The Balance of Power in Markets with Competitive and Direct Sales Channels*

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Highly preliminary and incomplete.

Abstract

We model the strategic interactions between firms and price comparison websites (PCWs). Equilibrium falls into one of two regimes: either the PCW charges high commission and faces competition from firms' direct sales channel, or it charges low commission and accommodates them. Seemingly pro-competitive developments can have a non-monotonic effect on prices. Specifically, increasing the number of prices consumers check can increase prices and decrease total consumer surplus. We then endogenise the market structure, allowing firms and PCWs to fight for consumer attention via a technology which can be interpreted as more traditional advertising outlets or as search-engine marketing. We show how marketing reinforces the fee regime, and can lower consumer welfare. (*JEL* D43, D83, L11, M3)

Keywords: price comparison websites; market structure; price competition; search; advertising; search-engine marketing

1 Introduction

Price comparison websites (PCWs) have become major participants in markets for a variety of goods and services including flights, insurance products, telecommunications services, personal financial services, and domestic utilities. The first instinct of many

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commentators has been to welcome the growth of these new intermediaries on the basis that they facilitate the comparison of prices and therefore strengthen competition. Recent work that takes into account PCWs' role as active participants in the market has, however, raised some potentially harmful effects of their emergence such as PCW-enforced price clauses (e.g., Edelman and Wright, 2015; Johnson, 2017) and PCW commissions (e.g., Ronayne, 2015).

Such concerns have led competition authorities to more closely scrutinise the PCW industry. Two factors that are important in these practical policy debates remain relatively absent from extant academic analysis. Firstly, one argument against intervention in the PCW industry, especially since competition authorities have begun to prohibit MFN clauses, is that PCWs must compete against the price offered by firms to consumers buying direct. A high PCW fee will tend to lead to high prices on the PCW, making it less competitive against the direct channel. A key policy-relevant question is therefore whether and how the direct channel can serve as a competitive constraint on the PCW. Secondly, the market is evolving quickly. One particular development is that PCWs are investing heavily in marketing, and many (such as Expedia in the US or CompareTheMarket in the UK) have become household names in their own right. This raises the question for competition authorities of whether the growing brand-recognition and influence of PCWs is to be welcomed or treated with suspicion.

We provide a model of a homogeneous goods market to address these issues. Our modelling framework contributes to the existing literature in several novel ways. First, we tractably accommodate multiple, competing firms and PCWs.[1] Second, we allow for a fully asymmetric setup where both PCWs and firms may vary fully in the amount of market power they have, which allows us to answer questions about the shifting balance of power in these markets. Third, and facilitated by the generality of the approach, we study endogenous changes to the market structure.

The actors in the model are firms, PCWs, and a unit mass of consumers. Firms set two prices: one for consumers who buy direct, and one for consumers who buy via the PCW. The PCW shows the price of both firms and sets a commission fee that is paid by a firm each time it makes a sale through the PCW. Some of the consumers are savvy "shoppers" who buy from the lowest price available anywhere in the market. The remainder of the consumers check only one website and can be thought of as being loyal to a seller, relatively uninformed or inactive, or as facing high search costs. Because we will discuss branding and marketing activities we term these consumers "loyals". Loyals go to only one website (either a firm or the PCW) and buy at the best price they see there, provided it is below their willingness to pay. The number of loyals a firm or PCW

[1] We are confident that we can extend the model to accommodate an arbitrary number of PCWs and firms with little substantive change to the equilibrium. So far we have solved a model with $n > 1$ firms and $k \in \{1, 2\}$ PCWs. The model presented below takes $n = 2$ firms and a monopoly PCW.

has determines its market power or 'brand size'. Accordingly, we refer collectively masses of loyals and shoppers as the 'market structure'.

We compute the equilibrium prices and fees for any given market structure. The equilibrium involves a discontinuity between two 'regimes'. In the case of a relatively weak PCW, the PCW sets a low fee and hosts the lowest prices in the market. Shoppers buy through the PCW, while firms set a high direct price to exploit their loyal consumers. However, in the case of a relatively strong PCW, the PCW demands a high commission, exploiting its position as bottleneck provider of access to its loyal consumers. To avoid commission payments, firms compete for shoppers via direct prices and undercut the prices on the PCW. In this regime, direct prices are the lowest in the market.

Armed with this equilibrium characterisation, we proceed to analyse the effects of market structure on outcomes. In particular, to consider the effect of PCWs' increasing share of market power, we investigate how converting firm-loyals into either PCW-loyals or into fully-informed shoppers impacts equilibrium prices and consumer welfare. Either change increases the number of consumers who compare prices across firms. Nevertheless, we find that prices and consumer welfare are non-monotonic in such redistributions of market power: increasing the fraction of consumers who compare prices can increase prices and decrease consumer surplus. Intuitively, when a firm has fewer loyal consumers it becomes more focused on attracting shoppers, and therefore more willing to undercut the PCW. As the number of firm-loyal consumers decreases further, it eventually becomes so difficult for the PCW to deter undercutting that it gives up and switches to the high-fee regime and sells only to its own loyal consumers. In the high fee regime, firms compete in direct prices for shoppers. However, this channel is less effective than the frictionless competition offered on a PCW. We show that this shift in market structure can drive (average) prices up and total consumer welfare down.

The aforementioned analysis considers exogenous redistributions of consumer types. In Section 5, we develop a model of marketing where the action variable can either be interpreted as traditional advertising efforts, or as search-engine marketing (SEM). We then analyse competition for consumer attention, endogenising the market structure. Specifically, firms and PCWs compete over costly allocations of additional loyal consumers. However, marketing efforts are also allowed to change the number of shoppers in the market. As may be expected, consumers benefit when the predominant effect of marketing is to increase the number of shoppers in the market. However, when the additional market power available to websites through marketing is sufficiently high, we show that prices tend to increase, reducing consumer welfare. This last result is not so obvious as it might at first sound. Equilibrium prices can either increase or decrease as a website's market share increases, depending on the *relative* size of firms and the PCW. But we show that the market for attention tends to allocate consumers in a way that favours price increases.

