Essays in Industrial Organization and Competition Policy

Sébastien Broos

Ph.D. thesis in
Economics and Management

Jury
Joe Tharakan (ULg, Chairman)
Axel Gautier (ULg, Thesis Director)
Cédric Argenton (Tilburg U.)
Paul Belleflamme (UCLouvain)
Joshua Gans (U. of Toronto)
Nicolas Petit (ULg)

HEC Liège
Academic Year 2016–2017

Contents

General Introduction **5**

1 The Exclusion of Competing One-Way Essential Complements: Implications for Net Neutrality **6**

1 Introduction 7
2 Literature review 12
3 Model 16
4 Monopoly ISP 19
4.1 Exclusion 19
4.2 No Exclusion 20
4.3 Comparisons 21
4.4 Price surcharge 23
4.5 App exclusion and the net neutrality debate 24
4.6 Sabotage vs. app exclusion 27
5 Duopoly 28
5.1 Symmetric ISPs 29
5.2 Asymmetric ISPs 31
5.3 Exclusivity 33
6 Conclusion 34
7 Appendix 35
7.1 Proof of Lemma 1 35
7.2 Proof of Proposition 2 40
7.3 Complement to the proof of Proposition 3 41
7.4 Proof of Lemma 2 41

7.5 Proof of Proposition 5 44
7.6 Proof of Proposition 6 45
7.7 Proof of Proposition 7 45
7.8 Proof of Proposition 8 48

2 Targeted Advertising and Consumer Information 51
1 Introduction 52
2 The baseline model 55
2.1 Consumers 55
2.2 The firm 56
3 When is complex targeting the best strategy? 59
4 The impact of complex targeting on prices, consumer surplus and welfare 63
5 First-best 70
6 Discussion and extensions 71
6.1 The firm's information and personalized pricing 73
6.2 The valuation of uninformed consumers 75
7 Conclusion 77
8 Appendix 78
8.1 Proof of Proposition 2 78
8.2 Second-order conditions 79
8.3 The Kumaraswamy (2,5) distribution 81

3 Competing Business Models and Two-Sidedness: an Application to the Google Shopping Case 82
1 Introduction 83
2 The contentious definitions of two-sidedness 85
3 Business model competition 88
3.1 Two-sidedness: a characteristic of the firm 89
3.2 Merger control in the broadcasting industry 91
4 Single or separate markets? 92
5 Two-sidedness and business model competition in the Google Shopping case 96
5.1 The facts of the Google Shopping Case 96

5.2 The firms . . . 98
5.3 The market definition for two-sided intermediaries . . 101
5.4 When resellers and two-sided intermediaries belong to the same relevant market . . . 107
6 Conclusion . . . 108

4 Cartels in the EU: Who Appeals and Who Wins? 110
1 Introduction . . . 111
2 Related literature . . . 113
3 Cartel Enforcement and Appeal Procedure . . . 115
4 Data and hypotheses . . . 117
5 Empirical Analysis . . . 123
6 Conclusion . . . 128
7 Appendix . . . 128
7.1 Additional regressions . . . 128

Avenues for further research 132

Bibliography 133

General Introduction

In this dissertation, I study issues in industrial organization and competition policy, with a focus on the digital economy (Chapters 1, 2, and 3). Chapter 1 analyzes the incentives of Internet Service Providers (ISPs) to break net neutrality by excluding competing applications. Net neutrality is a particular form of internet regulation which, broadly, prohibits any type of discrimination of data on the internet. Because they usually sell the internet but also other goods –the phone, TV, music services– ISPs may have incentives to exclude applications which compete with these services. We study this problem in monopolistic and duopolistic frameworks.

In Chapter 2, I analyze the impact of better targeting on the optimal advertising strategy of a monopolist. While the literature has traditionally considered improvements in targeting as an increased ability to target high-valuation consumers, I argue that another advance is to be able to link a consumer's valuation with his information. While the former almost always leads to a higher price, the latter often reduces price. The welfare effects of such an improvement in targeting technology are also examined.

Chapter 3 studies the definition of a relevant market for competition policy purposes in the presence of two-sided intermediaries. We first show that two-sidedness is a feature of firms and not of markets and, hence, that the market definition should take into account competing firms which do not operate as two-sided intermediaries. We then discuss the conditions under which a single market encompassing both sides of the intermediary should be defined, as opposed to two interrelated markets, one for each side of the intermediary. Finally, we apply our findings to the Google Shopping Case.

Finally, in Chapter 4, we examine the determinants of cartel appeals and their success in the European Union. We show that new enforcement tools such as settlement, leniency and guidelines have a strong impact on both the probability to appeal and to win. We also find that undertakings appeal more often if they have a higher expected gain from doing so, i.e. if the fine they contest is high, and that the more appellants in a cartel, the higher the probability of successful appeal. Finally, we highlight that the estimates are very sensitive to econometric misspecifications.

Chapter 1

The Exclusion of Competing One-Way Essential Complements: Implications for Net Neutrality

Sébastien Broos, Axel Gautier

Abstract

We analyze the incentives of internet service providers (ISPs) to break net neutrality by excluding competing one-way essential complements, i.e. internet applications competing with their own products. A typical example is the exclusion of VoIP applications by telecom companies offering internet and voice services. A monopoly ISP may want to exclude a competing internet app if it is of inferior quality and the ISP cannot ask for a surcharge for its use. Competition between ISPs never leads to full app exclusion but it may lead to a fragmented internet where only one ISP offers the application. We show that, both in monopoly and duopoly, prohibiting the exclusion of the app and surcharges for its use does not always improve welfare.

Keywords: Net Neutrality, Foreclosure, One-Way Essential Complements

JEL classification: L12, L13, L51, L96

Acknowledgments: We thank participants at CISS, Connected Life 2014, the 18th Centre for Competition and Regulatory Policy Workshop, the 29th Jornadas de Economia Industrial, the EARIE meeting and the Ninth IDEI-TSE-IAST conference on the Economics of Intellectual Property, Software and the Internet. We also thank Juan José Ganuza, Jacques Crémer, Martin Peitz and Nicolas Petit for helpful discussions and, more particularly, Florian Schuett who discussed the paper twice. We are also grateful to the Co-editor (Martin Peitz) and two reviewers for their helpful comments and suggestions. We thank Isabelle Peere for proofreading the manuscript. This research was funded through the ARC grant for Concerted Research Actions, financed by the French-speaking Community of Belgium.

1 Introduction

In 2005, Madison River, a US internet service provider (ISP), excluded Vonage, a Voice over IP (VoIP) application, from its network, which resulted in a conflict between stakeholders over the control of the bundle of services offered on the internet. Most ISPs offer multiple services –internet, phone, television, video, etc.– and applications such as Vonage are competing with these services. These apps are "competing one-way essential complements" (Chen and Nalebuff, 2006): competing because Vonage is a substitute to the phone, and one-way essential complement because the internet is "essential" for the app to work but the opposite is not true. On the one hand, they create a business stealing effect and excluding them is a way for the ISP to limit unwanted competition. On the other hand, they create value for internet users who are willing to use and to pay for these new services. That value can possibly be extracted by the ISP through higher internet prices and, therefore, exclusion might not necessarily be optimal. The interplay of these two types of incentives is the main object of this article.

The concept of exclusion rings multiple bells. In this paper, we link the literature on vertical foreclosure and one-way essential complements with the literature on net neutrality. Indeed, the exclusion of competing applications is part of the larger debate on "net neutrality". Because it is still a very lively dispute, net neutrality does not have a unified definition. Still, Schuett (2010) summarizes it as "the principle that all data packets on an information network are treated equally". Accordingly, content exclusion is a breach of the net neutrality principle. The literature (Choi and Kim, 2010; Economides and Hermalin, 2012; Reggiani and Valletti, 2016, for instance) has generally focused on two implications of net neutrality: the **non-discrimination rule** and the **zero-price rule**.

The first interpretation simply means that a bit is a bit and that contents should be treated similarly, regardless of their nature, origin and destination. For example, there should be no prioritization: the bits sent by Youtube should not be transferred faster than those sent by Vimeo. Similarly, traffic management should be limited to isolated cases and the exclusion of particular applications –the most extreme form of discrimination– should be forbidden. Furthermore, the non-discrimination rule also implies that internet users can use applications without paying an extra fee to the ISP. Stated differently, the ISP cannot condition the use of an application to the payment of a surcharge. The non-discrimination rule prohibits the exclusion of competing apps (content-based discrimination, which we henceforth refer to as condition NN_1) and price surcharges for using such apps (financial discrimination, condition NN_2). We say that an ISP fully complies with net neutrality if there is no exclusion of the app and no surcharge to use it. An ISP partially complies with net neutrality if there is no exclusion but a surcharge to use the app.[1]

The zero-price rule prohibits financial transfers between residential ISPs and content producers (CPs). On the internet, CPs pay a backbone provider to be connected to the network and residential consumers pay to be connected to an ISP.[2] According to the zero-price rule, ISPs do not have the

[1]This distinction echoes the distinction between weak and strong net neutrality of Gans (2015) and Gans and Katz (2016) who state that net neutrality is *strong* if content-based price discrimination is outlawed both with regard to CPs and consumers, and that it is *weak* if discrimination is outlawed with regard to one group only.

[2]See Faratin et al. (2008) and Economides and Hermalin (2012) for more on the structure

right to make CPs pay a termination fee for the access to internet consumers. The zero-price rule implies that there is a "missing price"[3] prohibiting financial transfers between CPs and ISPs. The zero-price rule and the non-discrimination rule have been criticized for prohibiting the emergence of value-added services on the internet. In our model, the zero-price rule is always enforced and therefore our focus is exclusively on the no-discrimination rule.

The literature has generally focused on the implications of net neutrality on congestion (Choi and Kim, 2010; Choi et al., 2015a; Peitz and Schuett, 2016; Economides and Hermalin, 2012) and innovation and investment (Reggiani and Valletti, 2016; Bourreau et al., 2015; Choi et al., 2015b). By contrast, we will concentrate our analysis on the exclusion of competing applications. Indeed, as highlighted in a BEREC report (BEREC, 2012), most of the alleged net neutrality breaches are concentrated in two areas: data-intensive services and applications competing with ISPs' own services. This was also highlighted in Krämer et al. (2013): "*[...] there exist several examples of ISPs that have blocked voice over IP (VoIP) traffic which is in competition to their regular telephone service.*" Our focus is on this second category.

Let us consider, for instance, the first famous net neutrality breach, committed by Madison River, which we highlighted at the beginning of this introduction. After the blocking of Vonage, the FCC intervened, fined and made Madison River sign a consent decree to stop the throttling.[4] Exclusion was also the starting point of the net neutrality law in the Netherlands (International Telecommunications Union, 2012). In 2010, KPN, a Dutch ISP, started to develop a new strategy towards competing applications: users either had to pay to use Skype and WhatsApp or face blocking. The Dutch parliament reacted by enacting one of the first net neutrality laws in the world, effectively putting a halt to KPN's strategy. The reaction has not been so prompt in Spain where ISP Yoigo is still making mobile users pay for access to VoIP

of the internet and net neutrality.

[3]For an analysis of net neutrality as a case of missing prices (websites cannot use prices to regulate the usage of consumers because most websites are free), see Jullien and Sand-Zantman (2016).

[4]Federal Communications Commission, "*Consent Decree, Madison River Communications, LLC and affiliated companies,*" DA 05-543, 2005.

applications: users have to pay a fee for mobile data and an additional fee if they want to use VoIP. Yoigo's Swedish counterpart, Teliasonera, also tried to set the same pricing scheme but had to withdraw it after a public uproar (Grundberg, 2012). Hence, the intertwining of applications and of ISPs' own services is a major issue. When Yoigo applies a surcharge for VoIP applications, it respects NN_1 but not NN_2. When Madison River excludes Vonage, it respects neither NN_1 nor NN_2.

To better understand the issue, we build a model that focuses on the interaction of two markets: that for a communication-based service[5] ("the phone") and that for internet-based services ("the internet"). The ISP has an installed network and offers internet and phone services to consumers. An alternative firm competes on the communication market by offering some VoIP software to internet users. Consumers are thus offered three products: the internet, the phone and the VoIP application (hereafter "the app" or "the application").

Our model has four specific features. First, the app and the phone are both horizontally and vertically differentiated substitutes. Second, the app needs the internet to work but the phone does not. The internet and the app are therefore one-way essential complements (Chen and Nalebuff, 2006) and the incentives of the ISP are complex because the app is complementary to one of its products but is a substitute to another. This separates our set-up from more traditional vertical foreclosure models Rey and Tirole (2007). Third, the price of the app is exogenous. Finally, consumers' valuations for the internet are heterogeneous. Network congestion is not explicitly incorporated in the model but the possibility for the ISP to degrade the quality of the competing app may be interpreted as network congestion, e.g. through a lower bandwidth or a higher jitter/delay.

This paper is organized around three questions. First, does an ISP have incentives to exclude a competing application? Second, should it charge a premium to consumers to use the app? Last, is net neutrality welfare improving? Each question is considered in a monopolistic and a duopolistic

[5] We have picked this service for illustrative purposes but we could also have chosen Netflix and TV, Spotify and music services, WhatsApp and SMS, etc.

setting, i.e. competing ISPs. These questions are studied in a framework where the zero-price rule is always enforced, which is presumably the most appropriate set-up to analyze incentives to exclude the app. If the app is available in our setting, it will a fortiori also be available if the zero-price rule is relaxed and ISPs can extract revenue from CPs.

We show that a monopoly ISP will not exclude the app if it is a superior alternative to its own product. In this case, the value added by the app can be extracted through a higher internet price and it more than compensates the competition on the communication market. If the app is an inferior alternative, exclusion is a concern although not a systematic one. And, if the ISP can apply a surcharge for enabling the app, exclusion will never occur. Finally, we show that prohibiting such surcharges is not beneficial to the firm and, more surprisingly, can also hurt consumers. Therefore in a monopoly setting, implementing net neutrality rules can hurt welfare.

When several ISPs compete, we first show that it is not possible to have, in equilibrium, exclusion of the app by both ISPs. Complete exclusion of the app therefore is not an issue in duopoly. With competition between ISPs, offering the app is a way for firms to differentiate their products and, should one firm exclude the app, the other has no incentives to do so. Indeed, this other firm can escape fierce competition from the rival ISP by offering an improved product –the internet with the app. This product is a source of profit if the firm can sell it at a premium, i.e. if the firm can apply a surcharge for the use of the app.

We then characterize the equilibrium under competition, considering both symmetric and asymmetric ISPs. ISPs are symmetric when they both offer the phone; they are asymmetric when only one offers the product competing with the app. We first show that both firms offering the app without surcharge is a Nash equilibrium only in the symmetric case but this equilibrium is not unique. There also exist equilibria with a fragmented internet where the app is only made available at one ISP. In the asymmetric case, only fragmented internet equilibria exist. Consumer surplus is always highest when both ISPs comply with NN_1 and NN_2. On the contrary, firms have a higher profit in a fragmented internet. Consumers and firms have –in contrast to the monopoly case– different interests with regard to net neutrality obligations. Regarding total welfare, we show that in the symmetric case, welfare is highest when net neutrality is enforced but this may not be true in the asymmetric case.

Net neutrality, NN_1 and NN_2, can thus be seen as a “competition intensifier” which sometimes works well –as in the symmetric duopoly case– but sometimes hastens the pace too much –as in the monopoly and the asymmetric duopoly case. We therefore conclude that net neutrality should not be seen as a one-size-fits-all rule and that having a fragmented internet where apps are only available at some ISP does not necessarily hurt welfare. Regarding exclusion, an ex-post regulation assessing breaches case by case may thus be preferable to imposing a strong ex-ante rule on all market participants.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the basic model. In Section 4, we analyze the case of a monopolistic ISP. Section 5 extends the model to include competition between ISPs. Section 6 concludes. All omitted proofs are in the Appendix.

2 Literature review

The theoretical foundation of our approach is the literature on one-way essential complements initiated by Chen and Nalebuff (2006). They study the competition (à la Bertrand) between one-way essential complements, i.e. two goods that are complements but where one is essential for the other to be useful. We reach two conclusions that are reminiscent of theirs. First, they show that if the firm producing the essential good (A) can enter the other firm’s (B) market, and product B’s value is not too high, A will give away a substitute to product B and raise the price of A. In most cases, this resembles the equilibrium in our monopoly set-up: the monopolist has an interest in raising the price of the internet rather than that of the phone, the major difference being that, because of differentiation, prices will still be positive. Second, they find that if it has the choice, firm A will always set one price for a version of A compatible with B and another (lower) price for an incompatible product. We find a similar result: the price for a version of the internet which is compatible with the app is always higher than the price for a version that is not compatible. The reason is intuitive: the higher price is a way for the owner of the essential good to extract surplus from the presence of the competing product.

We adjust our model to better reflect the realities of the market we examine. We assume that the second good owned by the ISP does not need the internet to work, and therefore does not suffer when the price of the internet is raised. Also, we model competition between non-essential goods in a Hotelling framework. Finally, we extend their set-up to include competing ISPs, or in their terminology, competing essential goods.

By relating our model to the net neutrality literature,[6] we are able to compare our results to articles that examine the issue of net neutrality and vertical integration (Dewenter and Rosch, 2016; Guo et al., 2010; Brito et al., 2014; Fudickar, 2015). Compared to these articles, our major contribution is to highlight the link between the one-way essential complements literature and net neutrality. Instead, the main driver of most of that literature seems to be the competition for advertising revenues.

Dewenter and Rosch (2016) consider the incentives of a monopoly ISP, integrated with a CP, to exclude competing CPs from its network in a two-sided model where CPs compete for advertisers and their content is free. They show that a monopolistic ISP may find it profitable to exclude the rival's content if there is (i) little product differentiation on the content market and consumers only value differentiated products (ii) limited network externalities from consumers to advertisers and (iii) strong network externalities from advertisers to consumers.[7] In that case, the competitor steals a large fraction of the ISP's business on the advertising market because contents are close substitutes. This effect cannot be compensated by higher access fees since consumers do not obtain much value from the additional content because contents are very homogeneous, i.e. the competition effect on the advertising market is less than compensated by the complementarity effect. Thus, the

[6] See Schuett (2010), Krämer et al. (2013) and Greenstein et al. (2016) for literature reviews.

[7] There are other cases where exclusion can happen in their model but we do not comment on them since they only arise under extreme assumptions, e.g. if content is perfectly homogeneous and the ISP's users do not use the services of the competing app.

ISP finds it profitable to limit competition by excluding contents. The major divergence with us, besides the fact that we also consider a duopoly of ISPs, is that in our model when the competitive pressure exerted by the rival app is intense, its value to users is also high and therefore there exist possibilities to monetize the app. Still, exclusion is a concern both in the monopoly case, when price discrimination is limited by net neutrality rules, and in the duopoly case.

Guo et al. (2010) and Brito et al. (2014) consider, respectively, the case of a vertically integrated monopolist competing with another CP, and a two ISP-two CP situation where one of the ISPs is integrated with one of the CPs. Each ISP can offer a fast lane, against payment, to CPs. The leading factor in both papers is the heterogeneity in ad revenues that CPs can generate. Hence, the identity of the integrated CP matters. Both articles show that net neutrality is not always respected by ISPs but that it is not true that they always have incentives to discriminate competing applications. ISPs could even discriminate *against* their own CP if the advertising revenue difference is sufficiently strong, in order to extract more from the competing CP. Both articles also show that vertical integration is not *per se* bad for welfare.

Taking a slightly different point of view, Fudickar (2015) looks at the effect of vertical integration on prioritisation in the absence of advertising rents. Even if the integrated ISP favours its CP to reduce the congestion it faces, consumers are always unambiguously better off with the prioritisation regime. However, welfare may decrease because of the loss in profit of the non-integrated CP.

That one-way essential complements are an intrinsic part of the internet is indisputable. The major difference with the previous studies (Guo et al., 2010; Brito et al., 2014; Fudickar, 2015; Dewenter and Rosch, 2016) is that we consider competition with a good (the phone) that does not require the essential good (the internet) to work while they consider competition between goods that all require the essential good. This leads to two important differences which impact exclusion incentives. First, except for Fudickar (2015), in these articles the integrated ISP or ISPs compete with other CPs for advertising revenues. Because the phone is not financed through advertising, competition is mostly concentrated on the consumers' side. Second, because the app is a one-way complement while the phone is not, if the price of the internet increases, it directly affects the application but not the phone.

Our contribution also differs from the standard literatures on vertical foreclosure (Rey and Tirole, 2007) and on access pricing (Laffont and Tirole, 1994; Armstrong, 2002). First, it is different because of the specifics of net neutrality and the situation. We assume that the zero-price rule is enforced and thus that the "access charge" for the downstream entrant is 0. Also, the ISP's downstream product (the phone) does not require the use of the upstream product to function (the internet), and the consumers value the upstream good even in the absence of the downstream products. Second, our contribution differs because of the modelling strategy: competition on the downstream market is imperfect and (downstream) products are differentiated horizontally *and* vertically.

Kourandi et al. (2015) study the problem of internet fragmentation whereby some applications are only available through a particular ISP because of bilateral exclusivity contracts, and not on the internet as a whole. They build a two ISP-two CP model where there are two forces at play. On the one hand, CPs want to be available at both ISPs to maximize exposure and to increase advertising revenues. On the other hand, if both ISPs are available at an ISP, they compete for advertisers and prices for ads go down. They show that the zero-price rule cannot always prevent fragmentation, for instance if competition leads to very low ad prices, and that having no fragmentation is always beneficial to consumers but not always to total welfare. These two conclusions are in line with ours but for different reasons. In our case, fragmentation is not driven by advertising revenues but by the will to differentiate product lines to reduce competition. The consumer surplus result, in their case, arises because (i) consumers enjoy the joint consumption of CPs' contents more than they enjoy the consumption of the content of a single CP and (ii) competition between ISPs does not allow them to increase prices too much in case of no fragmentation. In our model, consumer surplus is always highest under no fragmentation, although consumers do not consume the phone and the app at the same time, because competition between ISPs leads to lower prices. Finally, their welfare result depends on advertising competition: if it is strong, ad prices –and hence ad revenues– may decrease so much that welfare decreases. In our setting, welfare may decrease because no fragmentation may lead to a situation where consumers are not matched with the right good, i.e. that which is closest to their location.

D'Annunzio and Russo (2015) also study fragmentation under the prism of competition for ads. Their crucial insight is that the decreasing marginal value of advertising may lead ISPs to fragment the internet to protect "their" CP from ad competition and be able to extract more revenue from it. They also obtain, as we and Kourandi et al. (2015) do, that the zero-price rule is not always sufficient to prevent fragmentation.

Finally, this work is related to studies on exclusivity in two-sided markets (Hagiu and Lee, 2011) and to the literature on access provision (e.g. Lewis and Sappington, 1999) in the telecommunications sector (e.g. de Bijl and Peitz, 2004, 2009, 2010). In particular, de Bijl and Peitz (2010) consider the case of an integrated ISP selling both the phone and VoIP, and a VoIP competitor. Their conclusion is that the incumbent might choose to underinvest in VoIP quality –even though it also affects its own VoIP business– so that the competitor cannot enter because it will not be able to set a high enough price to recover its entry cost. Note that a major difference with our model is that they do not examine peer-to-peer VoIP, and hence for each call the VoIP application has to pay a termination fee to the ISP.

