma},\ \pi_2^{RE} = \alpha(1-\beta_o)v,\ \pi_3^{RE} = \frac{\alpha(1-\beta_o)(\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b)v}{1-\gamma} - G, \\ \qquad \text{if } \frac{\alpha(1-\beta_o)}{1-\gamma} > \frac{\gamma\beta_b}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b}, \\ \pi_1^{RE} = \frac{\gamma\beta_b(1-\alpha-\gamma)v}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b},\ \pi_2^{RE} = \frac{\gamma\beta_b(1-\gamma)v}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b},\ \pi_3^{RE} = \gamma\beta_b v - G, \\ \qquad \text{if } \frac{\alpha(1-\beta_o)}{1-\gamma} \le \frac{\gamma\beta_b}{\alpha\beta_o+(1-\alpha-\gamma)\beta_s+\gamma\beta_b}. \end{cases} \tag{B5}$$

Then, we should ensure that (a) seller 1 can improve profit by deterring entry, i.e., $\pi_1^{R\bar{E}} > \pi_1^{\bar{R}E}$, and (b) conditional on entry, seller 3 earns positive profit in the absence of referral but earns negative profit in the presence of referral, i.e., $\pi_3^{\bar{R}E} > 0$ and $\pi_3^{RE} < 0$. Note that when $\frac{\alpha(1-\beta_o)}{1-\alpha-\gamma} \le \frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}$, as shown in Eq. B4, $\pi_3^{\bar{R}E} = \gamma\beta_b v - G$ which is equal to or lower than π_3^{RE}. This could not be the equilibrium. Thus, we must have $\frac{\alpha(1-\beta_o)}{1-\alpha-\gamma} > \frac{\gamma\beta_b}{2\alpha\beta_o+(1-2\alpha-\gamma)\beta_s+\gamma\beta_b}$, under which $\pi_1^{\bar{R}E} = \alpha(1-\beta_o)v$. Simplifying $\pi_1^{R\bar{E}} > \pi_1^{\bar{R}E}$ yields the condition $\alpha < \beta_o(1-\gamma)$. Finally, define

$$\underline{G} = \pi_3^{RE} + G, \tag{B6}$$

$$\bar{G} = \pi_3^{\bar{R}E} + G. \tag{B7}$$

Obviously, seller 3 will be blocked out of the market for $\underline{G} < G < \bar{G}$. Note that simplifying the condition $\underline{G} < G < \bar{G}$ is not worth doing because the expression(s) will be rather complicated with few new insights. In the main text, we give a numerical example to show the existence of the equilibrium.

Proof of Proposition 6

The derivation process is quite similar to the main model and we omit it here.

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