1.1 Related literature and contribution

This paper builds on an established literature focused on price clearinghouses of which a classic example is Varian (1980).[2] In such models, a fraction of consumers only consider one firm's price, while the remainder use a price clearinghouse to see all firms' prices, typically resulting in mixed-strategy pricing. Baye et al. (1992) extend Varian (1980) to provide a full equilibrium characterisation when the loyal consumers are non-uniformly distributed among firms. In a symmetric setup with a monopolist intermediary, Baye and Morgan (2001) allow a more active role for the clearinghouse (PCW). They model a two-sided environment in which the PCW sets fixed advertising and subscription fees in order to get both consumers and firms on board. One feature common to clearinghouse models is that informed consumers are a source of discipline for firms, resulting in lower prices for the uninformed.[3] In a recent review, Armstrong (2015) refers to this effect as a 'search externality'. He contrasts this situation to models (such as Gabaix and Laibson, 2006) with 'rip-off externalities', where informed consumers benefit at the uninformed's expense.

We provide a new model with features that reflect empirical characteristics of the modern PCW industry: (i) PCWs that charge commissions rather than lump-sum fees, (ii) firms that can set different prices for direct and PCW sales and thus strategically interact with the PCW, and (iii) some consumers only consider prices on the PCW. We show that both search and rip-off externalities can arise in this environment. This is somewhat surprising given that clearinghouse models generally exhibit unambiguous search externalities. Our model also allows us to address the capacity of firms to provide a competitive discipline for the PCW and how the strategic interaction between firms and the PCW is affected by the relative power of these two types of actor. Both issues are highly relevant for policy makers who are currently studying whether intervention in the PCW industry is warranted, and what form such intervention should take.[4]

The broader literature on two-sided markets was originally chiefly concerned with optimal platform pricing in the face of exogenous network externalities (e.g., Armstrong, 2006; Caillaud and Jullien, 2003; Ellison and Fudenberg, 2003; Rochet and Tirole, 2003). Competition has since been explicitly modeled, but the platform is often assumed to be the only available business channel (e.g., Belleflamme and Peitz, 2010; Boik and Corts, 2016; Hagiu, 2009; Johnson, 2017). Most recently, the platform literature has focused on issues such as price clauses in markets with differentiated products and platforms (e.g., Boik and Corts, 2016; Edelman and Wright, 2015; Johansen and Vergé, 2016; Johnson, 2017; Wang and Wright, 2016). In this model, we directly model competition in prices,

[2]For a review see Baye et al. (2006).

[3]Firms care more about attracting informed consumers when there are many of them, and therefore compete harder with lower prices.

[4]See for example, the ongoing study of the UK's Competition and Markets Authority: https://www.gov.uk/government/news/cma-launches-study-into-digital-comparison-tools

allow firms to sell through multiple channels, and study the impact of the market structure on equilibrium prices and consumer welfare.

Another advantage of our framework is that it allows us to study competition between firms and PCWs for consumers through advertising. Classic advertising models such as Butters (1977) and Grossman and Shapiro (1984) are not suitable because they do not reflect the busy modern digital landscape where firms advertise their prices not only directly but also via PCWs, where PCWs both affect competition and themselves advertise. Chioveanu (2008) provides an analysis of advertising within a clearinghouse framework, and shows that equilibrium in such a model necessarily involves asymmetries in the size of firms. However, Chioveanu's analysis does not feature an active clearinghouse, and only permits firms one sales channel. Extending their 2001 framework, Baye and Morgan (2009) study a symmetric setup where the platform does not partake in its own advertising. In contrast, and to better capture the current online marketplace, we allow: firms to set a direct price and to choose to advertise a price on the PCW; for prices to be determined through the strategic interaction of firms and the PCW; for asymmetric firm sizes; and for any website to engage in marketing activities to determine its market power, be it a firm or a PCW.

We model both firms and the PCW as having loyal consumers. Asides reflecting the reality that some consumers only use one PCW to complete their purchases, this also specifies the market power of the PCW in the same currency as that of the firms. As such, our model offers a commensurable measure to each website in the market, be it a firm's or a PCW's. Furthermore, the model allows for a general interpretation of advertising, either as informational (making consumers aware of a website) or persuasive (fostering loyalty to a website). We consider this a strength because of the agnosticism stemming from the empirical work regarding whether the informational or persuasive interpretation of advertising fits the evidence best is mixed (see Bagwell, 2007 for a review). This generality can be seen in our application to marketing, where we allow the new consumers the marketing outlets provide to be any combination of shoppers and loyals.

2 Model description

Firms are indexed $i = 1, 2$, and the PCW, 0. There is a mass of consumers of measure $\mu + L$ who wish to buy one unit of a good and have reservation price $v > 0$. There are two types of consumer: shoppers and loyals. Shoppers are of mass $\mu > 0$. They are informed of all prices, buying at the lowest price available.[5] Firms each have a mass of loyal consumers, $L_i > 0$, who shop directly i.e., on the firm's website or at the firm's

[5]If there is a tie for the lowest price and all such prices are direct prices or all are listed on the PCW, then shoppers choose one of these firms randomly. If there is a tie in the lowest price where some of these prices are direct and some are on the PCW, the shopper completes the purchase directly through the firm's site.

physical store. Without loss of generality, we index the firms such that $L_1 \leq L_2$. The PCW also has a mass of loyal consumers, $L_0 > 0$, who shop exclusively on the PCW. In the baseline model, the PCW's strategy is a choice of fee, $c \in \mathbb{R}_+$, which a firm must pay each time a sale takes place via the PCW. Given c, firms choose a direct price, $p_i^d \in \mathbb{R}_+$, and a price to list on the PCW, $p_i \in \mathbb{R}_+$.[6] The solution concept is subgame-perfect Nash equilibrium, and the timing of the game is as follows:

$t = 1$ PCW sets fee c,

$t = 2$ Firms observe c and set prices p_i^d and p_i,

$t = 3$ Consumers shop.