3 Model

There are three products –the internet, the phone and the app– which cater for the demand of consumers for two services: internet-based services (the internet) and communication-based services (the phone and the app). The application and the internet are one-way essential complements: the app cannot be used without the internet but the internet and the phone can be used on their own. The internet and the phone are offered by a monopolistic residential ISP: we relax this assumption in Section 5 where we introduce competing ISPs. The app is made available on the internet. It is financed through exogeneous means such as advertising or a given price paid by consumers. In the latter case, the gross utility of the app, u^a (see *infra*), should be understood as a net utility. The only assumption needed is that the owner of the application does not pass-through internet price variations to consumers. In line with this assumption, despite very different prices for the internet, there is a single price for WhatsApp worldwide. We note that since we consider a single app and there are no network externalities, our model is not two-sided. Production costs are all normalized to zero.

The app and the phone are both horizontally and vertically differentiated substitutes. With respect to vertical differentiation, all consumers obtain gross utility $u^a \in [0,1]$ if they consume the app and $u^t \in [0,1]$ if they consume the phone. Consumers are therefore homogeneous with regard to the utility provided by the app and the phone. They also single-home: they use either the app, the phone or nothing. While multi-homing may be pervasive in the VoIP/phone industry, it is less so for television/VOD[8] or SMS/WhatsApp.[9] Single-homing is the set-up where the competition exerted by the app is the strongest and, as for the zero-price rule, the worst case for not excluding the app.

The utility difference $\Delta u = u^a - u^t$ is our measure of vertical product differentiation. With respect to horizontal differentiation, the app and the phone are located at the extremes of a Hotelling line of size 1. A consumer located at x incurs a disutility τx when he consumes the app and a disutility $\tau(1-x)$ when he consumes the phone. Let τ be our measure of horizontal product differentiation.

Consumers have heterogeneous valuations $\theta \in [0,1]$ for the internet. Consumers are uniformly distributed on the unit square with the vertical axis measuring the consumers' heterogeneous valuations for the internet θ and the horizontal axis being the Hotelling line. The population size is normalized to

[8] The Wall Street Journal, "*Streaming Services Hammer Cable-TV Ratings*", 2015, avalaible at `http://www.wsj.com/articles/streaming-services-hammer-cable-tv-ratings-1426042713`

[9] Bloomberg, "*WhatsApp Shows How Phone Carriers Lost Out on* \$33 *Billion*", 2015, available at `http://www.bloomberg.com/news/articles/2014-02-21/whatsapp-shows-how-phone-carriers-lost-out-on-33-billion`

1.

To limit the number of cases to consider, we restrict the parameter set by assuming the following.

Assumption 1.

$u^a, u^t \geq 2\tau$

Assumption 1 guarantees that the market will be fully covered in the monopoly case without the app. It also implies that –when the app is enabled– a consumer switching to the app was a previous phone user. There is therefore no demand expansion when the app is available. Hence, the business stealing effect of the app is maximized, which is presumably the most appropriate case to study incentives to exclude. Note that this assumption implies $\tau \leq 1/2$ since we assumed $u^a, u^t \in [0, 1]$.

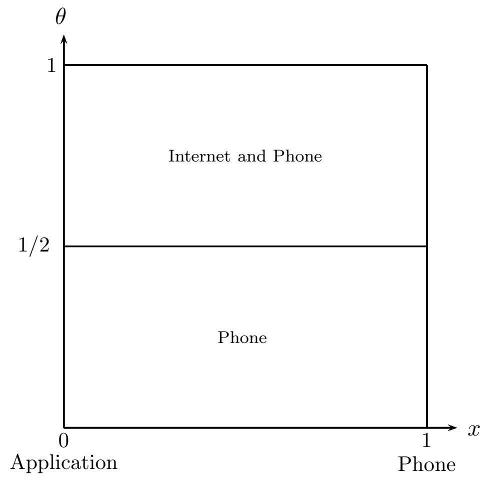
Let us denote the internet by i, the phone by t and the app by a. The consumer can choose between four combinations of goods, as consumers will not use the app and the phone together: (i, t), (i, a), (i), (t); they could also consume nothing $(\emptyset)$. The ISP offers the internet and the phone at prices $p_i \geq 0$ and $p_t \geq 0$, and consumers choose whether to subscribe to the services. The associated net utilities for a consumer located at (x, θ) are:

$$U(x,\theta) = \begin{cases} U(i,t) = \theta - p_i + u^t - \tau(1-x) - p_t, \\ U(i,a) = \theta - p_i + u^a - \tau x, \\ U(i) = \theta - p_i, \\ U(t) = u^t - \tau(1-x) - p_t, \\ U(\emptyset) = 0. \end{cases}$$

We ignore the possibility for the ISP to bundle the phone and the internet, but we will consider the possibility for the ISP to offer a version of the internet where the app is disabled. In that case, there are two prices for the internet: p_i without the app and $\tilde{p_i}$ with it. With a price surcharge, the utility $U(i, a)$ is:

$$U(i,a) = \theta - \tilde{p_i} + u^a - \tau x. \tag{1.1}$$

Figure 1.1: Monopoly ISP, app exclusion.



4 Monopoly ISP

In this section, we consider a monopolistic ISP. If the ISP offers the internet and the phone at prices $p_i \geq 0$ and $p_t \geq 0$, its profit is $\Pi = d_i p_i + d_t p_t$, where d_i and d_t are respectively the demand for the internet and for the phone.

4.1 Exclusion

Let us start with the case where the app is excluded by the ISP. The demand for the internet at price p_i is $d_i = 1 - p_i$ and the ISP's profit is maximized for $p_i^e = 1/2$ and $d_i = 1/2$. The demand for the phone at price p_t is $d_t = \min[(u^t - p_t)/\tau, 1]$. Under Assumption 1, the profit maximizing price is $p_t^e = u^t - \tau$ and the market is fully covered ($d_t = 1$). The total profit of the ISP is

$$\Pi^e = 1/4 + u^t - \tau. \tag{1.2}$$

Figure 1.1 represents consumers' product choices. Consumers with a high valuation of the internet buy both goods while those with a low valuation only buy the phone. As the transportation cost is low enough ($\tau \leq u^t/2$), all consumers buy (at least) one product.

4.2 No Exclusion

The impact of the app's entry on the ISP's profit is difficult to assess *a priori* because of two competing effects. On the one hand, there is a **complementarity** effect. Some users obviously benefit from the availability of the free app. This higher utility, or higher willingness to pay, can be extracted through a rise in the price of the internet, which will increase profit. On the other hand, the app's presence leads to a **competition** effect, whereby some consumers switch from the phone to the app. The impact of these two effects is *a priori* unclear as their relative importances are both linked to Δu. A higher Δu means that the app has relatively more value compared to the phone, amplifying both the competition effect (more consumers switch to the free app) and the complementarity effect (consumers are ready to pay more to use the internet). To assess the relative importance of these two effects, we first consider the case where the market is still covered when the app is available. This implies that the price of the phone satisfies $p_t \leq u^t - \tau$.

Lemma 1. *In a fully covered market situation,*

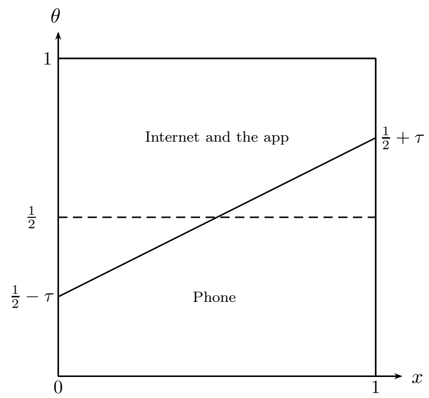
1. *If* $\Delta u \geq -\tau$ *or* $u^a > -\Delta u(2 + \Delta u)/4$*, the monopoly ISP charges prices* $p_i^{ne} = 1/2 + u^t - \tau + \Delta u/2$ *and* $p_t^{ne} = u^t - \tau$ *and realizes profit* $\Pi^{ne} = u^t - \tau + (1 + \Delta u)^2/4$.

2. *If* $\Delta u < -\tau$ *and* $u^a \leq -\Delta u(2+\Delta u)/4$*, the monopoly ISP charges prices* $p_i = 1/2$ *and* $p_t = -\Delta u - \tau > 0$ *and realizes profit* $\Pi^{ne2} = \frac{1}{4} - (\tau + \Delta u)$.

The two situations characterized by Lemma 1 differ substantially. In the first, the app, as compared to the phone, is either a superior or, at least, not a too inferior product. In the second situation covered by Lemma 1, the value of the app, relative to that of the phone, is so low that the ISP chooses prices such that no consumer purchases the application. The market configuration is similar to the exclusion case. As this scenario adds nothing to the discussion, we henceforth ignore it and we focus on the situations where the app is sufficiently valuable for the consumers.

Assumption 2. $\Delta u \geq -\tau$ *or* $u^a > -\Delta u(2 + \Delta u)/4$.

Figure 1.2: Rebalancing prices to exactly offset the app's entry for $\Delta u = 0$



4.3 Comparisons

In the covered market case, the price of the phone is left unchanged compared to the situation where the app is not available, implying that $u(i, a) > u(i, t)$ for all x. Thus, all internet users choose the free app rather than the phone, which reduces the ISP's profit (competition effect). Yet, the internet has more value as it enables the free app. The ISP is therefore able to compensate its losses on the phone market by rebalancing its prices to extract the extra surplus due to the app's entry. If the app and the phone are not vertically differentiated ($\Delta u = 0$), the ISP increases the price of the internet by $u^t - \tau$, which is exactly the price of the phone. In that case, the losses due to the competition effect are perfectly compensated by the extra surplus extracted via the complementarity effect.[10] Figure 1.2 illustrates this case. If the app is more valuable than the phone ($\Delta u > 0$), the internet price rises even more and the complementarity effect more than compensates the competition effect.

Proposition 1. *If $\Delta u \geq 0$, app exclusion is not a profitable strategy for the ISP.*

[10] Note also that by increasing the price of the internet, the ISP reduces competition on the voice market. Indeed, because the app and the internet are one-way essential complements, a rise in the price of the essential good is similar to one in the price of the non-essential product.

Proof. Suppose that the ISP sets the prices according to part 1 of Lemma 1 ($p_i = p_i^{ne} = 1/2 + u^t - \tau + \Delta u/2$, $p_t = p_t^{ne} = u^t - \tau$). Then, its profit is $u^t - \tau + (1 + \Delta u)^2/4$ which is higher than $\Pi^e = 1/4 + u^t - \tau$ because $\Delta u > 0$. ■

When the app has less value than the phone ($\Delta u < 0$), incentives to exclude depend on the market being covered or not. In a covered market, it is clear that the profit is smaller than Π^e but this is not necessarily the case if the market is not covered. We therefore proceed in two steps. First, we derive the condition for a covered market at equilibrium. In particular, it can be shown (see the Appendix) that if $\Delta u \leq \Delta \bar{u} = \frac{(1-2\tau)u^t - \tau(3-2\tau)}{u^t - \tau}$ the market will be covered. Second, we use a numerical example to illustrate that, if the market is not covered and $\Delta u < 0$, app exclusion is not always the preferred option.

Proposition 2. *If $\Delta u \leq \Delta \bar{u}$, the market is fully covered at equilibrium and the equilibrium prices are (p_i^{ne}, p_t^{ne}), giving a profit of Π^{ne}. If this condition is not satisfied, the market is not fully covered at equilibrium, $p_t > u^t - \tau$ and $\Pi > \Pi^{ne}$.*

Propositions 1 and 2 are summarized in Figure 1.3. To sum up, if $\Delta u \geq 0$, exclusion never arises. If $\Delta u < 0$ and $\Delta u < \Delta \bar{u}$, the market is covered at equilibrium and the ISP's profit is higher when it excludes the app. Last, for $\Delta \bar{u} < \Delta u < 0$, the market is not covered at equilibrium and exclusion is not systematic. The equilibrium analysis of this case ($\Delta \bar{u} < \Delta u < 0$) is rather involved and we use a numerical example to illustrate the incentives to exclude the app. Suppose that $\tau = 1/4$ and $u^t = 3/4$. Without the app, the profit is equal to $\Pi^e = 3/4$. Let us consider two values for $u^a < u^t$: 0.74 and 0.70 with, in both cases, $0 > \Delta u > \Delta \bar{u} = -1/2$. Equilibrium prices, demands and the corresponding profits are reported in Table 1.1. From the example, it is clear that exclusion is not profitable for $u^a = 0.74$ as the ISP manages to compensate the competition effect with higher prices even if the app has (slightly) less value than the phone. For the lower value of u^a, the ISP's profit is higher with exclusion. The competition effect is too strong and the ISP cannot compensate through price rebalancing.

Figure 1.3: Graphical Summary of Propositions 1 and 2

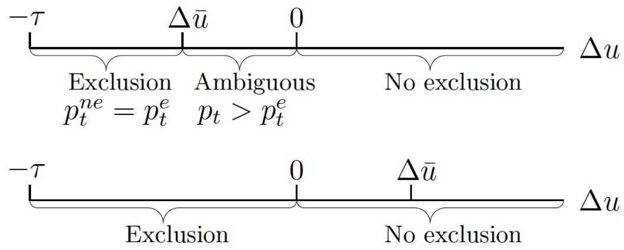


Table 1.1: Numerical simulations for $\Delta u < 0$: $u^t = 0.75$ and $\tau = 0.25$.

	$u^a = 0.74$	$u^a = 0.70$
p_i	0.98	0.96
p_t	0.56	0.55
d_i	0.56	0.53
d_t	0.37	0.39
Π	$0.76 > \Pi^e$	$0.73 < \Pi^e$

4.4 Price surcharge

An alternative for the ISP to monetize the app is to apply a surcharge to internet subscribers using the app. We show that selling two versions of the internet, one where the app is enabled at price $\tilde{p}_i$ and one where it is disabled at price p_i, increases consumer segmentation and hence profits. Thus, a monopoly ISP has no incentive to exclude a competing app, regardless of the quality differential, i.e. with a price surcharge, exclusion is not an issue for all values of Δu.

Proposition 3. *With a price surcharge, the ISP always realizes a profit weakly higher than the exclusion profit* Π^e.

Proof. Suppose that the monopolist applies the following prices: $p_t = u^t - \tau$, $p_i = 1/2$ and $\tilde{p}_i = 1/2 + u^t - \tau$, i.e. the phone price and the internet prices are equal to p_t^e and p_i^e, the surcharge is equal to the phone price: $\tilde{p}_i = p_i^e + p_t^e$.

At these prices, the market is fully covered with all consumers using either the phone (with or without internet) or the app (with internet at price $\tilde{p}_i$).

To prove Proposition 3, it suffices to show that the number of consumers buying one version of the internet is at least as high as in the exclusion case (where $d_i = 1/2$). In the Appendix, we show that it is the case for the whole parameter space. Therefore, with a price surcharge for the internet, the profit is always higher or (in the worst case) equal to Π^e and app exclusion is never a profitable strategy. ■

Proposition 3 shows that a price surcharge for the internet with the app is preferred to app exclusion as the surcharge reduces competition and allows the ISP to extract part of the surplus created by the app. In particular, the ability to set two different prices for the internet enables the ISP to better extract surplus from the different types of consumers, i.e. to price discriminate.

4.5 App exclusion and the net neutrality debate

Does net neutrality improve welfare and consumer surplus? To investigate this question, we focus on the covered market situation for which the welfare analysis remains tractable. In that case, $p_t = u^t - \tau$. Let us start by examining the optimal behaviour of the firm if it is able to set three prices. We know from Proposition 3 that a price surcharge is always more profitable than exclusion. The next Proposition compares profits in the no-exclusion case if the monopolist can set two or three prices.

Proposition 4. *Suppose that the market is covered ($p_t = u^t - \tau$). With a price surcharge, the ISP always realizes a profit weakly higher than Π^{ne}. If $-\tau < \Delta u < \tau$, profit is strictly higher.*

Proof. The proof is similar to that of Proposition 3. First, we know that the possibility to use three prices never lowers profit because in that case, the monopolist can simply set $\tilde{p}_i = +\infty$ and revert to the two price situation. Second, suppose that $\tilde{p}_i = p_i^{ne}$, $p_i = p_i^{ne} - p_t^{ne}$ and $p_t = p_t^{ne}$. At these prices, the market is covered ($p_t^{ne} = u^t - \tau$) and the prices of the bundles (i, a) and (i, t) are identical. At these prices, the consumer indifferent between (i, t) and (i, a) is located at $\tilde{x}_1 = \frac{\Delta u + \tau}{2\tau}$. For a price surcharge, with these prices, to be (strictly) profitable, we need $0 < \tilde{x}_1 < 1$, which implies $-\tau < \Delta u < \tau$.

With a price surcharge, consumers in $[\tilde{x}_1, 1]$ buy the internet and the phone if $\theta \geq 1/2 + \Delta u/2$ while with two prices, they buy the internet and the app if $\theta(x) \geq 1/2 + \Delta u/2 - \tau(1-2x)$. Consumers located in in $[\tilde{x}_1, 1]$ have a higher demand for internet when the ISP uses a price surcharge, while consumers in $[0, \tilde{x}_1]$ have the same demand.

Formally, denoting demand for the internet in the two price case, for the internet with the app and the internet with the phone in the three price case as, respectively, d_i, d_{ia} and d_{it}, we have that, if $\tilde{p}_i = p_i^{ne}$, $p_i = p_i^{ne} - p_t^{ne}$ and $p_t = p_t^{ne}$ and $-\tau < \Delta u < \tau$:

$$d_i < d_{it} + d_{ia}. \tag{1.3}$$

■

Therefore, condition NN_2 –no price surcharge to use the app– will not be voluntarily enforced by a monopoly ISP under the assumption that $-\tau < \Delta u < \tau$, i.e. so long as the app and the phone are not very strongly differentiated. Otherwise, the monopolist is indifferent to the price surcharge. If $-\tau < \Delta u < \tau$, the ISP has incentives to perform financial-based discrimination between contents. On the other hand, if it can impose a surcharge, then content-based discrimination (condition NN_1) is not a concern. If the ISP cannot apply a price surcharge, incentives to exclude depend on the relative value of the app and the phone to consumers. If $\Delta u \geq 0$, the ISP will not exclude the app (Proposition 2). If $\Delta u < 0$, app exclusion might be a concern depending on parameter values (see Table 1.1 for an example). In a nutshell, if $-\tau < \Delta u < \tau$, net neutrality requirements *always* constrain the behaviour of a monopolistic ISP.

By changing the price structure but not the price level, the monopolist can better segment the consumers and manages to increase demand for the internet without having to decrease its prices and consequently, its profit increases. With prices $\tilde{p}_i = p_i^{ne}$, $p_i = p_i^{ne} - p_t^{ne}$ and $p_t = p_t^{ne}$, consumer surplus also increases because some consumers start buying the internet (demand expansion effect) and consumers are better segmented, which therefore decreases transportation costs. However, the following Lemma establishes that the impact of a price surcharge on consumer surplus is difficult to assess because prices $\tilde{p}_i = p_i^{ne}$, $p_i = p_i^{ne} - p_t^{ne}$ are not optimal.

Lemma 2. *In the covered market situation ($p_t = u^t - \tau$), compared to the case where $\tilde{p}_i = p_i^{ne}$, $p_i = p_i^{ne} - p_t^{ne}$, the profit of the monopolist decreases if it sets (both):*

1. $\tilde{p}_i < p_i^{ne}$,

2. $p_i < p_i^{ne} - p_t^{ne}$.

Proof. See the Appendix. ■

This Lemma adds another difficulty to the assessment of the effect of a price surcharge on consumer surplus: at least some, perhaps all, internet users will face higher prices. This, however, has to be balanced with the improved matching. Some consumers who used to buy the phone or the internet with the app can now switch to the internet with the phone. Depending on the values of the parameters, any of the effects can prevail. As the example in Table 1.2 shows, even in the case where all consumers face higher prices, consumer surplus (and profit) can still increase because of the better matching. Firms' and consumers' interests may thus sometimes be aligned *against* net neutrality.

Table 1.2: Numerical simulations for $u^a = 0.31$, $u^t = 0.3$ and $\tau = 0.04$.

	Three Prices	Two Prices
p_t	0.26	0.26
p_i	0.507	0.765
$\tilde{p}_i$	0.768	/
Π	0.518	0.515
CS	0.152	0.146
W	0.67	0.661

From this example, it appears that net neutrality may intensify competition (prices decrease) but leads to an inefficient repartition of consumers (a transport cost increase) which, in this case, reduces consumer surplus. We will reach a similar conclusion in Section 5.2.

4.6 Sabotage vs. app exclusion

We have so far considered that, to reduce competition on the app/phone market, an ISP has no alternative but to exclude the app or to ask for a price surcharge. Another strategy to reduce competition is to sabotage the rival app by diminishing its quality. With the development of high bandwidth applications and content, the internet is becoming more and more congested and traffic management by ISPs is a growing concern, especially because net neutrality rules aim at prohibiting discrimination between contents. In this context, an ISP can reduce a rival product's quality either by slowing down traffic delivery or by increasing jitter/delay. This is particularly a concern when (1) the app provides time-sensitive or bandwidth-intensive content such as real-time audio/video streaming or VoIP services and (2) when this content competes with the ISP's own services.

Sabotage in the context of our model can be modeled as lowering the utility of the app u^a. Let us consider the covered market case ($\Delta u < \Delta \bar{u}$). Without exclusion, the ISP's profit is Π^{ne} and this profit unambiguously increases with u^a:

$$\frac{\partial \Pi^{ne}}{\partial u^a} = \frac{1 + \Delta u}{2} > 0. \tag{1.4}$$

This means that downgrading the rival app is not a profitable strategy. On the contrary, a higher app quality always benefits the ISP when the app is enabled. The recent deal between Comcast and Netflix whereby Netflix agreed to pay to be *directly* connected to Comcast's network illustrates our point. The agreement may be beneficial to Comcast even in the absence of any payment because it increases the value of Netflix through the improved connection, which is equivalent to an increase in u^a.[11]

Finally, if we are in the parameter space where, without surcharge, the ISP would exclude the app with certainty ($\Delta u < \Delta \bar{u} < 0$) but exclusion is

[11] See for instance The Wall Street Journal, *"Netflix to Pay Comcast for Smoother Streaming"*, 2014, available at `http://on.wsj.com/1ZdoCTx` or Dan Rayburn, *"Here's How The Comcast and Netflix Deal Is Structured, With Data and Numbers"*, 2014; available at `http://blog.streamingmedia.com/2014/02/heres-comcast-netflix-deal-structured-numbers.html`

not allowed, the ISP will not have incentives to degrade the quality of the rival app.

5 Duopoly

We now consider that there are two ISPs, ISP_1 and ISP_2, which compete à la Bertrand. We look at two different cases. In the first, the symmetric case, ISPs are both offering the internet and the phone. In the second, the asymmetric case, ISP_1 offers the internet and the phone while ISP_2 only offers the internet. Although the first case is more likely if we think of examples such as the phone and a VoIP app, the second aims at representing interactions of goods such as Netflix and ISPs' VOD products that are not offered by all ISPs.[12]

The internet offered by the ISPs is similar up to the availability of the app. Therefore, if both exclude or both admit it, the internet is considered by consumers as a homogeneous product. It is only when the application is available at one ISP and not at the other that the internet has two different versions. The same holds for the phone: it is a differentiated product with regard to the app but consumers see no difference between the phone offered by ISP_1 and that offered by ISP_2.

The reason why the contrast between the two cases is interesting is related to the complementarity and competition effects of the previous section. In the symmetric case, competition on the phone and the internet markets already exists, and admitting the app does not create additional competition. Only the complementarity effect remains, but for that, only one ISP should offer the app, otherwise all benefits would be dissipated by competition, fully in the case of Bertrand competition and partially in the case of less extreme competition, e.g. if ISPs have different bandwidth capacities. In contrast, in the asymmetric case, only one ISP offers the phone and admitting the app still creates competition. Both the complementarity *and* the competition effect remain present and incentives to admit the app are more ambiguous.

[12] The ISPs may decide in a previous stage on the bundles of services they want to offer. Our two structures can thus be endogenized.

We use the concept of *fragmented internet* (Kourandi et al., 2015) to refer to a situation where the application is available at one ISP but not at the other. Therefore, there is *no fragmentation* if the application is admitted by both ISPs. Our NN conditions are closely linked to fragmentation: fragmentation implies that one ISP does not respect NN_1 or in other words, that one ISP has some exclusive content, the application.

Finally, note that in this section, we only use Assumption 1.

5.1 Symmetric ISPs

We first consider two symmetric ISPs –each ISP offers the internet and the phone– competing à la Bertrand. We assume that consumers are one-stop shopping: they cannot buy the internet at one ISP and the phone at the other. The game is played in the following way:

1. ISPs decide to exclude or admit the application,
2. ISPs set the prices for the internet (p_i), the internet with the app ($\tilde{p}_i$) and the phone (p_t).

Let us start with the analysis of the second stage of the game. If both ISPs adopt the same policy towards the app –exclusion or no exclusion– they are perfectly symmetric, Bertrand competition leads to marginal cost pricing and profits are zero. All consumers are buying the internet and, if the app is available, consumers choose their preferred voice solution, the app for the consumers located at $x \in [0, 1/2 + \Delta u/2\tau]$ and the phone for consumers located at $x \in [1/2 + \Delta u/2\tau, 1]$. If the app is not available, all consumers buy the phone.

But homogeneity is not a definitive curse: one ISP could exclude the app from its network. In this case, the internet with the app is only offered by one firm. Still, the internet without the app and the phone are offered by the two firms leading to $p_i = p_t = 0$. The firm offering the app chooses a surcharge equal to $\tilde{p}_i = \tau/2 + \Delta u/2$, consumers located at $x \in [0, 1/4 + \Delta u/4\tau]$ buy the app and the ISP realizes a profit equal to $(\tau + \Delta u)^2/8\tau$.

Table 1.3: Pay-off Matrix in the Symmetric Case

		ISP 2	
		Admitting	Excluding
ISP 1	Admitting	0, 0	$\frac{(\tau+\Delta u)^2}{8\tau}$, 0
	Excluding	0, $\frac{(\tau+\Delta u)^2}{8\tau}$	0, 0

Through this exclusion, the ISP creates differentiated internet products catering to different consumers. One could see these products as a "high-quality" internet with the app and a "low-quality" internet without the app. Admitting the app enables the ISP to sell the internet with the app at a positive price, $\tilde{p}_i = \tau/2+\Delta u/2$, yielding a positive profit. Notice that because $p_i \neq \tilde{p}_i$, the ISP offering the app only complies with the NN_1 condition while the other ISP complies with none.

The above results are summarized in the pay-off matrix in Table 1.3. The details of the computations are relegated to the Appendix.

Let us turn to the first stage of the game. Except if $\Delta u = -\tau$,[13] it is clear that there are three possible Nash equilibria: one where both firms admit the app and offer it for free, and two where only one firm admits the app and offers it at a premium price while the other excludes it. Thus, as in the monopoly case, the application will not be completely excluded. It is however possible that the internet becomes fragmented with only one ISP offering the app. Intuitively, if one ISP excludes the app, the other can offer a differentiated product, thereby making positive profits by charging a positive price for this good. Compared to the monopoly case, there is no longer a competition effect created by the app, as competition already exists on the phone market. Only the complementarity effect and the possibility to monetize the value created by the app remain. This possibility only exists if there is reduced competition, i.e. if only one firm offers the app. Therefore, total exclusion is not an equilibrium.

[13]We ignore this particular case from here on.

Moreover, net neutrality may be enforced in equilibrium even without regulation or government intervention because "admit" is a weakly dominant strategy for both ISPs.

Proposition 5. *If two symmetric ISPs compete à la Bertrand, there are two classes of equilibria: one where the internet is not fragmented and both firms respect* NN_1 *and* NN_2*, and another where the internet is fragmented and one firm respects* NN_1 *while the other excludes the app and therefore respects neither* NN_1 *nor* NN_2*.*

Computing the consumer surplus and social welfare effects of each class of equilibrium, we show that:

Proposition 6. *Consumer surplus and welfare are highest under the equilibrium where both firms admit the application, i.e. when both* NN_1 *and* NN_2 *are respected.*

Imposing the net neutrality conditions is pro-competitive in the sense that this drives all prices down to marginal cost. Consumers choose their preferred voice solution. Because of the low prices and the better matching, consumer surplus is highest in that situation. Therefore, net neutrality is always pro-competitive and welfare enhancing in this case. We will see that this result may not hold if ISPs are asymmetric.

5.2 Asymmetric ISPs

Let us now suppose that ISP_1 sells the phone and the internet while ISP_2 only sells the internet. First, because of the asymmetric situation, ISP_1 has the upper hand: whatever ISP_2's choice, ISP_1 will always get a positive pay-off because it has one differentiated good, the phone. Second, the only way for ISP_2 to have a positive pay-off is to offer the app when ISP_1 excludes it. The equilibrium in the pricing game is represented by the pay-off matrix in Table 1.4.

Proposition 7. *If two asymmetric ISPs compete à la Bertrand, the only pure Nash equilibria are those with fragmentation.*

Table 1.4: Pay-off Matrix in the Asymmetric Case

		ISP 2	
		Admitting	Excluding
ISP 1	Admitting	$\frac{(\tau-\Delta u)^2}{8\tau}$; 0	$\frac{u^a+u^t}{2} - \frac{\tau}{2}$; 0
	Excluding	$\frac{(3\tau-\Delta u)^2}{18\tau}$; $\frac{(3\tau+\Delta u)^2}{18\tau}$	$u^t - \tau$; 0

The first important result is that the application is never *completely* foreclosed from the market, i.e. at least one firm will always admit it. The reason is simple: the only chance for ISP_2 to obtain a positive profit is to admit the app. In other words, NN_1 will always be respected by at least one ISP.

Second, the situation where both firms admit the app is not a Nash equilibrium and therefore, NN_1 and NN_2 are never respected by both ISPs. ISP_1 does not have incentives to admit the app if ISP_2 also does. The reason is that, on the one hand, admitting will not lead to a complementarity effect because Bertrand competition will drive the price of the internet with the app to zero. On the other hand, because the price of the internet with the app will be zero, competition on the voice market will be extremely strong and the price of the phone will have to decrease. Both effects have a negative impact on the profit of ISP_1 and it therefore has no incentive to admit the app if ISP_2 also does.

Regarding consumer surplus and social welfare, the main question is whether imposing NN_1 and NN_2, i.e. whether imposing the admit-admit situation, increases consumer surplus and welfare.

Proposition 8. *1. Consumer surplus is always highest when both firms admit the application, i.e. when NN_1 and NN_2 are respected.*

2. Consumer surplus and welfare are not necessarily highest in the same situation.

3. Imposing NN_1 and NN_2 can increase or decrease welfare.

The first part of Proposition 8 is intuitive. When both firms admit the app, $\tilde{p}_i = 0$ due to Bertrand competition. Therefore the only good with a positive price is the phone but that price cannot be too high because of the very strong competition coming from the app. Consumers benefit from these low prices. However, as in Section 4.5, they lose some surplus due to higher transportation costs (they consume disproportionately the free app). Overall, the former effect is always stronger than the latter.

While net neutrality is pro-competitive and beneficial to consumers, it does not always enhance total welfare. Indeed, the gain in consumer surplus due to the lower prices can be outweighed by the lower profit and the higher transportation costs.

5.3 Exclusivity

It can be shown that both in the symmetric and the asymmetric cases, the profit of an ISP is highest if it is the sole provider of the app. Therefore, ISPs may compete to obtain the exclusivity to offer the app. Exclusivity can be obtained either by paying the rival in exchange for a commitment to block the app or by signing an exclusivity contract with the app developer (as in Kourandi et al., 2015). Since they are always better off under the net neutrality/no-fragmentation equilibrium, this type of exclusivity agreement is always detrimental to consumers but may be good for total welfare if it increases sufficiently profits and does not reduce consumer surplus too much (Proposition 8). Kourandi et al. (2015) find similar conclusions (see p.12 for more details).

Though in principle the zero-price rule prohibits financial transfers between ISPs and CPs, and hence also exclusivity contracts, telecom operators in Belgium and in France have signed contracts with Netflix to include its VOD catalogue on their internet/TV box, thereby admitting subscribers to watch Netflix on their TV. For these operators, it can therefore be expected that the complementarity effect exerted by Netflix will more than compensate the losses created by an intensified competition.

6 Conclusion

Applications and content are one-way essential complements to the internet. This paper analyzes a classic issue: the incentives of a vertically integrated essential good provider to exclude competing content. While most of the literature focuses on competing complements –competition between content providers–, we analyze the incentives to exclude an essential complement when it competes with a substitute that does not need the internet to be consumed. Examples of such situations abound: video on demand and Netflix, SMS and messaging apps, telephone and VoIP, etc. This paper studies the important question of the welfare effect of applying net neutrality regulation in those situations. We reach two main conclusions. First, exclusion of the app is not an issue. In monopoly, the ISP will simply adapt its price structure to take advantage of the presence of the app. In duopoly, at least one ISP will always be willing to offer the app to differentiate itself from its rival. Second, net neutrality is a competition intensifier in that it reduces prices. Unsurprisingly, its application hurts ISPs. More surprisingly however, net neutrality can also hurt consumers. Indeed, despite lower prices, the matching between consumers and products may be less efficient when net neutrality is enforced. Therefore, the interests of firms and consumers may sometimes be aligned *against* net neutrality. It is interesting to note that this arises in the monopoly case and that competition leads to a divergence of the interests of ISPs and consumers.

These results are important from competition policy and regulatory points of view because they show that foreclosure only arises under specific circumstances and only if the monopolist's price instruments are restricted. This displays the importance of the appropriate regulatory regime, even if the access price (because of the zero-price rule) is zero.

For simplicity's sake, we have overlooked a number of important issues. First, our model is static and does not encompass investment issues. Imposing net neutrality through regulation may decrease profits so much that investment could plummet. This argument against net neutrality has been put forward in the literature by, for instance, Choi and Kim (2010). In the monopoly setting, so long as the investment needed to accommodate the app is not too costly, our results should not change. This is especially the case if the cost of accommodating the app is linked to its value, in which case the ISP could choose between investing or degrading. In the duopoly setting, investment could change the selection of equilibrium but should not affect our main conclusions. Indeed, so long as investment is not too costly, the only difference would be to make firms which are indifferent between admitting and excluding, because they earn zero anyway, lean towards exclusion. That would not change the outcomes in the asymmetric case but would make the net neutrality equilibrium less likely in the symmetric scenario.

Second, we have maximized the possibility of exclusion through multiple assumptions: the zero-price rule, the covered market and the single-homing. To derive more policy recommendations, it may be a good idea to relax these assumptions.

Finally, it might also be interesting to generalize the model to include network effects. Indeed, while a phone user can be reached via Skype and vice versa, a WhatsApp user cannot send a message to someone who does not own the application. Thus a fragmented internet might lower users' willingness to pay and the profits of ISPs, thereby modifying incentives to exclude.

7 Appendix

7.1 Proof of Lemma 1

To prove the Lemma, we derive candidate equilibrium prices for the covered market situation. To be covered, the following condition must be satisfied for all x: $u(t) \geq u(\emptyset)$, implying that $p^t \leq u^t - \tau$. We prove the proposition in two steps. First, we identify a candidate equilibrium where the market is fully covered and consumers buy the internet (with the app) *or* the phone. Second, we derive a candidate equilibrium where consumers can also purchase the phone with the internet.

Step 1. If $p_t \geq -\Delta u + \tau$, then by Assumption 1 $u(i,t) \leq u(i,a)$ for all $x \in [0,1]$. We will start our analysis by searching for candidate equilibrium prices satisfying $-\Delta u + \tau \leq p_t \leq u^t - \tau$. Under these conditions, the market is fully covered and consumers buy either the internet and the app or the phone. The firm's profit is given by:

$$\Pi = p_i d_i + p_t d_t.$$

Solving $u(i, a) = u(t)$, we identify those consumers who are indifferent between the two options.

$$\theta(x) = (p_i - p_t) - \Delta u - \tau(1 - 2x). \tag{1.5}$$

From this equation, we can identify two boundary values corresponding to the extremes of the Hotelling line: $\theta(0) = (p_i - p_t) - \Delta u - \tau$ and $\theta(1) = (p_i - p_t) - \Delta u + \tau$ that will be used to derive the demand functions. Four configurations (see Figure 1.4) for the demands need to be considered:

(a) $0 \leq \theta(0) \leq 1$ and $0 \leq \theta(1) \leq 1$,

(b) $0 \leq \theta(0) \leq 1$ and $\theta(1) \geq 1$,

(c) $\theta(0) \leq 0$ and $0 \leq \theta(1) \leq 1$,

(d) $\theta(0) \leq 0$ and $\theta(1) \geq 1$.

Note first that case (d) can be ruled out because the conditions for $\theta(0) \leq 0$ and $\theta(1) \geq 1$ to be simultaneously respected are respectively $(p_i - p_t) \leq \Delta u + \tau$ and $(p_i - p_t) \geq \Delta u + 1 - \tau$, which is impossible given $\tau < 1/2$. If $\tau = 1/2$, case (d) is just a boundary case of the others.

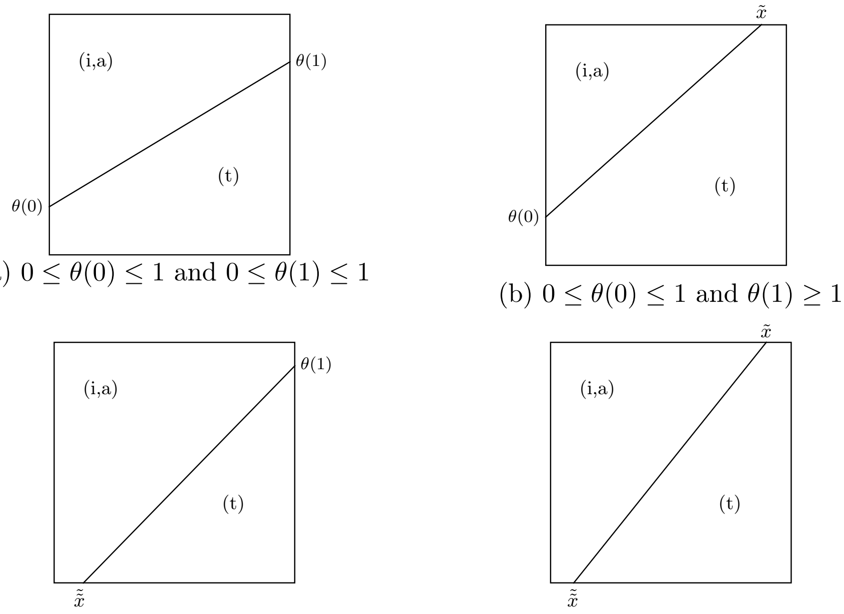
In case (a), the demands are given by:

$$d_i = \frac{(1 - \theta(0)) + (1 - \theta(1))}{2}, \tag{1.6}$$

$$d_t = 1 - d_i. \tag{1.7}$$

Profit maximizing prices are $(p_i, p_t) = (\frac{1}{2} + u^t - \tau + \frac{\Delta u}{2}, u^t - \tau)$ and Assumption 1 guarantees that at these prices $\theta(0)$, $\theta(1) \in [0, 1]$. The corresponding demands are given by $(d_i, d_t) = (\frac{1}{2} + \frac{\Delta u}{2}, \frac{1}{2} - \frac{\Delta u}{2})$ and the firm's profit is equal to $\Pi^{ne} = u^t - \tau + \frac{(1+\Delta u)^2}{4}$.

Figure 1.4: Configurations when $-\Delta u + \tau \leq p_t \leq u^t - \tau$



(a) $0 \leq \theta(0) \leq 1$ and $0 \leq \theta(1) \leq 1$

(b) $0 \leq \theta(0) \leq 1$ and $\theta(1) \geq 1$

(c) $\theta(0) \leq 0$ and $0 \leq \theta(1) \leq 1$

(d) $\theta(0) \leq 0$ and $\theta(1) \geq 1$

In case (b), $\theta(1) > 1$ and the demands are given by:

$$d_i = \frac{(1 - \theta(0))}{2}\tilde{x}, \tag{1.8}$$

$$d_t = 1 - d_i. \tag{1.9}$$

where $\tilde{x}$ is the consumer with the highest internet valuation $\theta = 1$ indifferent between (i, a) and (t):

$$\tilde{x} = \frac{1 + p_t - p_i + \Delta u + \tau}{2\tau}. \tag{1.10}$$

Profit-maximizing prices for this demand configuration are given by $(p_i, p_t) = (1 + u^a, u^t - \tau)$ resulting in a profit equal to $u^t - \tau$ which is lower than the profit in case (a).

In case (c), $\theta(0) < 0$ and the demands are given by:

$$d_i = 1 - d_t, \tag{1.11}$$
$$d_t = \frac{\theta(1)}{2}(1 - \tilde{\tilde{x}}). \tag{1.12}$$

where $\tilde{\tilde{x}}$ is the consumer with the lowest internet valuation $\theta = 0$ indifferent between (i, a) and (t):

$$\tilde{\tilde{x}} = \frac{p_t - p_i + \Delta u + \tau}{2\tau}. \tag{1.13}$$

Profit-maximizing prices for this demand configuration are given by $(p_i, p_t) = (u^a - 2\tau, u^t - \tau)$ resulting in a profit equal to $u^a - 2\tau$ which is lower than the profit in case (a).

There is thus a unique equilibrium candidate for this covered market situation: $(p_i, p_t) = (\frac{1}{2} + u - \tau + \frac{\Delta u}{2}, u - \tau)$.

Step 2.

At price $p_t = u^t - \tau$, we have $u(i, a) > u(i, t)$, for all x. To have $u(i, a) < u(i, t)$ for some x, p^t must decrease by at least $u^a - 2\tau$. This means that there is a discontinuity in the phone demand at $p_t = u^t - \tau$. For $p_t < -\Delta u + \tau$, the consumer indifferent between (i, a) and (i, t) is located at

$$x^* = \frac{1}{2} + \frac{\Delta u + p_t}{2\tau}. \tag{1.14}$$

From this, we can derive the demand functions. Two cases must be considered depending on whether $\theta(0)$ is positive or negative. Suppose first that $\theta(0) \geq 0$. Then, we have:

$$d_i = \frac{(1 - \theta(0)) + (1 - \theta(x^*))}{2}x^* + (1 - x^*)(1 - p_i), \tag{1.15}$$
$$d_t = 1 - \frac{(1 - \theta(0)) + (1 - \theta(x^*))}{2}x^*. \tag{1.16}$$

In Equation (1.15), the first term is the internet demand of consumers using the app; the second term is the internet demand of those buying the phone. Let us notice that in this case, $d_i + d_t \geq 1$.

The profit is equal to $p_t d_t + p_i d_i$. Taking the first order conditions of the profit-maximization problem, we can show numerically[14] that for all admissible parameter values satisfying $u^a, u^t \in [0,1]$, $\tau \leq \frac{1}{2}$ and Assumption 1, there is no interior maximum giving a higher profit than Π^{ne}. Then, the only possible solution is a corner solution where $u(i,a) \leq u(i,t)$ for all x. If no consumers are using the app, then the internet price is $p_i = \frac{1}{2}$ as there is no longer a complementarity effect. The phone price solves the equation $u(i,a) = u(i,t)$ for $x = 0$ giving $p_t = -(\Delta u + \tau)$. This solution is admissible if p_t is non-negative, requiring $-(\Delta u + \tau) \geq 0$. For this to be true, it is necessary for the phone to have more value than the app ($\Delta u < 0$). At these prices, $d_t = 1$ and $d_i = \frac{1}{2}$, giving a profit equal to $\Pi = \frac{1}{4} - (\tau + \Delta u)$. This profit is higher than the profit derived above if:

$$\frac{1}{4} - (\tau + \Delta u) \geq \Pi^{ne} \Rightarrow u^a \leq -\Delta u \frac{(2 + \Delta u)}{4}.$$

If this condition holds true, then the equilibrium prices in a covered market are $(p_t, p_i) = (-\Delta u - \tau, \frac{1}{2})$.

The corresponding profit is obviously lower than the profit with exclusion as the partition of consumers is the same but the price of the phone is lower.

Suppose now that $\theta(0) < 0$. In that case, demands and profit are:

$$d_i = (1 - p_i) + \left(\frac{x^* + \tilde{\tilde{x}}}{2}\right) p_i, \quad (1.17)$$

$$d_t = (1 - p_i)(1 - x^*) + \frac{(1 - \tilde{\tilde{x}}) + (1 - x^*)}{2} p_i, \quad (1.18)$$

$$\Pi = p_i d_i + p_t d_t. \quad (1.19)$$

[14] We proceed in the following way. We compute analytically the first-order conditions. Because the profit function is a cubic, the first-order conditions are quadratic in prices. This makes the analytical computation of the optimal prices particularly complex. Therefore, we proceed numerically. The software is fed numerical values and delivers optimal prices. We then check that, at these optimal prices, the relevant indifferent consumers are within their bounds (0 and 1) and therefore, that demands are positive and weakly smaller than 1. For many parameter values, this is not the case and the optimal prices are not admissible. Then, we have corner solutions. For other parameter values, we obtain admissible prices but they always lead to a lower profit than with $p_t = u^t - \tau$.

It is then easy to check using any standard mathematical software that the first-order conditions are never satisfied. Therefore, we have corner solutions. There are two possibilities. Either $x^* = 1$ but then no one consumes the internet and the phone together, and we are back to Step 1, or $\tilde{\tilde{x}} = 0$ and we are in the previous case where $\theta(0) \geq 0$.