2.1 Institutional setting and stylized facts

A key assumption of our model is that there exist consumers who are loyal to the PCW as well as consumers loyal to firms. This assumption is consistent with empirical experience. For example, a recent survey commissioned by the UK's Competition and Markets Authority (CMA)[7] found that 30% of PCW users consult only a PCW and no other source of price quotes (p21, p30). Furthermore, 58% of PCW users knew which PCW they wanted to use and went straight there i.e., are PCW loyals (p101). Meanwhile, in some sectors, there are many consumers who don't use a PCW, e.g., only 55% of shoppers in broadband use a PCW. Among the most commonly cited reasons for not shopping around is "brand loyalty" (p34). Loyalty to PCWs, in particular, has been encouraged by significant investment in brand-building. For example, the top four UK PCWs together spent an estimated £110m on marketing in 2014, placing all of them among the top 100 advertisers in the country.[8]

A second important feature of the model is the assumption that firms can separately set a direct price and a price via the PCW. Many price comparison sites, particularly in sectors such as energy, utilities, or travel, go beyond simply listing suppliers' prices and provide a comprehensive transaction and fulfillment service that allows consumers to complete the entire purchase without ever leaving the PCW. This means that consumers can be exposed to different prices via the the PCW and direct channel. Many times, PCWs have sought to mitigate competition from firms' direct prices through contractual constraints (so-called 'most favoured nation' [MFN] clauses). However, competition authorities such as the CMA and Germany's Bundeskartelamt have taken steps to reduce or prohibit the

[6] Firms might, in principle, choose not to list on the PCW, which is formally equivalent to listing price $p_i > v$.

[7] `https://assets.publishing.service.gov.uk/media/58e224f5e5274a06b3000099/dcts-consumer-research-final-report.pdf`

[8] http://www.thisismoney.co.uk/money/bills/article-2933401/Energy-price-comparison-sites-spend-110m-annoying-adverts.html

use of MFNs. One justification for doing so is that this will subject PCWs to a new source of competitive discipline, namely firms' direct prices. A key question for policy, which we address below, is the extent to which the direct channel is able to serve this role.

3 Equilibrium

3.1 Pricing subgame

We begin by studying the best-responses of firms in stage $t = 2$ for any choice of c by the PCW. In equilibrium, competition à la Bertrand in prices on the PCW implies that firms make zero profits from sales made there.

Lemma 1. *Fix $c \leq v$. In any equilibrium, the subgame starting at $t = 2$ must have $\min_i p_i = c$.*

Proofs are in the appendix.[9] Lemma 1 means that every equilibrium of the subgame starting at $t = 2$ is pay-off equivalent to one with $p_1 = p_2 = c$. We henceforth take $p_1 = p_2 = c$ as given and focus on each firm's payoff-relevant choice of direct price.

Suppose that the lowest price in the market (the price at which the shoppers buy) is listed on the PCW. This implies that firms serve only loyal consumers through their direct channel and, therefore, that $p_i^d = v$. The corresponding profit is vL_i. The best deviation for the firm would be to a price just low enough to induce shoppers to buy direct. But this requires that a firm undercuts not only its rival's direct price, but also the prices listed on the PCW, i.e., $p_i^d = c$. This deviation yields profit $c(L_i + \mu)$ and is, therefore, not profitable if[10]

$$c \leq \underline{c}_i \equiv \frac{vL_i}{L_i + \mu}. \tag{1}$$

If condition (1) is satisfied for all firms then the unique equilibrium behaviour is for firms to set the monopoly price on their direct channel and allow the PCW to serve the shoppers.

Lemma 2 (Low fee regime). *Suppose $0 \leq c \leq \underline{c}_1$. An equilibrium of the subgame starting at $t = 2$ has $p_1^d = p_2^d = v$. The resulting equilibrium profits are $\pi_0 = c(L_0 + \mu)$, $\pi_1 = vL_1$, $\pi_2 = vL_2$. When $0 \leq c < \underline{c}_1$, this equilibrium is unique.*

Now suppose $\underline{c}_1 < c < \underline{c}_2$. In this range firm 1 finds it worthwhile to undercut the PCW prices in order to attract shoppers, The resulting increase in demand more than compensates it for foregone monopoly rents on its few loyal consumers. Firm 2, on the

[9] Some proofs are missing in this preliminary draft, but we are able to prove all of the formally stated results.

[10] Firm 1 finds such a deviation profitable for lower levels of c relative to firm 2 because firm 1 has fewer loyals and therefore loses less from a reduction in its direct price.

other hand, earns more from monopoly pricing on its loyals and is unwilling to cut its price as low as c. This gives rise to an subgame equilibrium in which firms pursue asymmetric strategies and the shopper buy directly from firm 1:

Lemma 3. *Suppose $\underline{c}_1 \leq c \leq \underline{c}_2$. An equilibrium of the subgame starting at $t = 2$ has $p_1^d = c$ and $p_2^d = v$. The resulting equilibrium profits are $\pi_0 = cL_0$, $\pi_1 = c(L_1 + \mu)$, and $\pi_2 = vL_2$. When $\underline{c}_1 < c < \underline{c}_2$, this equilibrium is unique.*

For $c > \underline{c}_2$, both firms find it profitable to fight for shoppers using direct prices. Because more than one firm now uses a single variable (direct price) to trade off competition for shoppers against sure sales to loyals, the equilibrium firm responses are mixed, with specific distributions given by Lemma 4.

Lemma 4 (High fee regime). *Suppose $\underline{c}_2 \leq c \leq v$. An equilibrium of the subgame starting at $t = 2$ has p_1^d and p_2^d mixed over supports $\left[\underline{p}, c\right]$ and $\left[\underline{p}, c\right] \cup v$ respectively via the strategies*

$$F_1(p) = \begin{cases} \frac{\mu p - L_2(v-p)}{\mu p} & \text{for } p \in \left[\underline{p}, c\right) \\ 1 & \text{for } p \geq c, \end{cases}$$

$$F_2(p) = \begin{cases} \frac{\mu p - L_2(v-p)}{\mu p} \frac{\mu + L_1}{\mu + L_2} & \text{for } p \in \left[\underline{p}, c\right) \\ \frac{\mu c - L_2(v-c)}{\mu c} \frac{\mu + L_1}{\mu + L_2} & \text{for } p \in [c, v) \\ 1 & \text{for } p \geq v, \end{cases}$$

where $\underline{p} = \frac{vL_2}{L_2+\mu}$. The resulting profits are $\pi_0 = cL_0$, $\pi_1 = \frac{vL_2(L_1+\mu)}{L_2+\mu}$, and $\pi_2 = vL_2$. When $\underline{c}_2 < c \leq v$, this equilibrium is unique (up to payoff equivalence).