7.2 Proof of Proposition 2

If the price of the phone is above $u^t - \tau$, then the market is no longer fully covered and consumers have three options: (i, a), (t) and $(\emptyset)$. Solving the equations $u(i, a) = 0$ and $u(t) = 0$, we have the indifferent consumers defined as:

$$\hat{\theta}(x) = p_i - u^a + \tau x,$$

and

$$\hat{x} = 1 - \frac{u^t - p_t}{\tau}.$$

Under the conditions $\hat{\theta}(0) \in [0, 1]$, $\theta(1) \in [0, 1]$ and $\hat{x} \in [0, 1]$, the demands are given by:

$$d_i = \frac{(1 - \hat{\theta}(0)) + (1 - \theta(\hat{x}))}{2}\hat{x} + \frac{(1 - \theta(\hat{x})) + (1 - \theta(1))}{2}(1 - \hat{x}), \quad (1.20)$$

$$d_t = \frac{\theta(\hat{x}) + \theta(1)}{2}(1 - \hat{x}). \quad (1.21)$$

In this case, $d_i + d_t \leq 1$.

It is important to note that the candidate equilibrium with covered market described in Part 1 of Lemma 1: $(p_i^{ne} p_t^{ne}) = (1/2 + u^t - \tau + \Delta u/2, u^t - \tau)$ corresponds to the limit case where $\hat{x} \to 0$. This means that if we use the demand functions defined in (1.20) and (1.21) to compute the profit and if $\partial\Pi/\partial p_t|_{p_i = p_i^{ne}, p_t = p_t^{ne}} < 0$, setting p_t above $u^t - \tau$ does not increase the profit. Consequently, $(p_i^{ne}, p_t^{ne}) = (1/2 + u^t - \tau + \Delta u/2, u^t - \tau)$ is the unique equilibrium.

Conversely, if $\partial\Pi/\partial p_t|_{p_i = p_i^{ne}, p_t = p_t^{ne}} > 0$, then increasing p_t above $u^t - \tau$ gives a strictly higher profit. Therefore in that case (p_i^{ne}, p_t^{ne}) is not an equilibrium. Performing the adequate computations we obtain that:

$$\left.\frac{\partial \Pi}{\partial p_t}\right|_{p_i=p_i^{ne},p_t=p_t^{ne}} < 0 \text{ if } \Delta u \leq \Delta \bar{u} = \frac{(1-2\tau)u^t - \tau(3-2\tau)}{u^t - \tau}. \tag{1.22}$$

The candidate equilibrium when the market is not covered can be derived numerically but a complete analytical characterization is particularly complex as many cases should be considered.

7.3 Complement to the proof of Proposition 3

With prices $(p_i, p_t, \tilde{p}_i) = (1/2, u^t - \tau, 1/2 + u^t - \tau)$, the consumer indifferent between (i, a) and (i, t) is located at

$$\tilde{x}_1 = \frac{\Delta u + \tau}{2\tau}. \tag{1.23}$$

Depending on the location of $\tilde{x}_1$, three cases should be considered (see Figure 1.5).

(1) $\tilde{x}_1 < 0$ if $\Delta u < -\tau$. In this case, the app has too little value and no consumer uses it. The outcome is similar to the exclusion case.

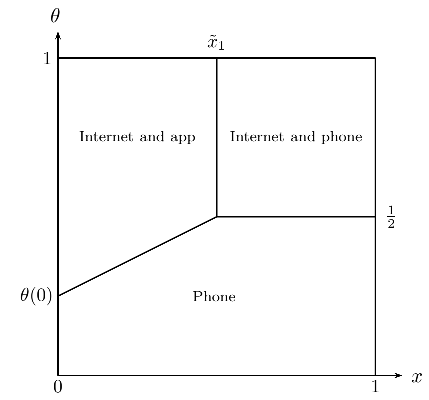
(2) $\tilde{x}_1 > 1$ if $\Delta u > \tau$. In this case, the phone has too little value and all internet users choose the app. The consumer indifferent between (i, a) and (t) is characterized by $\theta(x)$ given in Equation (1.5). Evaluated at the prices considered, we have that $\theta(1) = 1/2 - (\Delta u - \tau) < 1/2$. The fact that $\theta(1) < 1/2$ implies that the demand for internet at price $\tilde{p}_i$ is larger than 1/2 leading to a larger profit than Π^e.

(3) $\tilde{x}_1 \in [0, 1]$ if $-\tau \leq \Delta u \leq \tau$. For these parameter values, the demand configuration is represented on Figure 1.5. Referring to Figure 1.5, it is immediate that the demand for internet services is larger than in the exclusion case as $\theta(\tilde{x}_1) = 1/2$. Therefore, profit is larger than Π^e.

7.4 Proof of Lemma 2

To prove Lemma 2, we show that in a covered market situation, i.e. a situation where $p_t = u^t - \tau$, increasing prices above $\tilde{p}_i = p_i^{ne}$ and $p_i = \bar{p}_i = p_i^{ne} - p_t^{ne}$

Figure 1.5: Demand with three prices and $\tilde{x}_1 \in [0, 1]$



is profitable.

Importantly, one must recall that in the case with only two prices, p_i^{ne} and p_t^{ne} are optimal. In that case, the profit and the first-order conditions with regard to the price of the internet are the following:

$$\Pi = p_i d_i + p_t d_t, \quad (1.24)$$

$$\frac{\partial \Pi}{\partial p_i} = p_i \frac{\partial d_i}{\partial p_i} + d_i + p_t \frac{\partial d_t}{\partial p_i} = 0. \quad (1.25)$$

We know that the market is covered and therefore that $\frac{\partial d_i}{\partial p_i} = -\frac{\partial d_t}{\partial p_i}$. Hence, optimal prices (p_i^{ne}, p_t^{ne}) are characterized by:

$$(p_i^{ne} - p_t^{ne}) \left(\frac{\partial d_i}{\partial p_i} \right) = -d_i. \quad (1.26)$$

With three prices, d_{ia} is demand for the internet with the app, d_{it} demand for the internet with the app disabled and d_t demand for the phone. The demand configuration is represented on Figure 1.5 and profit takes the following form:

$$\Pi = \tilde{p}_i d_{ia} + p_i d_{it} + p_t d_t. \quad (1.27)$$

We evaluate the impact of raising the internet prices p_i and $\tilde{p}_i$ by an equal amount. Taking the total differential of the profit, the impact of increasing both prices by $\mathrm{d}p_i$ on the profit is:

$$\left(\frac{\mathrm{d}\Pi}{\mathrm{d}\tilde{p}_i} + \frac{\mathrm{d}\Pi}{\mathrm{d}p_i}\right)\mathrm{d}p_i \tag{1.28}$$

This expression should be evaluated at $\tilde{p}_i = p_i^{ne}$, $p_i = \bar{p}_i = p_i^{ne} - p_t^{ne}$ and $p_t = p_t^{ne}$. Therefore, we know that:

$$\begin{aligned} \frac{\mathrm{d}\Pi}{\mathrm{d}\tilde{p}_i} + \frac{\mathrm{d}\Pi}{\mathrm{d}p_i} &= d_{ia} + p_i^{ne}\frac{\partial d_{ia}}{\partial \tilde{p}_i} + \bar{p}_i\frac{\partial d_{it}}{\partial \tilde{p}_i} + p_t^{ne}\frac{\partial d_t}{\partial \tilde{p}_i} \\ &+ d_{it} + \bar{p}_i\frac{\partial d_{it}}{\partial p_i} + p_i^{ne}\frac{\partial d_{ia}}{\partial p_i} + p_t^{ne}\frac{\partial d_t}{\partial p_i}. \end{aligned} \tag{1.29}$$

We want to show that Equation (1.29) is always positive. First, because the market is covered, we have that:

$$\frac{\partial d_t}{\partial \tilde{p}_i} = -\frac{\partial d_{ia}}{\partial \tilde{p}_i}, \tag{1.30}$$

$$\frac{\partial d_{ia}}{\partial p_i} = -\frac{\partial d_t}{\partial p_i}. \tag{1.31}$$

Using this and the fact that $\bar{p}_i = p_i^{ne} - p_t^{ne}$, we can rewrite Equation (1.29) as

$$\frac{\mathrm{d}\Pi}{\mathrm{d}\tilde{p}_i} + \frac{\mathrm{d}\Pi}{\mathrm{d}p_i} = d_{ia} + d_{it} + (p_i^{ne} - p_t^{ne})\left(\frac{\partial d_{ia}}{\partial \tilde{p}_i} + \frac{\partial d_{it}}{\partial \tilde{p}_i} + \frac{\partial d_{ia}}{\partial p_i} + \frac{\partial d_{it}}{\partial p_i}\right). \tag{1.32}$$

Given that $\tilde{p}_i$ and p_i increase by the same amount, the consumer indifferent between (i, a) and (i, t), $\tilde{x}_1$, is unchanged. Consequently, the impact of increasing both internet prices on the total demand for internet is the same as the impact of increasing the price p_i on the demand for internet in the two price case. Equation (1.32) then simplifies to:

$$\frac{\mathrm{d}\Pi}{\mathrm{d}\tilde{p}_i} + \frac{\mathrm{d}\Pi}{\mathrm{d}p_i} = d_{ia} + d_{it} + (p_i^{ne} - p_t^{ne})\frac{\partial d_i}{\partial p_i}. \tag{1.33}$$

Using the first order condition (Equation 1.26), we have:

$$\frac{\mathrm{d}\Pi}{\mathrm{d}\tilde{p}_i} + \frac{\mathrm{d}\Pi}{\mathrm{d}p_i} = d_{ia} + d_{it} - d_i. \tag{1.34}$$

Because we know from Proposition 4 that $d_{ia} + d_{it} > d_i$, the Lemma is proven.[15]

7.5 Proof of Proposition 5

In the case where both exclude or neither does, prices and profits are zero and all consumers buy the internet. Let us consider now that ISP_1 admits the app and ISP_2 does not. The price of the internet alone is zero, $p_i = 0$ and therefore, demand will be divided among internet with the app and internet with the phone. Comparing utilities in each case yields an indifferent consumer located at

$$x = \frac{1}{2} - \frac{\tilde{p}_i}{2\tau} + \frac{\Delta u}{2\tau}. \tag{1.35}$$

The profit of ISP_2 is zero and ISP_1's profit is:

$$\Pi_1 = x\tilde{p}_i. \tag{1.36}$$

This yields a unique solution, $\tilde{p}_i = \tau/2 + \Delta u/2$ and $\Pi_1 = (\tau + \Delta u)^2/8\tau$. ISP_2 makes no profit since $p_i = p_t = 0$ because of Bertrand competition. The indifferent consumer is located at $1/4 + \Delta u/4\tau$.[16] When ISP_2 admits the app, the proof is *mutatis mutandis* similar.

[15] To check that the market is covered with three prices, we can proceed as for the proof of Proposition 2 but in this case, it is complicated to derive the condition analytically.

[16] We ignore the corner solutions where all consumers buy exclusively the app or the phone.

7.6 Proof of Proposition 6

When there is no fragmentation (both ISPs admit the app), which we denote by an upper-script "nf", the indifferent consumer is located at $x = 1/2 + \Delta u/2\tau$. Then we have that:

$$
\begin{aligned}
W_{sym}^{\mathrm{nf}} &= CS_{sym}^{\mathrm{nf}} && (1.37)\\
&= \int_0^{\frac{1}{2}+\frac{\Delta u}{2\tau}} \int_0^1 \theta + u^a - x\tau \, d\theta \, dx \\
&+ \int_{\frac{1}{2}+\frac{\Delta u}{2\tau}}^1 \int_0^1 \theta + u^t - \tau + x\tau \, d\theta \, dx && (1.38)\\
& && (1.39)\\
&= \frac{\Delta u^2 - \tau^2 + 2\tau(1 + u^a + u^t)}{4\tau}. && (1.40)
\end{aligned}
$$

Throughout the Appendix, the superscripts "a" and "e" respectively stand for admit and exclude. The first letter refers to ISP_1 and the second letter to ISP_2.

In the exclusion/no-exclusion or no-exclusion/exclusion cases, welfare is equal to:

$$
\begin{aligned}
W_{sym}^{a/e} &= \int_0^{\frac{\tau+\Delta u}{4\tau}} \int_0^1 \theta + u^a - x\tau - \frac{\tau + \Delta u}{2} \, d\theta \, dx \\
&+ \int_{\frac{\tau+\Delta u}{4\tau}}^1 \int_0^1 \theta + u^t - \tau + x\tau \, d\theta \, dx + \Pi_1 && (1.41)\\
&= \frac{-5\tau^2 + 3\Delta u^2 + 2\tau(4 + 3u^a + 5u^t)}{16\tau}. && (1.42)
\end{aligned}
$$

Comparing the two, we have: $W_{sym}^{\mathrm{nf}} - W_{sym}^{a/e} = \frac{(\Delta u+\tau)^2}{16\tau} > 0$.

7.7 Proof of Proposition 7

Both exclude. Let us first consider that both exclude. Then, $p_i = 0$ because both ISPs supply the internet and homogeneous Bertrand competition takes place. Therefore, all consumers buy the internet and some also buy the phone. Comparing utilities in each case, we find the indifferent consumer between (i, t) and (i) to be located at:

$$\dot{x} = 1 - \frac{u^t - p_t}{\tau}. \tag{1.43}$$

Thus, the profit of ISP_1 can take two forms:

$$\Pi_1 = \begin{cases} p_t = u^t - \tau & \text{if } p_t \leq u^t - \tau, \\ p_t \left(1 - \dot{x}\right) & \text{if } p_t > u^t - \tau. \end{cases}$$

The first order condition of the second form of profit yields $p_t = u^t/2$ which cannot be since $u^t/2 < u^t - \tau$. Therefore, the corner solution, $p_t = \Pi_1 = u^t - \tau$ is the only solution.

Both admit. Suppose we have an interior solution. The only product offered for a price other than zero is the phone, for the usual Bertrand reasons. Everyone consumes the internet and demand is separated between those who consume it with the phone and those who consume it with the app. The indifferent consumer is located at:

$$\ddot{x} = \frac{1}{2} + \frac{p_t}{2\tau} + \frac{\Delta u}{2\tau}. \tag{1.44}$$

The profit of ISP_1 is:

$$\Pi = p_t(1 - \ddot{x}). \tag{1.45}$$

The first-order condition yields $p_t = \tau/2 - \Delta u/2$, $\Pi_1 = (\tau - \Delta u)^2/8\tau$ and $\ddot{x} = 3/4 + \Delta u/4\tau$.

If $\Delta u > \tau$, we have a corner solution, all prices are equal to 0 and consumers do not buy the phone.

ISP_1 excludes, ISP_2 admits. The price of the internet is zero again. Consumers are divided between those who consume it with the phone and those who consume it with the application. The indifferent consumer is located at:

$$\ddot{x} = \frac{1}{2} + \frac{p_t - \tilde{p}_i}{2\tau} + \frac{\Delta u}{2\tau}. \tag{1.46}$$

Firms' profits are:

$$\Pi_1 = p_t(1 - \ddot{x}), \tag{1.47}$$

$$\Pi_2 = \tilde{p}_i \ddot{x}. \tag{1.48}$$

Computing firms' best responses yields the equilibrium $\tilde{p}_i = \tau + \Delta u/3$, $p_t = \tau - \Delta u/3$, $\ddot{x} = 1/2 + \Delta u/6\tau$, $\Pi_1 = (3\tau - \Delta u)^2/18\tau$ and $\Pi_2 = (3\tau + \Delta u)^2/18\tau$. Another possible candidate equilibrium would be higher prices with some consumers buying the internet only. In that case, the indifferent consumer (between the internet and the app and the internet alone) and the profit of ISP_2 is:

$$\overset{\vdots}{x} = \frac{u^a - \tilde{p}_i}{\tau}, \tag{1.49}$$

$$\Pi_2 = \tilde{p}_i \overset{\vdots}{x}. \tag{1.50}$$

This yields an optimal price of $\tilde{p}_i = \frac{u^a}{2}$, implying that ISP_2 will want to cover the whole market with the app. The same holds true *mutatis mutandis* for ISP_1 and therefore this is not an equilibrium.

Finally, there are two corner solutions that we must examine: the app or the phone covering the whole market. These situations do not interest us but we provide the bounds for completeness. These cases happen respectively if $u^a \geq 3\tau + u^t$ and $u^t \geq 3\tau + u^a$. If we want to restrict the solution to be interior we must therefore impose $-3\tau \leq \Delta u \leq 3\tau$.

ISP_1 admits, ISP_2 excludes. Because it only supplies the internet, the profit of ISP_2 is zero. ISP_1 thus sets the prices of the internet with the app and of the phone freely. Two cases are possible: consumers are divided among app-users and phone users or some consumers choose to buy the internet alone. This second option can immediately be discarded for the same reason as in the exclusion/no-exclusion case. Let us consider therefore that no one consumes just the internet. One can think of the problem as finding the highest prices so that the consumers who are indifferent between the internet and the internet with the app –or between the internet and the internet with the phone– are located at $x = 1/2$. At $x = 1/2$, we know that $U(i, a) = U(i, t) = 0$. Therefore, we have that $\tilde{p}_i = u^a - \tau/2$, $p_t = u^t - \tau/2$ and $\Pi_1 = (u^a + u^t)/2 - \tau/2$.

Admit-Admit is not a Nash equilibrium. Suppose that ISP 2 admits the application, if ISP 1 also admits, its profit is $(\tau - \Delta u)^2/8\tau$. If ISP 1 excludes, its profit is $(3\tau - \Delta u)^2/18\tau$. Computations show that the former profit is higher than the latter if either $\Delta u < 0$ and $\tau < -\Delta u/3$ or $\Delta u > 0$ and $\tau < 5\Delta u/9$. To have an interior solution in the Admit-Admit (or no-fragmentation) case,[17] we need the consumer who is indifferent between the phone and the app to be located between 0 and 1: $0 < 3/4 + \Delta u/4\tau < 1$. This implies $-3\tau < \Delta u < \tau$.

Take the first set of conditions. Clearly, $\tau < -\Delta u/3$ is in contradiction with $-3\tau < \Delta u$. For the second set of conditions, $\tau < 5\Delta u/9$ is in contradiction with $\Delta u < \tau$ because $\Delta u > 0$. Therefore, we cannot have an interior equilibrium and higher profits in the Admit-Admit case. It is therefore not a Nash equilibrium.

7.8 Proof of Proposition 8

Under no fragmentation (both ISPs admit the app), and assuming that we have an interior solution, consumer surplus and welfare are:

[17] Because the price of the internet with the app is 0, the only corner solution is $p_t = 0$ which would lead to a profit of 0 for ISP_1 and is therefore clearly not a Nash equilibrium.

$$
\begin{aligned}
CS^{nf}_{asym} &= \int_0^{\frac{3}{4}+\frac{\Delta u}{4\tau}} \int_0^1 \theta + u^a - x\tau \, d\theta \, dx \\
&+ \int_{\frac{3}{4}+\frac{\Delta u}{4\tau}}^1 \int_0^1 \theta + u^t - \tau + x\tau - \frac{\tau}{2} + \frac{\Delta u}{2} \, d\theta \, dx && (1.51)\\
&= \frac{1}{2} + \frac{7u^a + u^t}{8} + \frac{\Delta u^2}{16\tau} - \frac{7\tau}{16}. && (1.52)\\
W^{nf}_{asym} &= \frac{1}{2} + \frac{5u^a + 3u^t}{8} + \frac{3\Delta u^2}{16\tau} - \frac{5\tau}{16}. && (1.53)
\end{aligned}
$$

Under the exclusion/no-exclusion case, they are:

$$
\begin{aligned}
CS^{e/a}_{asym} &= \int_0^{\frac{3\tau+\Delta u}{6\tau}} \int_0^1 \theta + u^a - x\tau - \tilde{p}_i \, d\theta \, dx \\
&+ \int_{\frac{3\tau+\Delta u}{6\tau}}^1 \int_0^1 \theta + u^t - (1-x)\tau - p_t \, d\theta \, dx && (1.54)\\
&= \frac{1}{2} + \frac{u^a + u^t}{2} - \frac{5\tau}{4} + \frac{\Delta u^2}{36\tau}, && (1.55)\\
W^{a/e}_{asym} &= \frac{1}{2} + \frac{u^a + u^t}{2} - \frac{\tau}{4} + \frac{5\Delta u^2}{36\tau}. && (1.56)
\end{aligned}
$$

Under the no-exclusion/exclusion case, they are:

$$
\begin{aligned}
CS^{a/e}_{asym} &= \int_0^{\frac{1}{2}} \int_0^1 \theta + u^a - x\tau - u^t + \frac{\tau}{2} \, d\theta \, dx && (1.57)\\
&+ \int_{\frac{1}{2}}^1 \int_0^1 \theta + u^t - (1-x)\tau - u^t + \frac{\tau}{2} \, d\theta \, dx && (1.58)\\
&= \frac{1}{2} + \frac{\tau}{4}. && (1.59)\\
W^{a/e}_{asym} &= \frac{1}{2} - \frac{\tau}{4} + \frac{u^a + u^t}{2}. && (1.60)
\end{aligned}
$$

1. Consumer surplus is always highest when both firms admit the application In the no-fragmentation case, if the profit maximization problem leads to a corner solution, we have that all prices are equal to 0 and consumers are unambiguously better off in that situation compared to any other.

Let us now consider the case of an interior solution. We have that $CS^{nf} < CS^{a/e}$ if:

$$\frac{7u^a + u^t}{8} + \frac{\Delta u^2}{16\tau} - \frac{7\tau}{16} < \frac{\tau}{4}. \tag{1.61}$$

It can be shown that this in contradiction with the conditions that $u^a > 2\tau$ and $u^t > 2\tau$.

We have that $CS^{nf} < CS^{e/a}$ if:

$$\frac{7u^a + u^t}{8} + \frac{\Delta u^2}{16\tau} - \frac{7\tau}{16} < \frac{u^a + u^t}{2} - \frac{5\tau}{4} + \frac{\Delta u^2}{36}. \tag{1.62}$$

This can be shown to be in contradiction with the conditions that 1) $u^a > 2\tau$ and $u^t > 2\tau$ and 2) $-3\tau \leq \Delta u \leq 3\tau$. Therefore, the Proposition is proven.

2. Consumer surplus and welfare are not necessarily highest in the same situation We know that consumer surplus is highest in the Admit/Admit situation. Let us simply provide an example where welfare is highest in the Exclusion/Admit case. If $\tau = 1/8$, $u^a = 1/2$ and $u^t = 3/4$ then $W^{e/a} = 335/288 \simeq 1.16319$, $W^{nf} = 147/128 \simeq 1.14844$ and $W^{a/e} = 35/32 \simeq 1.09375$.

3. Imposing $\mathbf{NN_1}$ and $\mathbf{NN_2}$ can increase or decrease welfare This is a direct result from the two previous parts of the proposition.