3.2 PCW fee-setting

Now we solve the game starting at $t = 1$. Accordingy, consider the incentives of the PCW when it chooses its fee level, c. For all levels of $c > 0$, the PCW makes positive profit from the fees paid by firms for purchases made by its L_0 loyals. In addition, when c is in the low-range of Lemma 2 firms do not offer a direct price that is competitive with the prices listed on the PCW, so shoppers also buy through the PCW. At higher levels of c, at least one firm sets a direct price lower than all prices on the PCW, leaving the PCW selling only to its loyals. The PCW therefore faces a trade off between i) a low-fee regime where it facilitates sales to shoppers and loyals; and ii) a high-fee regime where it facilitates sales only to loyals. By Lemmas 2–4, the highest c such that the PCW sells to shoppers and its loyals is $\underline{c}_1$, whereas the highest c such that it sells only to its loyals is v. Hence the PCW prefers i) to ii) if:

$$\frac{vL_1(L_0 + \mu)}{L_1 + \mu} \geq vL_0 \iff L_0 \leq L_1.$$

A higher L_1 increases $\underline{c}_1$ and hence profits for the PCW in the low-price regime. On the other hand, a higher L_0 increases profits in both regimes, but increases profit by more in the high-fee regime precisely because that is where the marginal revenue is higher. Our model reveals that a comparison of brand-size is central to a PCW's trade-off. If the PCW has a relatively strong brand, it chooses to set a high-fee and generate profit through sales to its loyals. When it has a relatively weak brand, it sets a low-fee in order to capture shoppers. Proposition 1 formalizes these forces and states the equilibrium.

Proposition 1. *There is a low-fee equilibrium when $L_0 \leq L_1$: the PCW sets $c = \underline{c}_1$ and firms price in accordance with Lemma 2. When $L_0 \geq L_1$, there is a high-fee equilibrium: the PCW sets $c = v$ and firms price in accordance with Lemma 4.*

When the PCW has a relatively weak brand i.e., does not have many loyal customers relative to the firms, the low-fee regime results in equilibrium. Through its low fee, the PCW disciplines the market, allowing shoppers and PCW loyals to buy at a relatively low equilibrium price. However, when the PCW has a relatively strong brand, it chooses to set a high fee in equilibrium to exploit its loyal consumers. This leaves firms to fight for shoppers through direct prices. The competitive force through firms' direct prices in the high-fee regime is less than that exerted through firms' prices listed on the PCW in the low-fee regime. Specifically, the lower bound of the support of equilibrium prices in the high-fee regime is higher than the prices listed on the PCW with probability one in the low-fee regime. As a result, the average price in the market is higher in the high-fee regime.

4 Comparative statics: price comparison and consumer welfare

Given that PCWs reduce search frictions and help consumers to compare prices, should their growth be unambiguously welcomed by regulators? For many, the obvious answer seems to be yes. But our model suggests that more caution is warranted. To see why, consider the following thought experiment: Let the PCW have little market power, i.e., $L_0 < L_1$. Now take mass D of the consumers loyal to firm 1 and make them, instead, loyal to the PCW. Note that this corresponds to an increase in the number of consumers' comparing price quotes from both firms, and might ordinarily be expected to intensify competition.

Indeed, if $D < (L_1 - L_0)/2$, then the market remains in the low-fee regime of Lemma 2 and it can be verified that prices on the PCW fall and consumer surplus increases. However, at $D = (L_1 - L_0)/2$ there is a discontinuity in consumer surplus caused by the fact that, as the PCW becomes large enough, the market switches from the low-fee regime

to the high-fee regime. This discontinuous increase in PCW fees brings with it a discontinuous increase in prices that, one can show, reduces consumer surplus overall. Indeed, one can show that consumer surplus is also decreasing in D for any $D > (L_1 - L_0)/2$ so there is a threshold beyond which any growth in PCW usage makes consumers worse off. Figure 1 illustrates and the result can be stated more formally:

Proposition 2. *Consumer surplus is increasing in D for $D < (L_1 - L_0)/2$, maximised when $D \nearrow (L_1 - L_0)/2$, and decreasing in D for $D \geq (L_1 - L_0)/2$. In words: consumer surplus can decrease when consumers switch from being loyal to a firm to using a PCW.*

Mechanically, there are three effects of increasing D: (i) consumers compare more prices, (ii) firm 1 has fewer loyals and is more willing to fight for shoppers, and (iii) the PCW has more loyal consumers to exploit. The first and second effects, in isolation, tends to make the market more competitive. But the second and third effects together make the PCW less interested in competing for shoppers, and more likely to set high fees. Proposition 2 establishes that these latter (anti-competitive) effects eventually dominate, to the detriment of consumers.

On a more intuitive level, the pro-competitive market transparency effect of a PCW must be weighed against the extra costs it injects into the market by using its market power to set fees. It is natural to expect that a growth in market power (thanks to an increase in PCW-loyals) will lead to higher fees. Proposition 2 establishes that, at least initially, competition from the direct channel suffices to discipline the intermediary such that the transparency effect dominates. But once the PCW attains a sufficient size relative to firms, the ability of the direct channel to function as a disciplinary device collapses and further growth in the PCW is unambiguously harmful to consumers.

Perhaps more striking still is the fact that we can also prove a result similar to Proposition 2 in which we take loyal consumers from firm 1 and convert them into shoppers who face no kind of search friction whatsoever. Formally, suppose $L_0 < L_1$ and D' consumers loyal to firm 1 become fully-informed shoppers. Then we again find that consumer surplus increases as consumers become more active shoppers only upto a point, whereafter surplus is non-monotonic.

Proposition 3. *Consumer surplus is increasing in D' for $D' < L_1 - L_0$, maximized when $D' \nearrow L_1 - L_0$, and decreases discontinuously in D' at $D' = L_1 - L_0$. Thus, consumer surplus can decrease when consumers switch from being loyal to a firm to using a PCW.*

The intuition is similar to that above: as firm 1's loyal base shrinks the PCW finds it hard to deter firm 1 from undercutting and stealing the shoppers. Eventually, the PCW gives-up and switches to charging higher fees, resulting in higher equilibrium prices. This strategic effect is sufficiently strong that consumers can be left worse-off, even though the direct effect of an increase in shoppers is for consumers to make better purchase decisions.