Chapter 2

Targeted Advertising and Consumer Information

Sébastien Broos

Abstract

In many markets, the information that consumers possess about a product increases with their valuation for that product or product category. For instance, video game fans are more likely to know about the release of new games and their characteristics than consumers who do not enjoy video games. Using ever-increasing amounts of data, firms are now able to use this information heterogeneity in their targeted advertising strategy. We analyse the impact of this new ability on a monopolistic market. The firm often benefits from this more complex targeting strategy because it reduces its ad spending on highly informed consumers, allowing it to spend more of its advertising budget on poorly informed consumers. In that case, it is profitable for the firm to reduce its product's price to be able to sell to these low-information/low-valuation consumers. This benefits most consumers but not all: highly informed consumers are not perfectly informed and when the firm withdraws its ads aimed at them, some stop purchasing.

Keywords: Targeted Advertising, Information, E-Commerce.

JEL classification: D42, D80, L12, M37

Acknowledgments: I would like to thank participants to the 2nd IO in the Digital Economy workshop in Louvain-la-Neuve, the Augustin Cournot Doctoral Days in Strasbourg, the Annual Conference of the Leibniz Science-Campus 2016 MACCI, EARIE Lisbon and seminar participants at Télécom ParisTech, Tilburg, Liège and Mannheim. I also thank Axel Gautier, Julien Jacqmin, Anna D'Annunzio, Jorge Marcos Ramos, Jonas Teusch, Florian Schuett, Alexandre de Cornière and Bertrand Koebel for their helpful comments, and Isabelle Peere for proofreading the manuscript. This research was funded through the ARC grant for Concerted Research Actions, financed by the French-speaking Community of Belgium.

1 Introduction

If a major role of advertising is to convey information about products to consumers, then firms should adapt their targeted advertising strategy to take into account that different consumers have different levels of information. Until a few years ago, doing this would have been science fiction. Nowadays however, not only is it possible but firms are already doing so.

In a recent article (Blake et al., 2015)[1], industry and academic researchers analysed the advertising strategy of eBay on search engines. They showed that advertising did not work –it did not change the clicking behaviour– on consumers who were well informed about eBay, i.e. those whose queries on the search engine included the term 'eBay', for instance 'shoes eBay'. On the other hand, consumers whose queries did *not* include the term 'eBay' but which lead to a sponsored link to eBay responded positively (although the effect was very small) to advertising. Given that search ad spending in the US only was over 25 Billion dollars in 2016, this is important finding that is worth examining in more details.[2]

[1]See also The Guardian (2013), *Google keyword advertising is waste of money, says eBay report*, available at `https://www.theguardian.com/technology/2013/mar/13/google-keyword-advertising-wastes-money-ebay`.

[2]See eMarketer, *US Digital Display Ad Spending to Surpass Search Ad Spending in 2016*, 2015, `https://www.emarketer.com/Article/`

Admittedly, Blake et al. (2015)'s method is a crude way to distinguish between consumers who are informed and those who are not. Yet, this should become easier. Indeed, the amount of data that advertisers possess about consumers is massive. Facebook processes hundreds of millions of photos, likes and messages each day[3] and offers 98 targeting options to advertisers such as age, income, location, credit rating, political orientation, etc.[4] Bluekai, a data broker, has data about more than one billion consumers with, on average, fifty attributes per individual.[5] More practically, firms such as eBay are able to proxy consumer information through the recency and frequency of purchases (Blake et al., 2015).

We assume that there is a positive correlation between information and the value that a consumer has for a product. Consider the following example. We observe two consumers, Jane and Joe. Jane is a fan of best-selling author Nassim Taleb[6] and regularly reads blogs and forums about Taleb's work. Joe is a casual reader who does not have strong preferences but sometimes reads essays. Taleb is on the brink of publishing a new book. His publisher, using the service of an advertiser or of a data broker, learns that Jane is a high-valuation/high-information consumer while Joe is a middle-valuation/low-information consumer. How should the publisher target its ads and price the product? If both consumers were informed, the pricing trade-off would be classical: setting a high price but selling only to Jane or setting a low price but selling to both Jane and Joe. What if information heterogeneity is taken into account? There are four possibilities: send an ad to Jane and set a high price, send an ad to both and set a low price, send no ad and set a high price, and send no ad and set a low price.

We show the circumstances under which a profit-maximizing firm should

US-Digital-Display-Ad-Spending-Surpass-Search-Ad-Spending-2016/1013442.

[3]Share Lab, *Facebook algorithmic factory(1)*, 2016, available at https://labs.rs/en/facebook-algorithmic-factory-immaterial-labour-and-data-harvesting/.

[4]The Washington Post, *98 personal data points that Facebook uses to target ads to you*, 2016, available at https://www.washingtonpost.com/news/the-intersect/wp/2016/08/19/98-personal-data-points-that-facebook-uses-to-target-ads-to-you/.

[5]The Economist, *Getting to know you*, 2014, available et http://www.economist.com/news/special-report/21615871-everything-people-do-online-avidly-followed-advertisers-and-third-party.

[6]Taleb is the author of 'The Black Swan'.

adapt its pricing and advertising strategies to take information heterogeneity into account. We also show how this affects consumers in terms of the price they pay and the identity of those who purchase the product: it is not profit-maximizing to send ads to high-valuation/high-information consumers.

To that end, we suppose that, if technology does not allow the firm to benefit from information heterogeneity, it has only two choices: (i) advertise to all consumers who are willing to pay a sufficiently high price, which we call "simple targeting" and (ii) advertise to no one ("no advertising"). Our main question of interest is the effect of a switch to a more "complex" targeting strategy on the market, i.e. the effect of not sending ads to the highly informed consumers.

So long as (i) advertising is neither too costly nor too cheap and (ii) there is a sufficient discrepancy between the levels of information of different consumers, then complex targeting is the profit-maximizing strategy of the firm. In that case, some high-valuation consumers do not receive ads.

Compared to simple targeting, some high-valuation consumers stop purchasing the good because they have not received ads and therefore, are no longer informed. This reduces demand and *always* causes the monopolist to lower its price. This is one of our main results: better targeting, in the sense of being able to take advantage of information heterogeneity, may lead to a lower price. We say "may" because a switch from no advertising to complex targeting can result in a lower or a higher price.

Interestingly, a lower price benefits some consumers but hurts others. This is in line with the literature on targeted advertising but for opposite reasons. Typically, in a monopoly setting, better targeted advertising is seen as a device to reach high-valuation consumers. Hence, total consumer surplus decreases because the price increases with targeting but, on the other hand, better targeting leads to more transactions with high-valuation consumers (who, by definition, obtain the most surplus from transactions). In our case, complex targeting may reduce the number of transactions and, importantly, the consumers who stop buying because they are no longer targeted are exactly those who would have obtained the most surplus from the purchase. This may lead to a decrease in total consumer surplus. The impact of complex targeting on total welfare is ambiguous for the same reasons.

This paper is part of the literature on targeted advertising (Athey and Gans, 2010; Bergemann and Bonatti, 2011; Brahim et al., 2011; Esteban et al., 2001; Esteves and Resende, 2016) and in particular of that which is concerned with exogeneously informed consumers (Meurer and Stahl, 1994; Xu et al., 2012).[7] Typically, this literature finds that in the absence of competitive constraints, firms use targeting to reach consumers with a high valuation and therefore increase their market power. As a result, a monopolist that can target its ads will increase its price (Esteban et al., 2001; Hernandez-Garcia, 1997). Our main contribution to this literature is to add (i) heterogeneity to consumer information and (ii) the possibility for advertisers to include this heterogeneous information in their advertising strategy.

Section 2 sets up the basic model and the major hypotheses. Sections 3, 4 and 5 respectively examine the conditions under which complex targeting is optimal, its impact on prices, consumer surplus and welfare, and the first-best. In Section 6, we discuss our main assumptions and analyse some extensions. Section 7 concludes.

2 The baseline model

2.1 Consumers

There is a unit mass of consumers, each of whom has use for maximum one unit of a product. Consumers have valuations v distributed on $[0, 1]$ according to log-concave density function $f(v)$ and the corresponding log-concave cumulative distribution function $F(v)$.[8] They do not incur any nuisance cost from receiving ads.[9]

Consumers are imperfectly informed about the good: they may not know

[7]This is also considered in an extension in Iyer et al. (2005). See Bagwell (2007) and Renault (2016) for literature reviews on advertising with mentions/sections on targeted advertising.

[8]Many standard distributions such as the uniform or the normal distribution respect log-concavity. For more on log-concavity, see Bagnoli and Bergstrom (2005).

[9]This assumption does not change our qualitative results very much and is discussed in Section 6

that the good exists. There are two possible sources of information. First, there is an 'information function' $g(v)$, which is the probability that a consumer with valuation v is informed about the good, its price and his valuation for it. We assume that $g(v)$ is invertible and log-concave. Second, information can be transmitted through advertising: a consumer who receives an ad is perfectly informed.

There are two important questions that must be considered regarding consumer information. First, how uninformed are uninformed consumers? In the main case, they have no information about the product: they know neither of its existence nor of its characteristics. Therefore, uninformed consumers do not buy. Formally, this is equivalent to assuming that they have a valuation of 0. This is a common assumption in many (targeted) advertising models. In Section 6.2, uninformed consumers have a common ex-ante valuation $\tilde{v} \in (0, 1]$. Although it does not change the nature of our conclusions, it may affect the circumstances in which they hold.

Second, what is the structure of information and in particular, what is the link between the information function and the valuations of consumers? We assume that the valuation of a consumer and his probability to be informed are uncorrelated or positively correlated, i.e. $g'(v) \geq 0$. What this means exactly is the topic of Section 3.

2.2 The firm

A monopolist sells one good, produced at a constant marginal cost which is normalized, without loss of generality, to 0. It knows the information function and the distribution of the valuation but not necessarily the valuation of each consumer. It is still able to target ads very precisely, for instance because ads are sent through an intermediary which knows the valuation of each consumer, but cannot reveal it for privacy reasons. The firm is therefore unable to price discriminate and sets a uniform price p. Allowing the firm to have more precise information about consumers' valuations and to price discriminate does not change the nature of our conclusions and is discussed in details in Section 6.

Advertising costs a per consumer[10] and is perfectly informative: after receiving an ad, consumers know their valuation v with certainty. Advertising is also perfectly precise: an ad intended for consumer v will reach consumer v. The profit-maximization problem of the firm is the following:

$$\max_{p,\underline{v},\bar{v}} \left[p \int_p^{\underline{v}} f(v)g(v)dv + (p-a) \int_{\underline{v}}^{\bar{v}} f(v)dv + p \int_{\bar{v}}^{1} f(v)g(v)dv \right]. \quad (2.1)$$

There are three strategic variables: the price p, the lower targeting bound $\underline{v}$ and the upper targeting bound $\bar{v}$. Consumers with $v \in [\underline{v}, \bar{v}]$ receive ads, while the others do not. The following Lemma shows that the problem can be simplified because it is always optimal for the firm to use the price as the lower targeting bound.

Lemma 1. *It is always optimal for the firm to use the price as the lower targeting bound ($p = \underline{v}$).*

Proof. The first-order conditions, with regards to $\underline{v}$ and $\bar{v}$, of the maximization problem set out in Equation (2.1) are:

$$\frac{\partial \Pi}{\partial \underline{v}} = p^* f(\underline{v}^*)g(\underline{v}^*) - f(\underline{v}^*)(p^* - a) = 0, \quad (2.2)$$

$$\frac{\partial \Pi}{\partial \bar{v}} = f(\bar{v}^*)(p^* - a) - p^* f(\bar{v}^*)g(\bar{v}^*) = 0. \quad (2.3)$$

If both first-order conditions are satisfied, then we have:

$$\underline{v}^* = \bar{v}^* = g^{-1}\left(1 - \frac{a}{p^*}\right). \quad (2.4)$$

In that case, there is no advertising and the targeting bounds can be ignored. Another possibility is that either $\bar{v}^* = 1$ or $\underline{v}^* = p^*$. If the latter is true, our point is proven. Suppose instead that the former is true. In that

[10] The linearity of the cost function is similar to that in Iyer et al. (2005). The more usual convexity assumption implies decreasing returns to scale to advertising. There is no reason for this here since (i) consumers cannot be reached twice inadvertently and (ii) ads do not miss their targets.

case, from Equation (2.3):

$$g(1) < 1 - \frac{a}{p^*}. \tag{2.5}$$

But from Equation (2.2), we also have that:

$$g(\underline{v}^*) = 1 - \frac{a}{p^*}. \tag{2.6}$$

This implies that $g(1) < g(\underline{v}^*)$. Given that $g'(v) \geq 0$, this is a contradiction and the Lemma is proven. ■

The profit-maximization problem can therefore be simplified as follows:

$$\max_{p,\bar{v}} \left[(p-a) \int_p^{\bar{v}} f(v)dv + p \int_{\bar{v}}^1 f(v)g(v)dv \right]. \tag{2.7}$$

The price is thus a double instrument. It is what buyers pay but it is also the lower targeting bound: consumers with $v \in [p, \bar{v}]$ receive ads.

The monopolist has three advertising strategies. Denote by p^* and $\bar{v}^*$ the price and upper targeting bound which solve the profit-maximization problem in Equation (2.7). There are three possibilities regarding $\bar{v}^*$: it is either interior, a lower corner solution ($\bar{v}^* = p^*$) or an upper corner solution ($\bar{v}^* = 1$). These solutions represent the three different advertising strategies available to the monopolist.

First, the monopolist may rely on the fact that high-valuation consumers are highly informed and choose not to send ads to some of them. In that case, $p^* < \bar{v}^* < 1$: consumers with $v \in [p^*, \bar{v}^*)$ receive ads but those with $v \in [\bar{v}^*, 1]$ do not. While the former buy with certainty, the latter do not because they only have a *probability* to be informed thanks to the information function The trade-off for the firm in this situation is the following: saving the ad cost but losing some consumers. We call this strategy **complex targeting**.

Second, the monopolist may choose to send ads to all consumers with $v > p^*$: $\bar{v}^* = 1$. This is costly but ensures that all potential buyers are informed. Information is thus ignored in the sense that whether a particular consumer receives an ad does not depend on the information function. We call this strategy **simple targeting**.

Finally, the firm may choose to abstain from advertising: $\bar{v}^* = p^*$. Because of the information function, some consumers are still informed and profit is positive. We call this strategy **no advertising**.

We *assume* that the profit function is concave at $p = p^* < \bar{v} = \bar{v} < 1$. The precise assumptions that this implies are discussed in Appendix 8.2. They are respected for all the examples used throughout this article. In the case of simple targeting and no advertising, concavity (in p) is implied by the log-concavity of $f(v)$ and $g(v)$ because (i) the product of two log-concave functions is a log-concave function and (ii) log-concavity implies an increasing hazard rate.[11]

Valuation targeting is of particular interest because it is a proxy for the way the economics literature has generally understood targeted advertising. Coming back to Equation (2.7), if targeting is on valuation only, the second term collapses and only the first remains. If there is no advertising, it is the first term which disappears and the second that remains. This implies that the information function only plays a role in the case of complex targeting or if there is no advertising.

3 When is complex targeting the best strategy?

The first question we want to tackle is that of the conditions under which complex targeting is optimal, i.e. the conditions under which a monopolist maximizes its profit by choosing (i) $\bar{v}^* < 1$ and (ii) $p^* < \bar{v}^*$. In other words, when is $\bar{v}^*$ an interior solution? If the solution is indeed interior, the optimal price and upper targeting bound satisfy the following first-order conditions:

$$\frac{\partial \Pi}{\partial p} = \int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p^*}^{\bar{v}^*} f(v)dv - (p^* - a)f(p^*) = 0, \tag{2.8}$$

$$\frac{\partial \Pi}{\partial \bar{v}} = (p^* - a)f(\bar{v}^*) - p^* f(\bar{v}^*)g(\bar{v}^*) = 0 \Longleftrightarrow \bar{v}^* = g^{-1}\left(1 - \frac{a}{p^*}\right) \tag{2.9}$$

[11]See Tirole (1988) for more details.

To satisfy requirement (i) assuming that $p < \bar{v}$, we need that:[12]

$$\left.\frac{\partial \Pi}{\partial \bar{v}}\right|_{\bar{v}=1} = (p^* - a)f(1) - p^* f(1)g(1) < 0 \Longleftrightarrow 1 - \frac{a}{p^*} < g(1). \tag{2.10}$$

In words, consumers with the extreme valuation of 1 should have a sufficiently high probability to be informed without advertising, so that sending them ads would be a waste of resources. More generally, this can be extended to $\bar{v}$ smaller than any threshold valuation. This also rules out the case of $a = 0$. Obviously, if it is costless, there is no reason to abstain from advertising.

Requirement (ii) has two different implications. First,we have:

$$\left.\frac{\partial \Pi}{\partial p}\right|_{p=\bar{v}^*} = \int_{\bar{v}^*}^{1} f(v)g(v)dv - (\bar{v}^* - a)f(\bar{v}^*) < 0 \tag{2.11}$$

$$\Longleftrightarrow a < \bar{v}^* - \frac{\int_{\bar{v}^*}^{1} f(v)g(v)dv}{f(\bar{v}^*)} \equiv \bar{a}. \tag{2.12}$$

Because p^* is only implicitly defined, we cannot go much further in interpreting this threshold.

Second, consumers should not be 'too informed'. To take an extreme case, if all consumers are perfectly informed, there is no reason to advertise. Formally:

$$\left.\frac{\partial \Pi}{\partial \bar{v}}\right|_{\bar{v}=p^*} = (p^* - a)f(p^*) - p^* f(p^*)g(p^*) > 0 \Longleftrightarrow g(p^*) < 1 - \frac{a}{p^*}. \tag{2.13}$$

If we combine this condition with that of requirement (i) (Equation 2.10), we obtain:

$$g(p^*) < 1 - \frac{a}{p^*} < g(1). \tag{2.14}$$

[12] The case where $f(1) = 0$ is uninteresting. As, in this case, there are no consumers with $v = 1$, the valuation targeting scenario implies that the targeted consumers are those with $v \in [p, \tilde{v}]$ where $\tilde{v}$ is the highest v with strictly positive density. Therefore, the corner solution is not defined as $\bar{v} = 1$ but as $\bar{v} = \tilde{v}$. This case does not change any of the conclusions.

A necessary (but not sufficient) condition for this to hold is that consumers are heterogeneous with regard to the information they possess. Therefore, information functions such as $g(v) = k$ with $k \in [0, 1]$ do not lead to complex targeting.[13] Intuitively, in that case, it would not make sense to have a targeting strategy based on information because all consumers have the same information. To use an analogy, there would be no reason to set different prices for different consumers if they all had the same valuation.

This condition can also be interpreted in terms of the advertising cost; it should neither be too high nor too low:

$$p^*(1 - g(1)) < a < p^*(1 - g(p^*)). \tag{2.15}$$

If the advertising cost is too low, it is better to target on valuation only. If it is too high, it is better not to advertise. The following Proposition summarizes these conditions.

Proposition 1. *Complex targeting is the most profitable strategy if and only if:*

1. $g(p^*) < 1 - \frac{a}{p^*} < g(1)$.
2. $0 < a < \bar{a}$.

Otherwise, no advertising or simple targeting is more profitable for the firm.

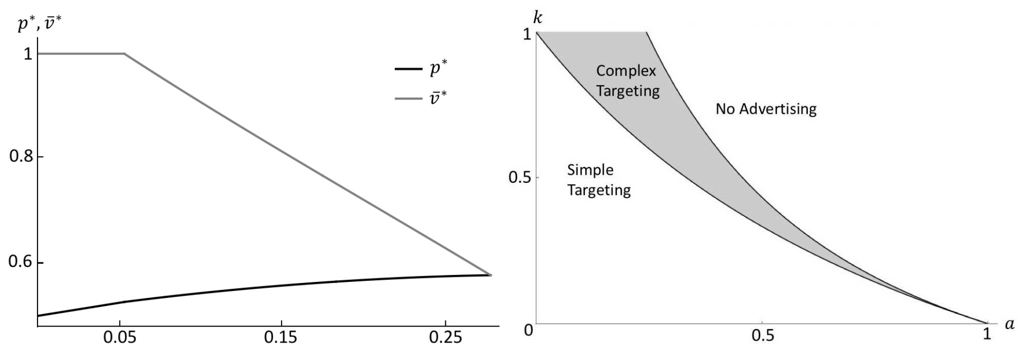
There are many sets of $f(v)$ and $g(v)$ satisfying this Proposition for at least some values of a. Let us take two examples to clarify it.

Example 1. Suppose that $v \sim U[0, 1]$ and that $g(v) = 0.9v$. This implies that even the highest-valuation consumer is not informed with certainty. Then, it can be shown that if $a \in [0, 0.0526)$ valuation targeting is optimal, if $a \in [0.0526, 0.2773)$ complex targeting is optimal and finally, if $a \geq 0.2773$, no advertising occurs. This case is illustrated on Figure 2.1a.

[13]Moreover, technically, a function of this form is not invertible and thus violates our invertibility assumption.

Example 2. Suppose that $v \sim U[0,1]$ and that $g(v) = kv$ with $0 \leq k \leq 1$. The interesting feature of this example is that a higher k implies that all consumers see their probability to be informed increase. Therefore, we can establish, albeit in a particular case, how the level of information influences the possibility to observe complex targeting. From the first condition of Proposition 1,[14] we must have $kp^* < 1 - a/p^* < k$, which can be rewritten as $p^*(1-k) < a < p(1-kp^*)$. This is depicted on Figure 2.1b. If the probability to be informed is very low, we observe that simple targeting is the best strategy for most of the range of a. As k increase however, both complex targeting and no advertising become more likely. The example is limited to $0 \leq k \leq 1$ for computational reasons but it is intuitive that if $k > 1$, no advertising will become more prevalent with a higher k. It is easy to show that if $k \geq 2$, the no advertising strategy maximizes profit for all a.[15]

Figure 2.1: Examples 1 and 2.



(a) Example 1: Price and targeting bound if $v \sim U[0,1]$ and $g(v) = 0.9v$.

(b) Example 2: Optimal strategies if $v \sim U[0,1]$ and $g(v) = kv$.

As shown by the examples, Proposition 1 applies to numerous situations. What is required is that advertising is neither too cheap nor too costly and

[14] The second condition is weaker in this case and can thus be ignored.

[15] If $k = 2$, all consumers with $v \geq 1/2$ are informed. We know that a monopolist facing a fully informed demand and a marginal cost of 0 would set a price of 1/2. If $k = 2$, the monopolist can exactly reproduce this outcome by setting $p = \bar{v} = 1/2$. This obviously holds true for $k > 2$.

that some consumers are better informed than others if they have a higher valuation for the good.

Of course, the impact of consumer information is not limited to this set-up. For instance, if $g(v) = k$ with $k \in [0, 1]$, the conditions of Proposition 1 are not respected and complex targeting does not arise. Yet, information affects profit and targeting strategies but in a simpler way: the outside option of no advertising becomes more profitable. We now turn to the effects of complex targeting on prices and welfare.

4 The impact of complex targeting on prices, consumer surplus and welfare

Suppose that the conditions of Proposition 1 are fulfilled, that complex targeting could not be used by the firm because of the absence of knowledge on the information function, but that new technologies now enable its use. How are price, consumers and welfare affected by this switch?

Notation. *In the absence of complex targeting, we denote the optimal price by*

- p_s *for 'simple targeting' if, in that case, the firm sets* $\bar{v} = 1$*, i.e. it chooses to advertise to all consumers with* $v \geq p$*.*
- p_n *for 'no advertising' if, in that case, the firm sets* $\bar{v} = p$*, i.e. it chooses not to advertise.*

We denote the optimal price under complex targeting by p_c*.*

The first-order conditions with regard to price are the following:

$$\frac{\partial \Pi}{\partial p} = \int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p_c}^{\bar{v}^*} f(v)dv - (p_c - a)f(p_c) = 0, \tag{2.16}$$

$$\left.\frac{\partial \Pi}{\partial p}\right|_{\bar{v}=1} = \int_{p_s}^{1} f(v)dv - (p_s - a)f(p_s) = 0, \tag{2.17}$$

$$\left.\frac{\partial \Pi}{\partial p}\right|_{\bar{v}=p} = \int_{p_n}^{1} f(v)g(v)dv - p_n f(p_n)g(p_n) = 0. \tag{2.18}$$

First, complex targeting always lowers the price compared to simple targeting: $p_c < p_s$. The reason is simply that $\bar{v}^* < 1$. To see why, suppose that the two prices are equal (and hence also, implicitly, the lower bound) and that they are lowered by a small amount. We have the two traditional effects of a change in price in a monopoly setting: (i) the firm loses the price differential on consumers to whom it sells (the 'margin effect') but (ii) it gains some additional consumers (the 'demand effect'). That demand effect is the same whether the firm uses complex or simple targeting because the involved consumers receive ads and are thus perfectly informed. However, the margin effect is different. Indeed, the lost profit is computed on consumers who *effectively* buy. For consumers with $v \in [p; \bar{v}^*]$, it does not make a difference: they all buy regardless of the targeting strategy. But for those with $v \in [\bar{v}^*; 1]$, the effect is smaller under complex targeting: all consumers buy under simple targeting but only those who are informed make a purchase under complex targeting. Formally, this can be seen by rewriting the first-order condition in the simple targeting case as follows:

$$\left.\frac{\partial \Pi}{\partial p}\right|_{\bar{v}=1} = \int_{\bar{v}^*}^{1} f(v)dv + \int_{p_s}^{\bar{v}^*} f(v)dv - (p_s - a)f(p_s) = 0. \qquad (2.19)$$

This conclusion contrasts strongly with the literature on targeted advertising. In general, targeting is seen as a device that enables firms to reach consumers with a high valuation so that price can be raised. Here, better targeting lowers the price because the firm is willing to trade a reduction in demand against a reduction in cost.

In contrast, there is no *a priori* ranking of p_n and p_c. To see this, compare again the first-order conditions. Clearly, the first term in Equation (2.18) is smaller than the sum of the first two terms in Equation (2.16): the margin effect under no advertising is weaker because more consumers do not buy due to a lack of information. However, the second term in Equation (2.18) is also smaller than the last term in Equation (2.16).[16] On the one hand, demand diminishes less under no advertising because consumers do not receive ads and hence, only those who are informed through the information function are

[16] We have that $pf(p)g(p) < (p-a)f(p) \Longleftrightarrow g(p) < 1 - \frac{a}{p} \Longleftrightarrow p < \bar{v}^*$.

lost (those who are uninformed do not buy anyway). On the other hand, a lost consumer induces a bigger loss under no advertising than under complex targeting because the advertising cost is not incurred if consumers do not receive ads.

This is a somewhat strange result because p_n is constant in a, p_c is not, and we know that for some high a (at worst, $a = 1$), no advertising is always the optimal strategy and thus $p_c = p_n$. Hence, we would expect a clear-cut ranking for all advertising cost values. This is not obtained because p_c is not *necessarily* monotonically increasing in a. The intuition (see Appendix 8.1 for details) is that a change in a has a double effect on p_c:

$$\frac{\mathrm{d}p_c}{\mathrm{d}a} = \frac{\partial p_c}{\partial a} + \frac{\partial p_c}{\partial \bar{v}^*}\frac{\partial \bar{v}^*}{\partial a}. \tag{2.20}$$

The direct effect ($\frac{\partial p_c}{\partial a}$) leads to an increase in price to compensate the increase in cost. But there is also an indirect effect. A hike in a leads to a lower $\bar{v}^*$, which in turn pressures p_c downwards because of the lower margin effect (the same as when we compared p_c and p_s).

In some cases, the sum of these two effects is positive for all a, for instance if $v \sim U[0,1]$ and $g(v) = v$, but in others it can be negative, for example if $v \sim \text{Kumaraswamy}(2,5)$ and $g(v) = v$.[17]

Because, as explained earlier, p_n is constant in a and $p_n = p_c$ for sufficiently high a, a necessary condition to obtain $p_n < p_c$ is that p_c should *not* be monotonically increasing in a for all a.

We summarize these results in the following Proposition.

Proposition 2. *A switch to complex targeting does not necessarily increase prices:*

1. *The price under complex targeting is always strictly smaller than the price under simple targeting.*

[17] The use of this relatively obscure distribution is due to the simplicity of its closed-form expression. It is closely related to the Beta distribution, which is more commonly used in economics. Given enough computing power, there is no limitation on using other, more common, distributions. For more detail on the Kumaraswamy distribution, see Appendix 8.3 or, for a more complete treatment, Jones (2009).

2. *If the price under complex targeting is*

    (a) *strictly monotone increasing in the advertising cost, then it is strictly smaller than the price under no advertising.*

    (b) ***not** strictly monotone increasing in the advertising cost, then it may be higher or lower than the price under no advertising.*

Proof. See Appendix 8.1. ■

The impact of complex targeting on price therefore highly depends on the counter-factual situation, i.e. the strategy that the firm uses when it does not have the possibility to use complex targeting. Moreover, this Proposition contrasts strongly with the literature on targeted advertising. In general, targeting is seen as a device that enables firms, especially in a monopolistic context (Esteban et al., 2001; Hernandez-Garcia, 1997), to reach consumers with a high valuation so that price can be raised. The reason for that difference is the correlation between valuation and information. The Proposition is illustrated in Figure 2.2.

The effect of complex targeting on consumer surplus also depends on the counter-factual. Formally, consumer surplus is:

$$CS_c = \int_{p_c}^{\bar{v}^*} f(v)(v - p_c)dv + \int_{\bar{v}^*}^{1} f(v)g(v)(v - p_c)dv, \quad (2.21)$$

$$CS_s = \int_{p_s}^{1} f(v)(v - p_s)dv \quad (2.22)$$

$$= \int_{p_s}^{\bar{v}^*} f(v)(v - p_s)dv + \int_{\bar{v}^*}^{1} f(v)(v - p_s)dv, \quad (2.23)$$

$$CS_n = \int_{p_n}^{1} f(v)g(v)(v - p_n)dv. \quad (2.24)$$

A switch from simple to complex targeting impacts consumers in two ways. There is a price effect which is unambiguously positive: consumers pay a lower price. But there is also a demand effect which is ambiguous: more consumers buy because of the lower price but other consumers stop purchasing because $\bar{v}^* < 1$. The identity of these consumers is important:

those who stop buying have $v \in [\bar{v}^*, 1]$ while the new consumers have $v \in [p_c, p_s]$. Clearly, the former exert a much stronger (negative) effect: they are exactly those who would benefit the most from a purchase. The monopolist does not internalize this at all since it can only set a single price.[18] A better targeting technology is therefore *not* synonymous with a higher surplus for all consumers despite a lower price. In other words, a lower price does not imply a Pareto improvement for consumers.

The ambiguity remains if we compare complex targeting with no advertising but for different reasons. There is always a positive demand effect because at least a few consumers receive ads and become informed. If $p_c < p_n$, demand increases even more, all consumers pay less and consumer surplus must increase. However, if $p_n < p_c$, demand decreases and consumers pay more: the impact of complex targeting is ambiguous.

The non-monotonicity of p_c carries on to consumer surplus: if p_c decreases in a, consumer surplus may increase in the advertising cost. These effects are illustrated in Figure 2.3 which displays a case where consumer surplus is monotonically decreasing in a everywhere (Figure 2.3a) and a case where is it is monotonically increasing in some parameter range (Figure 2.3b).

The ambiguous effects of complex targeting on consumer surplus also affect welfare: W_c, W_s, W_n, defined as the sum of profit and consumer surplus in each case. It is therefore unclear *a priori* whether the switch to complex targeting increases or decreases total surplus despite a possible lower price. The only exception is if p_c is monotonically increasing for all a. If so, welfare under complex targeting is higher than under no advertising because both consumer surplus and profit are higher.

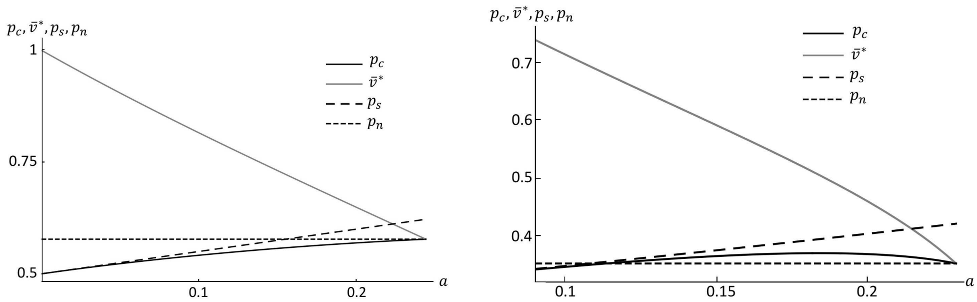
The non-monotonicity result also carries on to welfare. Generally, welfare decreases in a, but it may also rise (see Figure 2.4) if consumer surplus increases sufficiently so that the loss in profit is more than compensated. This result is possible not only because of the non-monotonicity of p_c but also because of the availability of two strategic variables: when a increases, the monopolist's profit is reduced (weakly) less than if it could only choose the price. These results are summarized in Table 2.1.

[18] See Section 6.1 for the case of perfect price discrimination.

Table 2.1: Summary of the effects of a switch to complex targeting.

Switch	Price		Consumers: Winners	Consumers: Losers	Consumers: Overall	Pareto improvement?
No advertising to complex targeting	p_c monotonically increasing in a for all a ($p_c < p_n$)		All	/	+	Yes
	p_c decreasing in a for some a	$p_c < p_n$	All	/	+	Yes
		$p_c = p_n$	New buyers	/	+	Yes
		$p_c > p_n$	New buyers	Those who buy under no advertising	?	No
Simple to complex targeting	$p_c < p_s$		Those who still purchase and new buyers	The high-valuation consumers who stop buying	?	No

Figure 2.2: Prices and targeting bound with different valuation distributions.

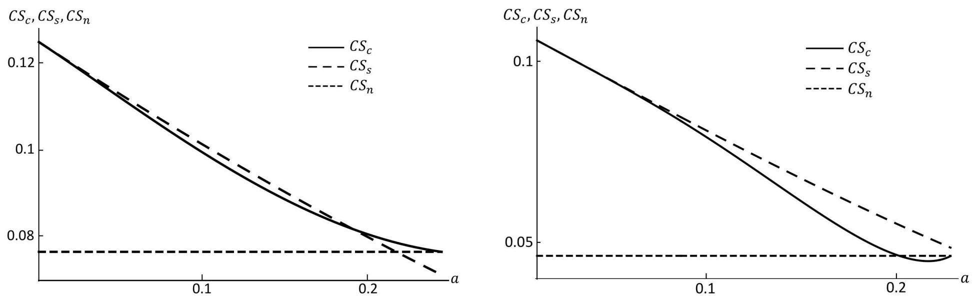


(a) $v \sim U[0, 1]$ and $g(v) = v$.

(b) $v \sim$ Kumaraswamy$(2, 5)$ and $g(v) = v$.

Notes: so that Figure 2.2b is as clear as possible, we only show the range where $a \in [0.09, 0.2288]$. If $a > 0.2288$, complex targeting is not optimal any more.

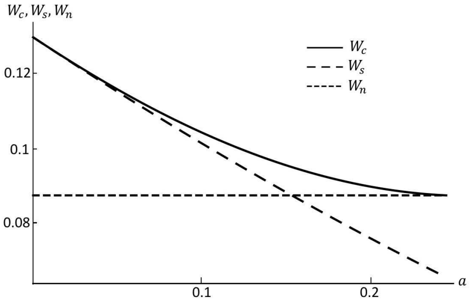
Figure 2.3: Consumer surplus with different valuation distributions.



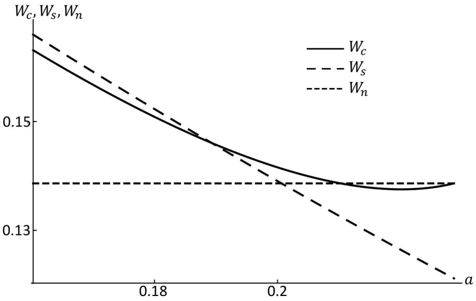
(a) $v \sim U[0, 1]$ and $g(v) = v$.

(b) $v \sim$ Kumaraswamy$(2, 5)$ and $g(v) = v$.

Figure 2.4: Welfare with different valuation distributions.



(a) $v \sim U[0, 1]$ and $g(v) = v$.



(b) $v \sim$ Kumaraswamy$(2, 5)$ and $g(v) = v$.

Note: so that the different effects are displayed clearly, we have restricted the parameter range to $a \in [0.16, 0.2288]$ on Figure 2.4b

5 First-best

Finally, we would like to compare the complex targeting outcome with what a social planner would choose. The social planner solves the following problem:

$$\max_{p,\underline{v},\bar{v}} W. \tag{2.25}$$

Where

$$\begin{aligned} W = CS + \Pi &= p\int_p^{\underline{v}} f(v)dv + (p-a)\int_{\underline{v}}^{\bar{v}} f(v)dv \\ &+ p\int_{\bar{v}}^1 f(v)g(v)dv + \int_p^{\bar{v}} f(v)(v-p)dv \\ &+ \int_{\bar{v}}^1 f(v)g(v)(v-p)dv. \end{aligned} \tag{2.26}$$

The first-order conditions, after some algebra, are:

$$\frac{\partial W}{\partial p} = -f(p)g(p)p = 0 \tag{2.27}$$

$$\frac{\partial W}{\partial \underline{v}} = g(\underline{v})\underline{v} + a - \underline{v} = 0 \tag{2.28}$$

$$\frac{\partial W}{\partial \bar{v}} = \bar{v} - g(\bar{v})\bar{v} - a = 0 \tag{2.29}$$

The first thing to notice is that the first-order condition with regard to p is never satisfied and the optimal value of p is 0. .

Proposition 3. *A social planner sets a lower price and targets more broadly than a monopoly firm.*

Proof. The part about price is obtained immediately from Equation (2.27). Regarding the lower bound, we have from Equation (2.13) that:

$$\left.\frac{\partial W}{\partial \underline{v}}\right|_{\underline{v}=p^*} = g(p^*)p^* + a - p^* < 0. \tag{2.30}$$

Similarly, for the upper bound, because $\bar{v}^* = g^{-1}\left(1 - \frac{a}{p_c}\right)$ and $p_c < \bar{v}^*$:

$$\left.\frac{\partial W}{\partial \bar{v}}\right|_{\bar{v}=\bar{v}^*} = g(\bar{v}^*)\bar{v}^* + a - \bar{v}^* > 0. \tag{2.31}$$

■

This is reminiscent of the classical result of Shapiro (1980): a monopolist advertises too little because it cannot extract the surplus of high valuation consumers who, here, are most likely informed anyway. Interestingly, contrary to the monopoly situation, there is a divergence between the lower bound and the price. This is due to the fact that the social planner takes into account (i) that trade increases welfare even for the consumers with low valuations but (ii) that it is welfare-decreasing to spend money on advertising to consumers whose gains from trade are low.

6 Discussion and extensions

We first discuss two assumptions informally and then analyse three extensions.

We have assumed that the monopolist knows the information function but it is not required to obtain our results. All we need is that the information the firm has be sufficiently fine-grained so that there are enough different groups of consumers with different levels of information. For instance, it may be enough to know information about two groups to obtain the results of the main model. Indeed, the incentive behind the results is still present: take advantage of consumer information to avoid sending costly ads to everyone. Many such examples can easily be built.[19] Because of discontinuities in the pricing and advertising strategies, there are two differences with the main model. First, the conditions under which complex targeting arises are more stringent as a

[19] For instance, suppose that v is distributed according to pdf $f(v)$ and that the information function is $g(v)$ but that the firm only knows the following: in group 1, the consumer with the lowest valuation has $v = 1/3$ and his probability to be informed is $1/3$. For the second group, these numbers are respectively $1/2$ and $3/4$. Each group has mass $1/2$. Then, it can be shown that valuation and complex targeting occur, respectively, if $0 \leq a < 0.0833$ and if $0.0833 \leq a < 0.0972$. If $0.0972 \leq a$, there is no advertising. In each case, the price is $1/3$.

change in $\bar{v}$ implies that a *whole group* does not receive advertising. Second, all results involving strict inequalities now involve weak inequalities for a similar reason. Otherwise, all our main conclusions are qualitatively similar.

Another debatable assumption is that consumers do not suffer directly from advertising. Suppose instead that there is a strictly positive nuisance cost δ so that a consumer with valuation v only has valuation $v-\delta$ if he sees an ad for the product. There is a single difference with the profit-maximization problem of Equation (2.1). Because advertising reduces the utility of consumers, it can be shown that the firm should set $\underline{v} = p + \delta$. Otherwise, the rest of the problem is very similar. The reason for the use of the lower targeting bound is that if $p = \underline{v}$ then the consumers with $v \in [p, p + \delta]$ do not purchase. Therefore, even though these consumers are poorly informed, the monopolist chooses not to send them ads so that there is still a chance that they purchase. Similarly, in the simple targeting case, the monopolist will also set $\underline{v} = p + \delta$.

Regarding welfare, a few differences should be noted. First, if there is a switch from no advertising to complex targeting, consumers who purchase under both scenarios lose some surplus if the nuisance cost is bigger than the price difference, even if complex targeting targeting leads to a lower price. This means that a lower price under complex targeting than under no advertising does not necessarily imply a Pareto improvement. Second, if there is a switch from simple to complex targeting, consumer surplus computations should take into account that consumers with $v \in [\bar{v}, 1]$, who purchase in both scenarios do not incur any nuisance cost under complex targeting.

If there was a positive nuisance cost, a social planner would still set the price equal to zero and it is therefore always lower than what a monopolist would set. The result (Proposition 3) on the scope of advertising unsurprisingly changes. Indeed, the social planner would have to take into account that advertising diminishes the surplus of consumers and this has to be traded off with the informative impact of advertising. The second part of Proposition 3 is therefore no longer always true.

6.1 The firm's information and personalized pricing

The ability to price discriminate depends on the information the firm possesses about consumers and on the information that $g(v)$ provides to consumers. If the monopolist only knows the distribution of valuation, its only possibility to price discriminate is if it sends ads through an intermediary that can tailor the ads so that each consumer sees a different price. Advertising is much more advantageous than in the baseline model because the firm can extract all the surplus from consumers who see ads but can only set a uniform price for the others. This strategy only works so long as the uniform price is always higher than the personalized prices, which is always true. Indeed, because the information function is non-decreasing, it should always be (if any) consumers with a high valuation who do not receive ads and hence, the uniform price is higher than the personalized prices. Otherwise, it may be that consumers observe different prices through the ads and through the information function. We thus make the following assumptions:

1. Consumers who receive ads face personalized prices (first-degree price discrimination).

2. Consumers who do not receive ads face a uniform price p.

Given that perfectly extracting the surplus of a consumer costs a, there are two reasons not to send him an ad: (i) because $v < a$ and (ii) because he is highly likely to be informed. The profit-maximization problem is the following:

$$\max_p \Pi^{ppd} = \max_p \left[\int_a^p (v-a) f(v) dv + p \int_p^1 f(v) g(v) dv \right]. \quad (2.32)$$

The uniform price simultaneously plays the role of price and of targeting bound (thereby making $\bar{v}$ useless). The first term represents profit made on consumers who face perfect price discrimination while the second term is profit on consumers who do not receive ads and face a uniform price.

Denote by $\tilde{p}$ the price that solves this maximization problem. We define valuation targeting as $\tilde{p} = 1$, i.e. all consumers face perfect price discrimination.[20] If complex targeting is used, then $\tilde{p} < 1$.

Not to advertise to a consumer is more costly than in the model with a uniform price. Instead of losing the price, the monopolist loses the entire valuation (minus the advertising cost) of the consumer. Therefore, the conditions under which complex targeting arises are more stringent than in the uniform price scenario. The first-order condition is:

$$\frac{\partial \Pi^{ppd}}{\partial p} = (\tilde{p} - a) f(\tilde{p}) + \int_{\tilde{p}}^{1} f(v) g(v) dv - \tilde{p} f(\tilde{p}) g(\tilde{p}) = 0. \tag{2.33}$$

And the requirement to have $\tilde{p} < 1$ is therefore:

$$\left. \frac{\partial \Pi^{ppd}}{\partial p} \right|_{p=1} < 0 \Longleftrightarrow 1 - a < g(1). \tag{2.34}$$

This is indeed strictly more stringent than the requirement to have $\bar{v}^* < 1$ in Section 3, which is $g(1) > 1 - a/p^*$. If this condition is satisfied, the firm increases its profit by using complex targeting.

Consumers also benefit unambiguously from complex targeting. Nothing changes for consumers who face perfect price discrimination in both cases: their surplus is zero. However, consumers with $v \in [\tilde{p}, 1]$ are bound to gain, despite the fact that some of them may stop purchasing because of the lack of ads. Under valuation targeting, they face perfect price discrimination and their surplus is zero. Under complex targeting on the other hand, they face a uniform price and consumer surplus has to be positive. The fact that some consumers face $\tilde{p}$ instead of v is the analogue of the $p_c < p_s$ result in Section 4. Formally, we have that:

$$CS_s^{ppd} = 0, \tag{2.35}$$

$$CS_c^{ppd} = \int_{\tilde{p}}^{1} (v - \tilde{p}) f(v) g(v) dv > 0. \tag{2.36}$$

[20] We do not examine the case of no advertising as it would only arise under extremely high advertising costs. It can be shown that in this case, complex targeting raises the price and has ambiguous effects on consumer surplus (a higher price but less informed consumers) and welfare.

Since both profit and consumer surplus increase, complex targeting also increases welfare. By taking information into account, the monopolist wastes less resources on advertising aimed consumers who are likely to be informed. Consumers benefit because some face a uniform price and obtain positive surplus. The conclusions therefore are slightly stronger than those in the main model.

This is not the only possible form of price discrimination. If the monopolist knows the valuation of each consumer instead of the distribution only, it can potentially set a personalized price for each consumer. Then, the precise role of the information function is important. We have assumed that it provides information on the existence and the price of the product, and instructs each consumer of his valuation. It is unclear what the price information would be in a model where all consumers face personalized prices. Possibly, it would imply that consumers who are informed through the information function may know the price quoted to others. This may be conducive to arbitrage and should make price discrimination more difficult to enforce.