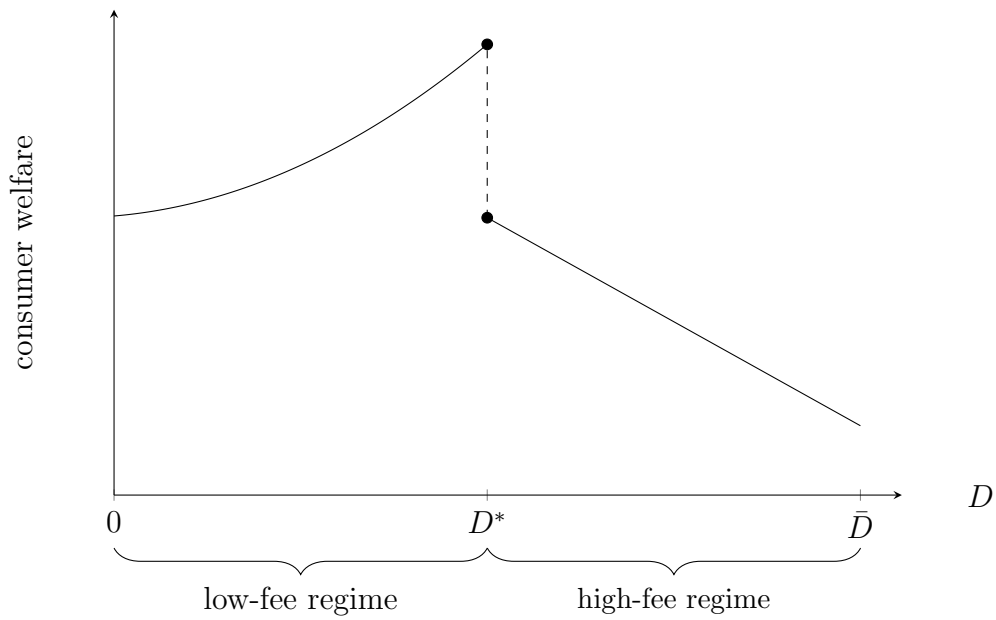

Figure 1: Redistributions of loyal consumers from firms to the PCW

5 Brand advertising and search-engine marketing

In the previous section's analysis we held the number of consumers fixed. In this section, we allow firms and the PCW to capture new customers at a cost, which is achieved by introducing marketing into our framework.

We suppose that there exists a menu of marketing options, $\mathbf{s} = (s_1, s_2, s_3) \geq \mathbf{0}$, such that a firm can increase its stock of loyal consumers by s_i if it chooses the i'th option. One can think of s_i as the extra market power gained by having the ith-best airtime slot on television, i^{th}-best page in a newspaper or magazine, or being ranked i^{th} in a relevant search result (we use the search engine marketing—SEM—terminology below for concreteness). Without loss of generality we let $s_1 \geq s_2 \geq s_3 \geq 0$. For simplicity, we assume that any SEM-provider (be it a search engine a digital marketeer) extracts the full surplus that advertising businesses make through SEM in equilibrium.[11]

Through engagement in SEM, firms and the PCW are able to reach a wider market and increase their market power. Therefore, changes in the firms' and PCW's market power could result in a transition from the high-fee to the low-fee regime, or vice versa. However, we now show that such SEM activity *never* causes a change in regime (Lemma 5). Furthermore, Lemma 5 follows because SEM *reinforces* the pre-existing regime (Lemma 6).

[11]Notice that because the full surplus is extracted by the SEM provider, an allocation (a one-to-one mapping between the firms and the PCW and elements of $\mathbf{s}$) is efficient if and only if it is revenue-maximizing for the SEM-provider. The assumption of full surplus extraction also allows us to maintain focus on the market of firms and the PCW without introducing any profits caused by new players in the game, the study of which is not our focus. In practical terms, this assumption could be the result of letting the SEM-provider move first. In this complete-information setup, this would mean the provider knows the profit players can make from any allocation and hence can charge a price equal to the relevant player's willingness to pay.

Lemma 5. *In equilibrium, if a market is in the low-fee (high-fee) regime prior to search-engine marketing (SEM), it is also in the low-fee (high-fee) regime following the SEM.*

Lemma 6. *For any equilibrium allocation of* $\mathbf{s}$ *resulting in a change to the stock of loyals for the PCW and the firms respectively,* (d_0, d_1, d_2)*, we have:*

$$|(L_0 + d_0) - (L_1 + d_1)| > |L_0 - L_1|.$$

These results follow because of the convex nature of firm and PCW payoff functions. This means that when a firm or PCW has a higher number of loyal consumers, they have a higher willingness to pay for a given increase in loyal consumers. Hence, if a player is initially larger than another, they also grow by more than the other, which in turn reinforces the initial fee regime. We now unpack the results in more detail.

For example, consider an initial market-size vector $\mathbf{L}$ where $L_0 < L_1$ so that the low-fee regime pertains in equilibrium, and profit functions are given by Proposition 1. Inspection of these functions reveals that the willingness to pay of each player i for a marginal increase in their stock of loyals is $\mathbf{d} = (d_0, d_1, d_2)$ is $w_0^l = v\frac{L_1+d_1}{L_1+d_1+\mu}, w_1^l = v, w_2^l = v$ respectively for the PCW, firm 1 and firm 2. The expression w_0 depends on d_1 because PCW profits depend on the equilibrium fee, which in turn depends on firm 1's stock of loyals. However, because profits are linear in own-loyals, a comparison of marginal profits is sufficient to determine WTP. If $\mathbf{s}$ is such that the relative order of the loyal stocks cannot be affected, then w_0^l, w_1^l, w_2^l describe profit sufficiently. Because $w_0^l < w_1^l = w_2^l = v$, firms attract the larger shares of new loyal consumers, s_1 and s_2, and therefore grow by more than the PCW. Because $L_0 < L_1$ initially and $d_0 \leq d_1$ from SEM, $L_0 + d_0 < L_1 + d_1$ i.e., the low-fee equilibrium is also obtained for any such $\mathbf{s}$. This logic is unaffected when $\mathbf{d}$ is instead large enough such that the relative order of the loyal stocks could change. This is because marginal profit can be no higher than v, and $w_1^l = w_2^l = v$ so long as the PCW is allocated s_3. Therefore, in equilibrium, s_1 and s_2 must be allocated to the firms, while s_3 is allocated to the PCW. Similar reasoning follows in the case where $L_0 > L_1$ such that we are initially in the high-fee regime (h), except there, $w_1^h < w_0^h = w_2^h = v$. Hence in equilibrium, s_1 and s_2 must be allocated to the PCW and firm 2, while s_3 is allocated to firm 1.