6.2 The valuation of uninformed consumers

A major assumption of the model of Section 2 is that uninformed consumers have absolutely no information about the good, i.e. it is as if their valuation were $v = 0$. What happens if, instead, they know about the existence of the good but do not know their valuation, i.e. they have a common ex-ante valuation, and advertising/information reveals their true valuation? For instance, (uninformed) consumers may be aware of the distribution of valuation and may have an ex-ante valuation equal to $\mathbb{E}(v)$. Another example would be for uninformed consumers to hold all valuations as equally likely and thus to have an ex-ante valuation equal to $1/2$. This setting is closer to the literature on information provision (Johnson and Myatt, 2006).

Formally, suppose that uninformed consumers have valuation $\tilde{v} \in [0, 1]$. If $\tilde{v} = 0$, we are back to the main case. The monopolist has two strategies to maximize profit.

First, it can set $p \leq \tilde{v}$ and nearly all consumers buy: only those with $v < p$ *and* who are informed do not purchase the good. The downside is that

p is constrained to be low. Here, advertising has no role to play. Sending ads to consumers with $v < \tilde{v}$ would decrease demand and increase costs while sending ads to consumers with $v \geq \tilde{v}$ is useless: they are already buying and nothing more can be extracted out of them. In equilibrium, it is likely that the constraint is binding ($p = \tilde{v}$). Indeed, setting a lower price would mean a lost margin on all buyers while only attracting some of those with $v < \tilde{v}$ *and* who are uninformed.

Second, the firm can set $p \geq \tilde{v}$ and in that case, we are back to the general framework, with the additional price constraint. Indeed, without being informed or receiving ads, all consumers abstain from buying. The fact that $\tilde{v} > 0$ does not change anything to prices and surplus so long as the price constraint is not binding.[21]

Formally, profit is respectively:

$$\Pi = p \int_0^p f(v)(1 - g(v))dv + p \int_p^1 f(v)dv \quad \text{if} \quad p < \tilde{v}, \tag{2.37}$$

$$\Pi = (p - a) \int_p^{\bar{v}} f(v)dv + p \int_{\bar{v}}^1 f(v)g(v)dv \quad \text{if} \quad p \geq \tilde{v}. \tag{2.38}$$

The interesting impact of having $\tilde{v} > 0$ is thus that it increases the profitability of not advertising. So long as the monopolist chooses to advertise, the nature of our conclusions does not change.

In the framework of Johnson and Myatt (2006), the advertising we consider is always a demand shifter because it is perfect: the firm never advertises to a consumer who may purchase if he is uninformed but does not if he is informed. This is a hint that big data and the ability to target consumers more precisely may tilt the impact of advertising towards demand shifts rather than demand rotations.

[21] If the price constraint is binding but the monopolist still chooses to advertise, profit is reduced but consumer surplus (and welfare) is affected ambiguously. Indeed, while consumers suffer from the higher price, the constraint on p also has an impact on $\bar{v}$ and it is a priori unclear how these two effects interact.

7 Conclusion

Big data is a new fact of economic life and has many ramifications. We have analysed one in detail: the ability to relate valuation with information and to target ads accordingly. This new type of advertising is highly important for firms' strategies. By *not* advertising to the right consumers, firms could save a big part of their advertising budget. Interestingly, there are many settings in which this is not only good for them but also for (some) consumers because the price of the product decreases. This has already been taken into account by some high-tech firms such as eBay.

The results highlighted in this article also matter for academics. Complex targeting leads to counter-intuitive consequences that sometimes go against well-established results, the most important being that better targeting often reduces prices. These consequences show that both practitioners and academics cannot assume information away.

That said, for simplicity's sake, we have overlooked a number of important issues. First and foremost, there is no competition on the product market. One interesting aspect of the absence of competition is that not advertising only has one consequence: a few consumers might be uninformed and not buy. If there is a competing firm that could steal consumers away, there may be stronger incentives to advertise than in the current model.

Related to this is the fact that the information function is exogenous. Under competition, the process behind the information function may be much more important. For instance, whether it informs consumers about only one product (consumers read a review) or about a product category (consumers read a detailed comparison article) should lead to different conclusions. Another important question regarding the information function is *who* controls it: is it consumers (via a search process for instance) or the firm (via broad information or advertising campaigns)?

Finally, our model of the advertising market is an extreme reduced-form. It is not impossible that a switch from simple to complex targeting reduces the number of ads purchased. In that case, is it always in the interest of advertising firms to implement such an advanced targeting technology and under what conditions will they do so? Central to this question should be the evolution of the price of ads (which is constant in this article) with regard to the advertising technology. These questions are left for further research.

8 Appendix

8.1 Proof of Proposition 2

For the first part of the result ($p_c < p_s$), we simply compare the first-order conditions (Equations 2.16 and 2.17). We have that $p_c < p_s$ if:

$$\int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p}^{\bar{v}^*} f(v)dv - (p-a)f(p)$$

$$< \int_{p}^{1} f(v)dv - (p-a)f(p), \tag{2.39}$$

$$\iff \int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p}^{\bar{v}^*} f(v)dv < \int_{p}^{1} f(v)dv, \tag{2.40}$$

$$\iff 0 < \int_{\bar{v}^*}^{1} f(v)(1-g(v))dv. \tag{2.41}$$

This always true because there is always at least one $v \in [\bar{v}^*, 1]$ such that $g(v) < 1$:

$$g(\bar{v}^*) = g\left(g^{-1}\left(1 - \frac{a}{p_c}\right)\right) = 1 - \frac{a}{p_c} < 1. \tag{2.42}$$

For the second part of the result, let us start by showing that p_c is not necessarily monotonically increasing in a. By the implicit function theorem, we find that:

$$\frac{dp_c}{da} = \frac{\partial p_c}{\partial a} + \frac{\partial p_c}{\partial \bar{v}^*}\frac{\partial \bar{v}^*}{\partial a} = \frac{-f(p_c)}{\frac{\partial^2 \Pi}{\partial p_c^2}} + \frac{f(\bar{v}^*)(1-g(\bar{v}^*))}{\frac{\partial^2 \Pi}{\partial p_c^2}}\frac{1}{pg'(\bar{v}^*)}. \tag{2.43}$$

On the one hand, $\frac{\partial p_c}{\partial a} > 0$ because both the numerator and the denominator are negative, but on the other hand, $\frac{\partial p_c}{\partial \bar{v}^*}\frac{\partial \bar{v}^*}{\partial a} < 0$ because $\frac{\partial^2 \Pi}{\partial p_c^2} < 0$. p_c

is decreasing in a if:

$$f(p_c)p_c < f(\bar{v}^*)(1-g(\bar{v}^*))\frac{1}{g'(\bar{v}^*)}. \quad (2.44)$$

That $p_c < p_n$ if p_c is strictly monotonically increasing in a is derived from the fact that (i) p_n is constant in a and (ii) if a is sufficiently large (e.g. $a = 1$) then $p_c = p_n$. Hence, if p_c is strictly monotonically increasing in a, it must be that $p_c < p_n$.

Part 2 (b) of the result is proven with the example from Figure 2.2b. The PDF of the Kumaraswamy $(2, 5)$ distribution is $f(v) = 10v(1-v^2)^4$. Assuming that the conditions of Proposition 1 are fulfilled, profit and the first-order conditions are:

$$\Pi = (p-a)\int_p^{\bar{v}} 10v(1-v^2)^4 dv + p\int_{\bar{v}}^1 10^2(1-v^2)^4 dv, \quad (2.45)$$

$$\frac{\partial \Pi}{\partial p} = \int_{\bar{v}}^1 10v^2(1-v^2)^4 dv + \int_p^{\bar{v}} 10v(1-v^2)^4 dv$$
$$-(p-a)10p(1-p^2)^4 = 0, \quad (2.46)$$

$$\frac{\partial \Pi}{\partial \bar{v}} = p - a - p\bar{v} = 0. \quad (2.47)$$

Hence, we have $\bar{v}^* = 1 - a/p_c$. The expression of p_c is too complex to be written down. Targeted advertising arises so long as $0 < a < 0.2288$. Up to $a \simeq 0.1836$, p_c is increasing in a. If $a > 0.1836$, it is decreasing.

8.2 Second-order conditions

Assuming that $p = p_c$ and $\bar{v}^* < 1$, to satisfy the second-order conditions of the profit-maximization problem exposed in Equation (2.7), we require the Hessian matrix to be negative definite, which implies that the following inequalities should be satisfied:

$$\frac{\partial^2 \Pi}{\partial p^2} = -2f(p^*) - (p^* - a)f'(p^*) \leq 0, \tag{2.48}$$

$$\frac{\partial^2 \Pi}{\partial (\bar{v}^*)^2} = -p^* f(\bar{v}^*) g'(\bar{v}^*) \leq 0, \tag{2.49}$$

$$\frac{\partial^2 \Pi}{\partial p^2} \frac{\partial^2 \Pi}{\partial (\bar{v}^*)^2} - \left(\frac{\partial^2 \Pi}{\partial p^* \partial \bar{v}^*} \right)^2 \geq 0. \tag{2.50}$$

Let us start with Inequality 2.48. From, the first-order condition (with regards to p, Equation 2.16) of the profit-maximization problem, we know that

$$p^* - a = \frac{\int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p^*}^{\bar{v}^*} f(v)dv}{f(p^*)} \tag{2.51}$$

and therefore, after some algebra, Inequality 2.48 can be rewritten as

$$f'(p^*) \geq \frac{-2f(p^*)^2}{\int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p^*}^{\bar{v}^*} f(v)dv}. \tag{2.52}$$

We have assumed that f is log-concave and hence, it has a monotonically increasing hazard rate, which implies that

$$f'(p^*)(1 - F(p^*)) > -f(p^*)^2 \Longleftrightarrow f'(p^*) \geq \frac{-f(p^*)^2}{1 - F(p^*)}. \tag{2.53}$$

Because $1 - F(p^*) > \int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p^*}^{\bar{v}^*} f(v)dv$, we therefore have that

$$f'(p^*) > \frac{-f(p^*)^2}{1 - F(p^*)} > \frac{-2f(p^*)^2}{\int_{\bar{v}^*}^{1} f(v)g(v)dv + \int_{p^*}^{\bar{v}^*} f(v)dv}. \tag{2.54}$$

The log-concavity of f implies that Inequality (2.48) is always respected. Inequality (2.49) is always respected because $g' \geq 0$.

The last inequality implies that we should have:

$$\left[-2f(p^*) - (p^* - a)f'(p^*)\right] \left[-p^* f(\bar{v}^*) g'(\bar{v}^*)\right] - f(\bar{v}^*)^2 \left[1 - g(\bar{v}^*)\right]^2 \geq 0 \tag{2.55}$$

This is an additional assumption that must be imposed on the information function and the distribution of valuation. We strongly suspect that it is implied by log-concavity but have not been able to prove it yet. It is verified for all examples used in this article.

For instance, if v is uniformly distributed on $[0, 1]$ and $g(v) = kv$ with $0 \leq k \leq 1$, then, it can be shown that the condition to be satisfied is

$$k \geq \frac{a^2}{2p^3}. \tag{2.56}$$

It can be shown that this is always true.

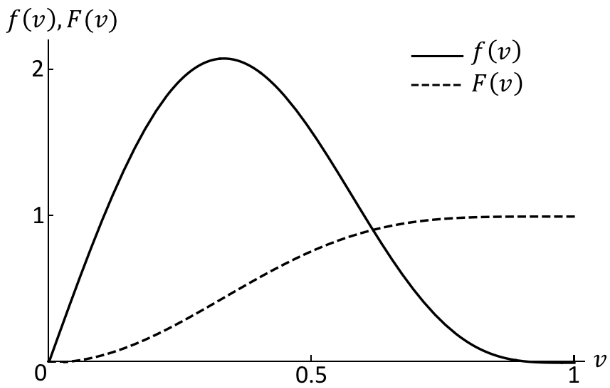
8.3 The Kumaraswamy (2,5) distribution

The Kumaraswamy (a,b) distribution has the following probability and cumulative distribution functions (PDF and CDF):

$$f(x) = abx^{a-1}(1-x^a)^{b-1} \quad \text{if} \quad x \in [0,1] \quad \text{and} \quad 0 \quad \text{otherwise} \tag{2.57}$$
$$F(x) = 1-(1-x^a)^b \quad \text{if} \quad x \in [0,1] \quad \text{and} \quad 0 \quad \text{otherwise} \tag{2.58}$$

The PDF and CDF of Figure 2.5 can be produced by setting $a = 2$ and $b = 5$. The main advantage of this distribution is that it has a simple closed form which allows us to have relatively complicated information functions and still be able to solve the model.

Figure 2.5: CDF and PDF of the Kumaraswamy (2,5) distribution.



Chapter 3

Competing Business Models and Two-Sidedness: an Application to the Google Shopping Case

Sébastien Broos, Jorge Marcos Ramos

Abstract

This paper provides a conceptual framework to help define relevant markets in the presence of two-sided intermediaries and competing business models. In particular, we argue that two-sidedness is not a feature of markets but of firms and hence, that firms with different business models may compete within the same relevant market. We then apply our framework to the Google Shopping case.
Keywords: Competition Policy; Abuse of Dominance; Two-Sided Intermediaries; Business Models; Relevant Market
JEL classification: D42, K21, L12, L41

Acknowledgments: We are thankful to Andrei Hagiu and Julian Wright for letting us use one of their figures. We also thank Nicolas Petit, Axel Gautier, the editor Bill Curran, and an anonymous referee for useful comments on previous drafts, and the participants of the 2015 Forum on Law and Governance in the Digital Era and of the 2016 Annual MACCI conference. This research was funded through the ARC grant for Concerted Research Actions, financed by the French-speaking Community of Belgium. The authors did not receive funding from any of the parties of the discussed cases.

1 Introduction

The definition of relevant markets in the context of antitrust proceedings continues to be an area of much contention (Kaplow, 2010, 2015). No wonder, much is at stake. Its boundaries will dictate market power considerations and the extent of anticompetitive foreclosure. In particular, the advent of the "new economy" has complicated the task of defining markets that accurately capture the competitive constraints that firms face.[1] The proliferation of two-sided intermediaries and the large window of opportunity that the Internet offers to swiftly implement a variety of business models have both brought an additional layer of complexity to this task.

In light of recent economic theory and a long-standing business strategy literature, this paper brings forward a conceptual framework to define relevant markets in the presence of two-sided intermediaries and different business models. It then applies the proposed framework against the current investigation of the European Commission in the "Google Shopping case". In short, Google has been accused of anti-competitively leveraging its dominant position from the general online search market into the online comparison-shopping market.

In the presence of two-sided intermediaries, we explain the circumstances under which antitrust authorities should define a single market encompassing both sides of the platform, as opposed to two interrelated markets. In the Google Shopping case, we propose that a single market should be defined. We argue that such a definition captures better the competitive constraints

[1] Commission Notice on the definition of relevant market for the purposes of Community competition law, OJ C 372, 9 December 1997, p. 5–13, at §2, ("Relevant Market Notice").

that Google faces.[2]

Moreover, the simultaneous presence of different business models that can be one-sided or two-sided further complicates the endeavour to accurately define markets. The Google Shopping case serves to demonstrate that a two-sided business model, such as that of Google, can compete head-to-head with other two-sided and one-sided business models, such as those that Amazon has in place. By "business models" we refer to the choice that firms face in the way they organize their interactions with buyers and sellers on the market. Essentially, it is the choice between four forms of organization: vertical integration, two-sided intermediary, input supplier or reseller.

Once we have accounted for the multifaceted competitive constraints that arise from different business models, and in particular those between Google and Amazon, we call into question the dominant position of Google in the Google Shopping case. The reason is that, when market dynamics are accurately understood, the role of Google is not that of an advertiser or a purveyor of search results but, more simply, that of an intermediary linking two sides of the same coin: consumers and retailers. In the case at hand, Google's main competitors are not necessarily only traditional advertisers or search engines but also other intermediaries or more traditional resellers. Therefore, we do not argue that Google never enjoys a dominant position but rather that, in the case at hand, it might not.[3]

The paper is structured as follows. First, we discuss definitions of two-sidedness, clarify some of the confusion surrounding two-sided intermediary and provide a workable definition. Second, we examine the differences between two-sided intermediary and other business models. We show that these different business models might compete and that two-sidedness is a decision of the firm and not a feature of markets. Third, we distinguish between cases where two-sidedness requires defining a single market that encompasses two sides and cases where two interrelated markets should be defined. Fourth, we

[2]We use the terms "platform" and "intermediary" interchangeably.

[3]We do *not* define an exact relevant market. This would require data to which we do not have access. Neither do we claim that Google has not degraded rivals. What we do claim is that even if Google has "misbehaved", it is unclear that Google has the dominant position required to trigger the application of Article 102 TFEU.

apply the insights of the previous three sections to the Google Shopping case. Finally, we conclude.

2 The contentious definitions of two-sidedness

It is no secret that the concept of two-sidedness or of two-sided intermediaries is not easy to define (Auer and Petit, 2015). It has a flavour of "you know one when you see one" but providing a clear and formal definition is difficult. Some scholars (Armstrong, 2006a; Evans, 2003) consider that the presence of indirect network effects between the different sides is an important attribute of two-sided intermediaries. Others, such as Rochet and Tirole (2006), argue that the defining feature of a two-sided intermediary is that the number of transactions occurring on the platform depends on the structure of prices –their ratio– and not only on the sum of the charged fees. For instance, if an intermediary decreases its price by 10% on one side and raises it by the same proportion on the other side –the ratio of the prices changes but not their sum– then, the number of transactions should be affected. The side that faces the price increase should not be able to completely pass it through to the other side (Filistrucchi et al., 2014).

The multiplicity and breadth of these and other definitions has made the task of distinguishing one-sided from two-sided intermediaries arduous. For instance, one would not consider shopping malls as two-sided under the definition of Rochet and Tirole (2006) but Rysman (2009) classifies them as such. Newspapers[4] are two-sided according to Anderson and Gabszewicz (2006) but not according to Luchetta (2014).

We use the definition developed by Andrei Hagiu and Julian Wright (Hagiu, 2007; Hagiu and Wright, 2014, 2015) in a series of recent papers. Firstly, because it encompasses the most important aspects of previous definitions without being so broad that it represents any type of firm. For example, it allows for network effects but does not require network effects. Secondly, this definition allows us to distinguish easily between two-sided intermediaries

[4]See Auer and Petit (2015) for a comparison of many industries under the light of different definitions.

and more traditional business models: resellers, vertically integrated firms and input suppliers (Figure 3.1). Finally, it seems that, following this definition leads to a classification of firms as two-sided or not which is natural, in the sense that it agrees with most commentators. For instance, newspaper are easily identified as a two-sided business, which, although not the consensus,[5] is the view of a majority of scholars.[6]

The first characteristic of two-sided intermediaries is that they enable *direct interaction between two (or more) sides.* It is the sides, not the intermediary, who control the most important variables of the interaction such as pricing, marketing efforts, etc. Secondly, it must be that both sides affiliate through the platform, i.e. the interaction requires that each side make some costly investment to join the platform. It can be explicit –a membership fee or the purchase of a required equipment– or implicit –an opportunity cost (going to mall A instead of mall B) or a transport cost (driving to the supermarket).

Definition 1. *A two-sided intermediary has two characteristics:*

1. *It enables direct interactions between two sides.*
2. *Each side is "affiliated" with the intermediary.*

Definition 2. *We consider that there are four business models. A firm can be*

1. ***Two-sided**, see Definition 1.*
2. *A **reseller** if it buys goods from one side and sells them to another.*
3. ***Vertically integrated** if it owns one side and sells to another.*
4. *An **input supplier** if it provides one side with an input that the side then sells, or transforms and sells, to the other side.*

The requirement of direct interaction separates two-sided intermediaries from resellers and vertically integrated firms. Indeed, in both cases, the two

[5]See e.g. Luchetta (2014)

[6]Anderson and Gabszewicz (2006), Ambrus et al. (2016), Argentesi and Filistrucchi (2007).

sides only interact via the intermediating firm. They do not interact with each other.

That is not true for input suppliers. However, in that case the second requirement is not respected: one side has no relation with the firm and is therefore not affiliated with it.

The definitions provided are reminiscent of the marketing literature. Buyers and sellers continuously resort to intermediaries to facilitate the exchange of goods that brought them to the market in the first place. Intermediation is thus a common feature of many markets that can adopt different shapes. In this respect, the marketing literature has consistently identified two main categories of intermediaries: merchants and brokers. On the one hand, a merchant or reseller is "an intermediary who purchases and then sells goods in the process of facilitating exchange between buyers and seller" (Hackett, 1992). On the other hand a broker is "an intermediary who facilitates exchange without buying and selling goods, and is compensated with a revenue-sharing commission." The fundamental difference between both means of intermediation is the way property rights are assigned; and eventually, the compensation structure.

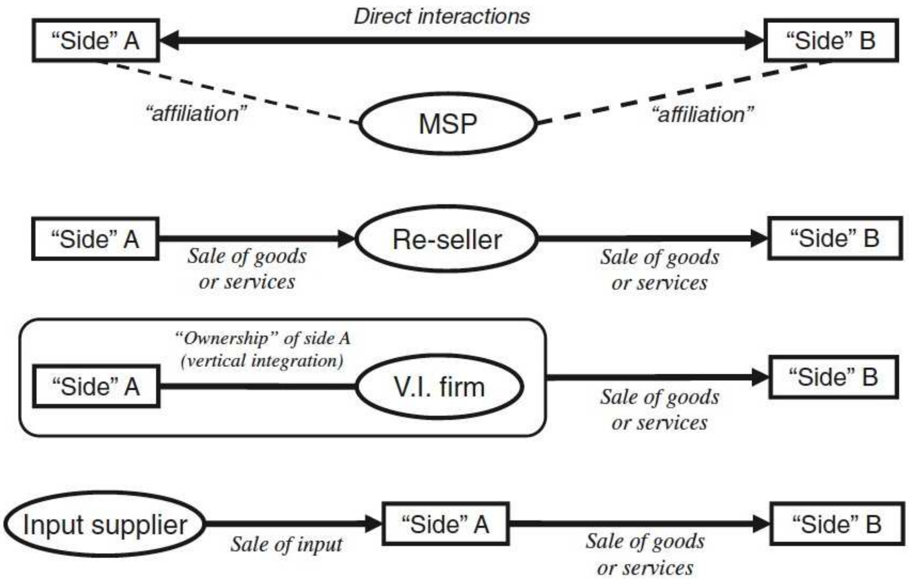
Now, by definition, brokers are all two-sided intermediaries but not all two-sided intermediaries are brokers. Indeed, because they derive revenue from a commission, brokers require an actual interaction to take place. In the case of two-sided intermediaries such as TV channels or newspaper, which link viewers/readers and advertisers, it is typically impossible to observe the actual occurrence of the interaction and therefore, a revenue-sharing commission system is not possible.

The examples discussed above are then easily classified. Both newspapers and shopping malls are two-sided intermediaries. Newspapers enable the direct interaction between readers and advertisers, both of which have chosen that particular outlet. Shopping malls enable the direct interaction between consumers and sellers who have both chosen that location to buy/sell.[7]

Conclusion 1. *Two-sidedness is difficult to define and different definitions*

[7] To be precise, consumers incur the cost of going to that precise mall while shops pay a rent at that particular location.