The above analysis considers SEM impacting only the number of loyal consumers. It is also plausible that SEM has a competitive effect by increasing the number of shoppers. We add this to the model by denoting the mass of shoppers created by SEM, $s_\mu \geq 0$. Within both the fee regimes, this does not alter the willingnesses to pay of the two larger players, but reduces that of the smallest. Therefore the allocation of $\mathbf{s}$, and the preceding results, are unchanged. We now consider the effect of SEM when the search-engine is defined by $\mathbf{s}, s_\mu$.

Proposition 4. *The introduction of SEM reduces aggregate consumer welfare if and only if:*

$$\frac{\Delta(L_1+\mu)}{\Delta(L_0+\mu)} \geq \Delta(\mu) \quad \text{if } L_0 \leq L_1$$

$$\frac{\Delta(L_2+\mu)}{\Delta(L_1+\mu)} \geq \Delta(\mu) \quad \text{if } L_0 > L_1$$

where $\Delta(x)$ is the ratio of x after the equilibrium allocation of $(\mathbf{s}, s_\mu)$, to before.

To explore this result we first offer two extreme cases. In one, total consumer welfare rises and in the other, it falls.

Corollary 1. *When the only effect of SEM is to introduce shoppers into the model i.e., $\mathbf{s} = \mathbf{0}$, $s_\mu > 0$, SEM increases welfare for every type of consumer.*

Corollary 2. *When the only effect of SEM is to introduce loyals into the model such that the lowest-ranked search result yields no extra custom i.e., $\mathbf{s} = (s_1, s_2, 0)$, $s_\mu = 0$, SEM decreases welfare for every type of consumer.*

When SEM has a purely-competitive effect, it works in the favour of consumer welfare. More precisely, introducing shoppers into the market ceteris paribus cannot change the fee regime, but always increases total consumer welfare. This is shown in Corollary 1. In the low-fee regime, an increase in the number of shoppers drives down the PCWs equilibrium fee, which benefits PCW loyals and shoppers. Furthermore, there are now more shoppers who enjoy these lower prices. In the high-fee regime, the increase in shoppers shifts (in a first-order stochastic sense) the distribution of direct prices down, benefiting firm-loyals and shoppers (of which there are an increased number), while making no difference to PCW loyals.

At the other extreme, when SEM has a purely brand-enhancing effect (and the lowest-ranked search-result offered by the search engine is zero), SEM lowers aggregate consumer welfare. This occurs because the larger two players (the firms in the low-fee regime; the larger firm and the PCW in the high-fee regime) secure s_1 and s_2 in equilibrium and grow by more. Because the large get larger, the fee regime that existed prior to any SEM is reinforced. Moreover, it is reinforced in the most insidious way for consumers. In the low-fee regime, the increase in firm 1's stock of loyals increases the equilibrium PCW fee and hence also the prices posted on it, while there is no change in the direct prices. Therefore, shoppers and PCW loyals pay more, while firm loyals are unaffected. In the high-fee equilibrium, the increase in the number of loyals of firm 2 shifts (in a first-order stochastic sense) the distribution of direct prices up, harming firm-loyals and shoppers, while making no difference to PCW loyals.

For general s, s_μ, the overall impact of SEM on aggregate consumer welfare balances the positive competitive (Corollary 1) and negative brand-strengthening (Corollary 2)

effects. Specifically, Proposition 4 pinpoints that whether of not consumer welfare rises or falls is determined by whether the ratio of the growth of the potential market of a larger firm to the smallest player is smaller or larger than the growth in the number of shoppers.

6 Preliminary remarks on a richer consumer typespace

Here we provide a rough outline of an alternative model that is still highly preliminary.

We have so far assumed that consumers are either shoppers or are loyal: we envisage a world in which consumers are, by default, active shoppers, but can be induced to exhibit loyalty to one particular outlet through persuasive brand advertising.

Alternatively, one might imagine a richer consumer typespace in which, for any $\mathcal{A} \subseteq \{0, 1, 2\}$, there is a mass of consumers who considers only prices listed at $i \in \mathcal{A}$. One convenient way to model this is to suppose that a consumer considers prices at i with probability λ_i. Thus, for example, a mass $\lambda_0(1-\lambda_1)(1-\lambda_2)$ of consumers are loyal to the PCW. This framework departs from the previous model because we would now have $\lambda_0\lambda_1(1-\lambda_2)$ consumers who consider prices on the PCW and firm 1's direct channel, but not firm 2's direct price; $\lambda_1\lambda_2(1-\lambda_0)$ consumers who consider only direct prices; etc.

Analysis of the game then proceeds along similar lines as before and the equilibrium has a structure reminiscent of the model considered above:

Remark 1. *When λ_i consumers consider prices at site i, the equilibrium is such that*

1. *If $\lambda_0 \leq \lambda_2$, there is a 'low-fee regime' in which the PCW sets $c = c_L \equiv v(1-\lambda_1)(1-\lambda_0)$. Firms set $p_i = c_L$ and mix in direct prices according the the distributions*

$$F_1 = \frac{1}{\lambda_1}\left[1 - \frac{v(1-\lambda_1)}{p}\right]$$

$$F_2 = \frac{1}{\lambda_2}\left[1 - \frac{v(1-\lambda_1)}{p}\right]$$

   on support $[v(1-\lambda_1), v]$ (firm 2 has a mass point at $p_2^d = v$).

   Any consumer with the PCW in their consideration set buys through the PCW at price c_L. A mass $\lambda_1\lambda_2(1-\lambda_0)$ consumers buy direct from the cheaper firm. Consumers with only one firm in their consideration set buy direct from that firm.

2. *If $\lambda_0 \geq \lambda_2$, there is a 'high-fee regime' in which the PCW sets $c = v(> c_L)$. Firms set $p_i = c = v$ and mix in direct prices according the the distributions*

$$F_1 = \frac{1}{\lambda_1}\left[1 - \frac{c(1-\lambda_1)}{p}\right]$$

$$F_2 = \frac{1}{\lambda_2}\left[1 - \frac{c(1-\lambda_1)}{p}\right]$$

on support $[c(1-\lambda_1), v]$ *(firm 2 has a mass point at* $p_2^d = c$*).*

Any consumer with at least one direct price in their consideration set buys direct at the cheapest price in their consideration set. Consumers who have only the PCW in their consideration set buy via the PCW.

Note that, as in the baseline model, an increase in s_0 (more consumers have access to the price comparison service) can trigger a discontinuous switch in equilibrium regime. Computing consumer surplus in the two regimes yields

Corollary 3. *Consumer surplus in the low-fee regime is* $v\lambda_1^2 + v\left[\lambda_0^2(1-\lambda_1) + \lambda_0\lambda_1(1-\lambda_1)\right]$*. This is increasing in* λ_0 *and unambiguously higher than the consumer surplus in the high-fee regime* ($v\lambda_1^2$)*.*

A familiar pattern emerges: increasing the size of a small PCW increases consumer surplus as consumers more actively compare prices. But once the PCW enjoys as much attention as any firm, expanding the mass of consumers using price comparison services is harmful.

Lastly, we can use this model to gain another perspective on competition for attention in markets with a PCW. Suppose $i \in \{0, 1, 2\}$ can determine λ_i at cost $\lambda_i^2/2$. We then find that the unique equilibrium in pure strategies is such that the high-fee equilibrium prevails in the continuation game. Thus, the model predicts that PCWs will invest aggressively in marketing and that consumers will be too reliant on price comparison services from the point of view of maximizing consumer surplus.

A Appendix

A.1 Proof of Lemma 1

Claim A1. *Listing a price* $p_i < c$ *is dominated.*

Proof. Suppose $p_i < c$. Then i's profit is (i) $p_i^d L_i + (p_i - c)L_0$ (if shoppers do not buy from i), (ii) $p_i^d(L_i + \mu) + (p_i - c)L_0$ (if shoppers buy from i directly), or (iii) $p_i^d L_i + (p_i - c)(L_0 + \mu)$ (if shoppers buy from i via the PCW). A deviation to $p_i > v$ would cause profit in these three cases to change to (i) $p_i^d L_i$, (ii) $p_i^d(L_i + \mu)$, and (iii) either $p_i^d L_i$ or $p_i^d(\mu + L_i)$. In all three cases this represents an increase. □

Denote the distribution of the lowest price listed on the PCW as $F_{\min}$. Denote the minimum and maximum of the support of $F_{\min}$ by $\underline{s}$ and $\bar{s}$ respectively.

Claim A2. *When* $c < v$*,* $\underline{s} = c$

Proof. By Claim A1 we know $\underline{s} \geq c$. Now we show that $\underline{s} > c$ is not possible. Firstly, consider $\bar{s} = \underline{s} > c$, then at least one firm plays $\underline{s}$ with probability one (but not all firms play $\underline{s}$ with probability one, else one of them could profitably undercut). Denote firm j as one of the firms not playing $\underline{s}$ with probability one and note that j could profitably undercut its PCW price to $p_j = \underline{s} - \epsilon$ in order to strictly increase its profit (in the case where $p_j^d = \underline{s}$ and there is a positive probability this is the cheapest direct price, then in addition consider firm j deviating to $p_j^d = \underline{s} - \epsilon$). Secondly, consider $\bar{s} > \underline{s} > c$. If so, all firms must make positive profits via the PCW: if not, a firm with zero profit could deviate to $\underline{s}$ (in the case where $p_j^d = \underline{s}$ and there is a positive probability this is the cheapest direct price, then in addition consider firm j deviating to $p_j^d = \underline{s} - \epsilon$). As firms make positive profits through the PCW and must be indifferent between all prices they play, all prices listed are no greater than v. Consider the highest price in the union of all the supports of all firms, $\bar{p} \leq v$. If there is a positive probability of a tie at $\bar{p}$, any firm would shift the associated probability mass to a price slightly below $\bar{p}$. If there is a zero probability of a tie, any firm called upon to play a price at or approaching $\bar{p}$ will make zero profit, a contradiction. □

Claim A3. *When $c < v$, $\bar{s} = c$*

Proof. From Claim A2, $\underline{s} = c$. Therefore some firm has c in its support and makes zero profit via the PCW. Call the firm that places the most probability on c, firm j. If j sets $\underline{s} = c$ with probability one, $\bar{s} = c$ which proves the claim. Suppose j sets $\underline{s}$ with probability less than one. It must be that some firm $l \neq j$ has the interval $[c, c + \epsilon]$ for $\epsilon > 0$ small in its support (otherwise there would be an interval $(c, c + \delta]$ which is not in the support of any firm's strategy, but then j could profitably set $p_j = c + \epsilon$ for $\epsilon > 0$ small). As c is in the support of firm l's strategy, it must make zero profits through the PCW, but this contradicts the supposition that prices in $(c, c + \epsilon)$ may win with positive probability. □

Claim A4. *When $c < v$, at least two firms list $p = c$ with probability one.*

Proof. Lemmas A2 and A3 show $\bar{s} = \underline{s} = c$. This implies that there is at least one firm, say firm j, which lists c on the PCW with probability one. Suppose j was the only firm to do so. If so, j makes zero profit through the PCW, yet could profitably deviate to some slightly higher price at which there is a positive probability of having the lowest listed price. Such an increase in p_j cannot reduce demand through j's direct sales channel, but would strictly increase expected profit through the PCW. □

Claim A5. *When $c = v$ forms part of an equilibrium, at least one firm lists $p = v$ with probability one.*

Proof. By Claim A1, every firm sets $p_i \geq c$. When $c = v$, firms are indifferent between any $p \geq v$. However, suppose that there is no firm that plays $p = v$ with probability one.

This implies PCW profit is lower than vL_0. This can't be an equilibrium because the PCW could slightly reduce c to induce at least two firms to list $p = c$ with probability one (by Claim A4). For a sufficiently small reduction in c, this increases PCW profit. □

A.2 Proof of Lemmas 2–4

Proof of Lemma 2. Firms earn zero profit from consumers served through the PCW in any equilibrium (Lemma 1). If a firm charges $p_i^d = v$ it makes total profit of $\pi_i = vL_i$. The highest profit possible from setting any other value of p_i^d is from $p_i^d = c$. In the best-case scenario where there is a zero probability of any other firm's direct price being tied or lower, this would generate $\pi_i' = c(L_i + \mu)$. Because $\pi_i' - \pi_i$ is decreasing in i, it suffices to check only firm 1 would not find this strategy more profitable,

$$\pi_1 \geq \pi_1' \iff c \leq \frac{vL_1}{L_1 + \mu}.$$

The equilibrium is unique because a firm can always obtain profit vL_i by deviating to $p_i^d = v$. □

Proof of Lemma 3. Firms $i = 2, \ldots, n$ can guarantee themselves profit of vL_i by setting $p_i^d = v$; no greater profit can be earned by serving loyals. Attracting shoppers would require $p_i^d \leq c$, which is not profitable by definition when $c \leq \underline{c}_i$. Thus, in any equilibrium we must have $p_i^d = v$ for all $i \geq 2$. Given that its rivals all set $p_i^d = v$, firm 1 can choose between serving loyals and earning profit vL_1 or setting a price of c to attract the shoppers, resulting in profit of $c(L_1 + \mu)$. When $c \geq \underline{c}_1$, firm 1 prefer to attract the shoppers and must therefore set $p_i^d = c$ in equilibrium. □

Proof of Lemma 4. When firm 1 sets $p_1^d \in \left[\underline{p}, c\right]$, its profit is $\pi_1\left(p_1^d\right) = p_1^d\left\{L_1 + \mu\left[1 - F_2\left(p_1^d\right)\right]\right\}$. Firm 1's profits when $p_1^d = \underline{p} \equiv \frac{vL_2}{L_2+\mu}$ are $\pi_1\left(\underline{p}\right) = \frac{vL_2}{L_2+\mu}\left(L_1 + \mu\right)$. Setting $\pi_1\left(p_1^d\right) = \pi_1\left(\underline{p}\right)$ and solving for F_2 yields

$$F_2(p) = \frac{\mu p - L_2(v - p)}{\mu p}\frac{\mu + L_1}{\mu + L_2}.$$

Similarly, when firm 2 sets $p_2^d \in \left[\underline{p}, c\right)$, its profit is $\pi_2\left(p_2^d\right) = p_2^d\left\{L_2 + \mu\left[1 - F_1\left(p_2^d\right)\right]\right\}$. Firm 2's profits when $p_2^d = v$ are $\pi_2\left(v\right) = vL_2$. Setting $\pi_2\left(p_2^d\right) = \pi_2\left(v\right)$ and solving for F_1 yields

$$F_1(p) = \frac{\mu p - L_2(v - p)}{\mu p}.$$

By construction, F_2 ensures 1 is indifferent over every $p_1^d \in \left[\underline{p}, c\right]$ and F_1 makes 2 indifferent over every $p_1^d \in \left[\underline{p}, c\right) \cup v$. We need to check that no firm can profit from a deviation outside of its support.

Deviations to $p_i^d > v$ yield zero profit and are not profitable. Neither firm can profit from a deviation to $p_i^d < \underline{p}$: this would result in the same demand as $p_i^d = \underline{p}$ but at a lower price. Any $p_i^d \in (c, v)$ is greater than the lowest price on the PCW and therefore only attracts loyals. The resulting profit, $p_i^d L_i$, is increasing in p_i^d so $p_i^d \in (c, v)$ is dominated by $p_i^d = v$. Since 1 has a mass point at c, $p_2^d = c$ induces a tie and yields strictly lower expected profit than does $p_2^d = c - \epsilon$ (for $\epsilon > 0$ small). Lastly, we check that firm 1 cannot profit from a deviation to $p_1^d = v$. We have $\pi_1(v) > \pi_1(\underline{p}) \iff vL_1 > \frac{vL_2}{L_2+\mu}(L_1 + \mu)$, which fails because $L_1 < L_2$.

Firms $i > 2$ set $p_i^d = v$ and earn profit vL_i. A deviation to $p_i^d \in (c, v)$ fails to attract any shoppers and is not profitable. A deviation to $p_i^d = c$ induces ties with firm 1's mass point, and are therefore dominated by deviations to $p_i^d = c - \epsilon$ for some small ϵ. Deviations to $p_i^d \in [\underline{p}, c)$ yield profit $p_i^d \left\{ L_i + \mu \left[1 - F_1\left(p_i^d\right)\right] \left[1 - F_2\left(p_i^d\right)\right] \right\}$. We observe that (i) firm i earns lower profit from $p_i^d \in [\underline{p}, c)$ than does firm 2; and (ii) $vL_i > vL_2$. Since firm 2 is indifferent between $p_2^d \in [\underline{p}, c)$ and $p_2^d = v$, firm $i > 2$ must strictly prefer the latter.

□

A.3 Proofs from Section 4

Proof of Proposition 2. In the low-fee and high-fee regime, consumer welfare is given by subtracting firm and PCW profit (given in Proposition 1) from total surplus $v(L_0 + L_1 + L_2 + \mu)$. After the proposed reallocation of consumers, this yields:

$$CW_L(D) = v\mu \frac{L_0 + D + \mu}{L_1 - D + \mu}, \qquad CW_H(D) = v\mu \frac{L_1 - D + \mu}{L_2 + \mu}. \tag{2}$$

It is clear by inspection that $CW_L'(D) > 0$ and $CW_H'(D) < 0$. Moreover,

$$CW_L[(L_1 - L_0)/2] = v\mu > CW_H[(L_1 - L_0)/2] = \frac{\mu v(2\mu + L_0 + L_1)}{2(\mu + L_2)}. \qquad \square$$

Proof of Proposition 3. In the low-fee and high-fee regime, consumer welfare is given by subtracting firm and PCW profit (given in Proposition 1) from total surplus $v(L_0 + L_1 + L_2 + \mu)$. After the proposed reallocation of consumers, this yields:

$$CW_L(D') = v\mu \frac{L_0 + D' + \mu}{L_1 - D' + \mu}, \qquad CW_H(D) = v\mu \frac{L_1 - D' + \mu}{L_2 + \mu}. \tag{3}$$

It is clear by inspection that $CW_L'(D') > 0$. Moreover,

$$CW_L(L_1 - L_0) = v(L_1 - L_0 + \mu) > CW_H(L_1 - L_0) = \frac{L_1 + \mu}{L_1 + \mu + L_2 - L_0} v(L_1 - L_0 + \mu). \quad \square$$

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