Figure 3.1: Figure 1 from Hagiu and Wright (2015). Different business models.



lead to different conclusions. The definition by Hagiu and Wright solves that problem and provides a workable framework for antitrust authorities.

3 Business model competition

One of the major advantages of the definition provided by Hagiu (2007) and Hagiu and Wright (2014; 2015) is that it identifies a common misrepresentation regarding two-sided intermediaries: "two sidedness" is not a characteristic of markets but of firms. This implies that firms with different business models may be competing within the same relevant market. Interestingly, this would not be controversial if it only concerned resellers, vertically integrated firms or input suppliers. Nevertheless, the proposition has encountered a certain amount of scepticism when two-sided intermediaries are present. First, we discuss the reasons why two-sidedness is a characteristic of the firm. Second, we review how the case law has been affected by the emergence of two-sided intermediaries.

3.1 Two-sidedness: a characteristic of the firm

As the attentive reader may have noticed, we have avoided using the term "market" when referring to two-sided platforms. This ambiguity, which we are not the first to notice,[8] is much more important than a terminological issue.

First, using the expression "two-sided market" in relation to a single company implies that this company is a market in itself. For instance, asking "Is Google a two-sided market?" (Luchetta, 2014) already presupposes that Google *is* a market. In turn, such misleading assumption would place Google under severe scrutiny from the antitrust authorities who would –*prima facie*– consider Google a monopoly. Arguably, this mistake is due to the emergence of the concept of two-sidedness in the economics literature where the term "market" is defined broadly and used in many different ways and contexts. The legal literature and, more importantly, practitioners and authorities should avoid confusing the broad term "market" used in economics with the more specific term "relevant market".[9]

The Commission and firms involved in antitrust proceedings have not been immunized against this confusion. For instance, in *Access/PLG*, the Commission considered whether the recorded music market should be viewed as a "two-sided market"; and in *BNP Paribas Fortis/Belgacom/Belgian Mobile Wallet JV* the notifying parties claimed to operate in a two-sided market.[10]

Second, the term "market" would also lead us to think that two-sidedness is a feature of the market (" *'Two-sided' markets have two different groups of*

[8] For instance "The term 'market' was meant loosely and does not refer to how that term is often used in antitrust." in Evans and Schmalensee (2007).

[9] Commission Notice on the definition of relevant market for the purposes of Community competition law OJ C 372, 9.12.1997, p. 5–13, at §3: "the concept of 'relevant market' is different from other definitions of market often used in other contexts. For instance, companies often use the term 'market' to refer to the area where it sells its products or to refer broadly to the industry or sector where it belongs."

[10] Case COMP/M.6884 - *ACCESS/PLG*, at §21. Also parties to the proceedings seem to fall in this confusion. In Case COMP/M.6967 - *BNP Paribas Fortis/Belgacom/Belgian Mobile Wallet JV* the notifying parties claimed to operate in a two-sided market, at §15. In the *Microsoft / Yahoo! Search Business* decision, the Commission correctly identified the Yahoo, Bing and Google search engines as two-sided platforms. By way of contrast, Case COMP/M.5727 - Microsoft/Yahoo! Search Business, at §100, where the Commission correctly identified Yahoo! Bing and Google search engines as two-sided *platforms*.

customers that businesses have to get on board to succeed", Evans (2003)). In reality, the opposite is true: two-sidedness is a characteristic of the firms or of their business models. A simple proof of this is the coexistence of two-sided and one-sided intermediaries in many markets, if not within the same firm. Rysman (2009) already noted this:

"Of course, one-sided markets have intermediaries, too. [...] Strikingly, one-sided and two-sided selling strategies exist side-by-side at Amazon.com. For some products, like certain new books, Amazon (basically) buys at a wholesale price and sells for a retail price, which is a one-sided model. But for many other products, Amazon provides a web portal for a producer that sets the retail price that a consumer would see. As this distinction often depends on the decisions of the intermediary rather than on purely technological features of the market, it may be better to use the term 'two-sided strategies' rather than 'two-sided markets'."

Therefore, the use of the term "market" hides the fact that if two-sidedness is a choice, then different firms can make different choices and that does *not* imply that they are necessarily operating in different markets. If we mistakenly define two-sidedness as a feature of markets, firms that do not operate as two-sided intermediaries would be automatically excluded from the relevant market and its definition may be too narrow.

Examples abound. For instance, shopping malls (Armstrong, 2006b), could compete with single-brand stores, which are not two-sided intermediaries but rather vertically integrated structures. Free-TV (Armstrong, 2006a) might compete with video on demand but the VOD service is only a one-sided reseller. Software producers (Rochet and Tirole, 2006) may be two-sided – OpenOffice needs to attract both consumers and developers – or one-sided – Microsoft employs the developers.

Economic theory also seems to disagree with the idea that different business models imply different relevant markets. Calvano and Polo (2016) show that starting from the exact same conditions and characteristics, two firms can choose different business models, not to be in two different relevant markets, but rather to relax competition *within* the same market. Different business models can therefore be proof of the existence of competitive constraints rather than proof of their absence. These are the competitive constraints that market definition efforts seek to unveil.[11] Similarly, in a series of papers, Hagiu and Wright (2014; 2015) show that a single firm selling to the same consumers can decide to use different business models. For instance, they argue that a firm should privilege two-sidedness when it does not have a lot of information about the goods sold, for example when there are many varieties. Certainly, it should be recalled that one of the requirements of the definition of two-sidedness highlighted earlier is that it is the sides that should control the most important strategic variables. It is intuitive that it is the most informed parties that should control decisions such as pricing and marketing.

It follows that even a market where all firms are two-sided is *not* two-sided in itself, and conversely. For instance, the retail market may have appeared to be a clear-cut one-sided market until technology made it possible for Amazon Marketplace and the likes to exist. To avoid distortions of market realities the terminology "two-sided intermediaries" or "two-sided platforms" rather than "two-sided markets" should be employed.

3.2 Merger control in the broadcasting industry

As the merger control activity in the broadcasting industry shows, the view that two-sidedness is a feature of the firm is a source of discrepancies between competition authorities. It also shows the importance that business models have had in defining *markets* (Filistrucchi et al., 2014). On the one hand, the European Commission considers that existing different business models are an indication of different relevant markets. On the other hand, the Competition and Markets Authority in the UK ("CMA") considers that different business models can coexist and compete within the boundaries of the same relevant antitrust market.

Broadly speaking TV broadcasters operate pay-TV and/or free-TV businesses. The main question is whether pay-TV and free-TV are considered as different relevant markets or rather should be defined as an all-TV market.

[11] Relevant Market Notice, "The purpose of market definition is thus to identify in a systematic way the competitive constraints that the undertaking involved faces" at §2.

Put another way, the underlying and fundamental consideration is whether these business models (pay-TV and free-TV) are different ways of financing the same activity, i.e. broadcasting television services, or on the contrary are representative of different relevant markets.

In *BSky/KirchPayTV*,[12] *News Corp/Premiere*[13] and *Antena3/La Sexta*[14] the Commission justified its view that pay-TV constituted a separate relevant product from the free-TV market based on the different financing mechanisms under which each business operated. "*While, in the case of advertising-financed television, there is a trade relationship only between the programme supplier and the advertising industry, in the case of pay-TV there is a trade relationship between the programme supplier and the viewer as subscriber.* ***In view of these trade relationships, the conditions of competition are accordingly different for the two types of television.***"[15] (Emphasis added)

Interestingly the CMA has taken a divergent approach. In *BSky/ITV* the CMA defined *one* relevant market –the market for all-TV[16] – comprising different business models: pay-TV and free-TV; and identified the two-sided strategy of the business models.

Conclusion 2. *Two-sidedness may be a business decision and not necessarily a feature of the market. Therefore, two-sidedness does not define the boundaries of a market and firms with different business models can compete within the same market.*

4 Single or separate markets?

As hinted above, the proper definition of a relevant market in cases involving two-sided intermediaries is a complex stumbling block for economists. A

[12]Case COMP/JV.37 – *BSky/KirchPayTV*. BSky was a broadcaster of pay-TV channels in the UK wanting to acquire joint control of KirchPay TV, a pay-TV operator in Germany and Austria. The Commission cleared the transaction subject to commitments.

[13]Case COMP/M.5121 – *News Corp/Premiere*.

[14]Case COMP/M.6547 – *Antena 3/La Sexta*, at §16.

[15]Case COMP/JV.37 – *BSky/KirchPayTV*, at §24.

[16]OFT in *BSky/ITV*, Dec. 14, 2007, at §§4.30-4.31.

particularly difficult question is whether the relevant market should encompass both sides, or whether two interrelated relevant markets, one for each side, should be defined (Filistrucchi et al., 2010, 2014). Some commentators have discussed this riddle and both arguments in favour and against single or separate relevant markets have been made. For instance, Hoppner (2015) considers that defining a single relevant market for a variety of multisided intermediaries cannot work because each side requires an independent substitutability analysis. On the contrary, Ratliff and Rubinfeld (2014)[17] argue that defining one relevant market per side may understate the interdependence of the sides.

We contend that the most important factor to defining a single relevant market is whether it is *feasible* for a two-sided firm to stop being two-sided. In other words, to cease serving one of the sides that makes it two-sided. In that case, we propose that two (interrelated) markets should be defined. Otherwise, both sides should be included in the definition of a single market.

The argument supporting the first assertion is intuitive: if it is feasible for the firm to interact with only one of the sides which make it two-sided, then a market definition that encompasses both sides is unsound because it ignores the (potential) competition coming from firms which operate on one side only.

A necessary condition for a firm to be able to interact with only one of the sides is that this side derives a positive utility from its affiliation to the platform regardless of the presence of the other side. For instance, in the music-streaming service Spotify, consumers can either choose the free version but listen to advertisements once in a while, or pay 9.99$/month and enjoy an ad-free version (and some other advantages such as premium quality). There are thus three possible sides in this market: listeners, advertisers and artists. Using our classification, when it is free, Spotify is a two-sided intermediary because it links advertisers and listeners, but it does *not have to be* two-sided as its premium version shows –it is then a simple reseller. Similarly, one of its competitors is TIDAL which only offers a paying ad-free version. In other words, it is *feasible* for Spotify to stop being two-sided and to focus

[17]Their research was financed by Google. Along the same lines, see Wiethaus (2015).

on the sale of music to listeners. A single-market definition encompassing both advertisers and listeners would understate the true competitiveness of the market by excluding potential competitors and even the own premium version of Spotify.

Other goods for which two markets may have to be defined are newspapers and TV channels. For instance, whereas most newspapers feature advertisements, the French "Le Canard Enchaîné" is a (profitable) ad-free satirical newspaper.[18] In that case, the membership utility derived by readers stems from the vertical integration of content (articles) and medium of distribution (the newspaper itself).

If a two-sided firm cannot *feasibly* serve one side only, then it must be that what the firm sells is the connection or the interaction between the sides. Therefore, the relevant market to be defined is one describing the particular interaction provided. Because, by definition, the interaction requires both sides to be on board, a single market encompassing the two sides should be defined. Heterosexual dating clubs and payments card systems are examples of situations where a two-sided firm could never be present on one side only.

Now, what do we mean when we say that it is "feasible" for a firm to stop being two-sided and having relations with one side only? This question has no obvious answer but there are two conditions, one necessary and one sufficient, which could guide lawmakers and agencies. The necessary condition has already been discussed: it has to be that one of the sides that makes the intermediary two-sided derives utility from its interactions with the intermediary, regardless of the presence of the other side. Spotify users listen to music, newspaper readers read news articles, TV viewers watch TV shows. This does not suffice however. For instance, it might simply be immensely more profitable to serve both sides rather than one even though it would *technically* be possible. The sufficient condition is the presence of a sizeable competitor which is already organized as one-sided.

Our criterion is close but not identical to that of Filistrucchi et al. (2014)

[18] Beardsley, Eleanor. "At 100, A French Newspaper Thrives – With No Ads And A Minimalist Webpage." Parallels, Dec. 29, 2016, available at `http://www.npr.org/sections/parallels/2016/12/29/506601779/at-100-a-french-newspaper-thrives-without-ads-or-a-website`.

and Filistrucchi et al. (2010). They propose that a single market should be defined if the interaction between the two sides is observable as that allows the firm to charge a transaction fee. They call this a "transaction market". If the interaction is not observable, it is thus a "non-transaction market", and only a membership fee can be charge. Therefore, two (interrelated) markets should be defined.

Essentially, the core of both definitions is whether the market is that for transactions/interactions. However, we take a more dynamic approach, highlighting that the commercial focus on selling the interaction may be the choice of the firm. If it is indeed a choice, potential competitors may have chosen to focus on selling membership instead of interaction and excluding them from the market definition would understate the true competitiveness of the market. In other words, if two-sidedness is a choice, the market definition should include other possible business models.

The more dynamic approach seems to better reveal market realities and is clearly shown if we consider again our example of Spotify and TIDAL. Using Filistruchi et al.'s criterion, free Spotify is part of a transaction market and therefore, only one market encompassing advertisers and listeners should be defined. TIDAL and Spotify Premium would then be excluded from the market. That said however, in many instances the criteria converge.

The lack of a theoretical framework elucidating when to define either a single or separate markets might explain why the decisional practice of the European Commission has rolled around. In the case concerning the acquisition of DoubleClick by Google, the Commission ventured into defining one relevant market for "*online advertising* ***intermediation*** *activities*[19]" (Emphasis added). In the well-known VISA case, the Commission acknowledged that the two-sided nature of "*card payment systems*" deserved the definition of *one* relevant market. The Commission could thus consider existing competitive constraints between different payment card schemes but it did not concede on VISA's claim that card payment systems competed in a larger "payment systems" market.

However, the Commission has also defined different relevant markets where

[19]COMP/M.4731 – *Google/ DoubleClick*, at §86

two-sided intermediaries are involved. Its position was clearly stated in *MasterCard* where it defined two relevant markets and strongly opposed the consideration that two-sidedness meant defining one relevant market: "*Two sided demand* ***does not imply the existence of one single joint product****.*" (Emphasis added). It is interesting to note that MasterCard appealed the decision and did not challenge the market definition before the General Court. However, it appears that while MasterCard overlooked in first instance the importance of such differentiation, it sought to remedy this before the Court of Justice. The ground was rejected: "*the appellants have not directly challenged the General Court's assessment in respect of that definition, namely the acquiring market*".[20]

In light of the above, it is safe to consider that the Commission has left the door open to defining one relevant market in cases where two-sided intermediaries are involved. It seems it will be for the parties to prove the pertinence of defining only one market.

Conclusion 3. *A single market should be defined for both sides of a two-sided intermediary if two-sidedness is the only business model feasible for the firm. Otherwise, two (interrelated) markets, one for each side, should be defined.*

5 Two-sidedness and business model competition in the Google Shopping case

Now that the ambiguities surrounding two-sided intermediaries have been clarified and a clear framework of analysis has been established we proceed to apply the learnt insights to the Google Shopping case.

5.1 The facts of the Google Shopping Case

In November 2010, the European Commission ("Commission") opened an investigation into Google's alleged abuse of a dominant position in the "online

[20]"In the present appeal, the appellants have not directly challenged the General Court's assessment in respect of that definition, namely the acquiring market", C-382/12P, *MasterCard v Commission*, ECLI:EU:C:2014:2201, at §159.

search" market.[21] Six years later the investigation is still ongoing. The original view that the case would be closed under the commitment procedure (Article 9) has been swept away by the issuance of a Statement of Objections ("SO"), suggesting that the case will most probably[22] end up with an infringement decision (Article 7).[23]

In turn, the Commission's allegations have shrunk. The SO was issued in April 2015[24] and reinforced by a supplementary SO in July 2016.[25] In a nutshell, the Commission, in this "Google Shopping case", considers that Google is dominant in the market of "general online search" and leverages its position into the "comparison shopping market" by treating Google Shopping in a more favourable way than Google Shopping's competitors. Notably, the Commission's supplementary SO states that comparison-shopping services (such as Google Shopping) and merchant intermediaries (like Amazon or eBay) "belong to separate markets". This statement makes the Google Shopping investigation an ideal case study to which to apply our framework.

The remainder of this section is structured as follows. First, we describe the business models of Google (Search and Shopping) and Amazon. Secondly, we show that the parts of these firms organized as two-sided intermediaries belong to a single market. Thirdly, we explain why the section of Amazon organized as a reseller should also be included in that market, despite not

[21] Press Release, European Commission – IP/10/1624, "*The European Commission has decided to open an antitrust investigation into allegations that Google Inc. has abused a dominant position in online search*". Available at http://europa.eu/rapid/press-release_IP-10-1624_en.htm

[22] Commissioner Vestager has hinted that a commitment decision is not completely excluded. Jean Leymarie, *Margrethe Vestager: "Un accord avec Google est encore possible"*, Oct. 22, 2015, France Info.

[23] Council Regulation (EC) No 1/2003 of 16 December 2002 on the implementation of the rules on competition laid down in Articles 81 and 82 of the Treaty OJ L 1, 4.1.2003, p. 1–25.

[24] The SO is not public. The factual information relating to the Commission's probe is mainly retrieved from the press release, available at http://europa.eu/rapid/press-release_MEMO-15-4781_en.htm

[25] Both SOs drop the concerns regarding exclusivity obligations on advertising partners and portability restrictions of online advertising campaign data, and focus on the more favourable treatment that Google allegedly gives to its price comparison service: Google Shopping. According to the Commission, Google's own algorithm mechanism should treat its service and those of its rivals in the same way.

being two-sided.

5.2 The firms

5.2.1 Google Search and Google Shopping

Google Search is a core search engine that provides links to consumers in response to their queries. There are two types of links, organic and sponsored. "Organic links" are provided for free as neither consumers nor websites pay for them. "Sponsored links", on the other hand, are paid for by advertisers. More precisely, each time a consumer clicks on a sponsored link, the advertiser pays Google. The fee is determined using auctions.[26] Advertisers bid for a keyword and the one bidding the most wins the auction and the sponsored link. A sponsored search ad mostly contains the name of the website and a brief description of it. Sponsored links and organic links are visually different (Figure 3.2).

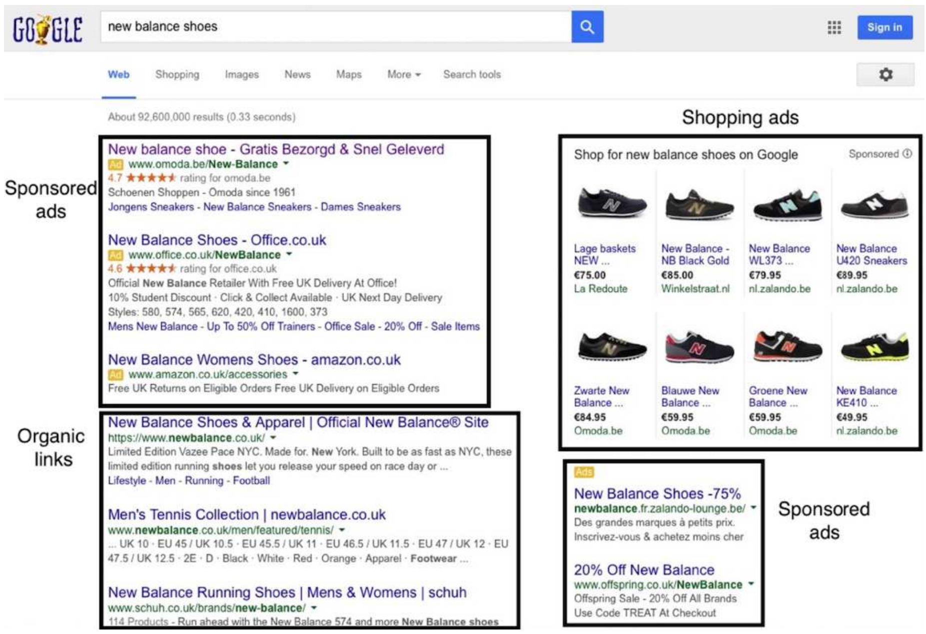
Google Shopping is a vertical search engine that only provides links to certain types of queries. Prominent examples of vertical search engines are kayak.com for flights or booking.com for hotels. Google Shopping is, as its name suggests, specialized in online shopping. All links provided are paid for by advertisers who, as in Google Search, set prices through auctions. Advertisers pay Google per click on their ad. Importantly, Google Shopping ads display more information than typical sponsored search ads. A picture of the good is usually shown as well as its price. Google Shopping can therefore be seen as a premium version of sponsored ads.[27] Finally, let us highlight that Google does not own any of the goods sold or listed on Google Shopping. Moreover, no sale actually takes place on Google Shopping. Rather, consumers buy on the merchant's website after having clicked on its ad. Figure

[26] The process is far more complex. For instance, the quality of the link plays an important role and the highest bidder will not necessarily win the auction if Google deems its quality is poor. Moreover, the highest bidder does not pay its bid but rather a function of the bids of the next highest bidders. For more information on sponsored search auctions, see Varian (2007) and Edelman et al. (2007).

[27] According to a report by Searchmetrics, in the second quarter of 2014, average cost-per-click is 1.63$ for Shopping and 1.07$ for sponsored links. Click-through rates were respectively 5.91% and 4.91%. Searchmetrics, *White paper: Google Shopping and Adwords. The 10 most important players,* 2015.

3.2 displays a screenshot where the two products have been highlighted.

Figure 3.2: Screenshot of the results from a query on google.co.uk



Both Google Search and Google Shopping are two-sided intermediaries –a statement often asserted but rarely proven. Following our definition, to ascertain whether a firm operates as a two-sided intermediary two requirements must be met.[28] First, it must enable a direct interaction between both sides. Both in the case of Google Search and Google Shopping there is a clear interaction in the form of a traceable click from a consumer to the ad placed on Google's webpage. It is the seller and not Google that sets the price of the good and takes all the important decisions regarding its commercialization (e.g. it decides to advertise via Google and to set up a bid).

The second requirement is that each side must be affiliated to the intermediary. Both consumers and advertisers are affiliated to Google Search

[28]Under other traditional definitions, it is not clear that Google is a two-sided market. For example, Manne and Wright (2011) and Luchetta (2014) argue that it is not (or at least, that it is unclear) because network externalities are only running in one direction namely, advertisers care about the number of consumers but consumers do not care about the number of advertisers. Nevertheless, as discussed above, network externalities are not an essential characteristic of two-sided intermediaries.

and Google Shopping. Consumers incur an opportunity cost: they choose to spend their time searching on Google instead of doing something else (e.g. searching on Bing). Advertisers spend their advertising budget on the Google platform.

There is thus no ambiguity: Google Search and Google Shopping are two-sided intermediaries. To make the terminology as clear as possible, we will refer to both Google Shopping and Google Search as "Google".

5.2.2 Amazon

Other possible competitors of Google could have been chosen to illustrate the framework set out above (eBay for instance). Indeed, Google has more competitors than may appear at first glance. The reasons for choosing Amazon are threefold. Firstly, the Commission considers that Amazon does not belong to the same relevant market as Google.[29] Secondly, Amazon uses several business models. This allows us to compare how competition between two-sided intermediaries and competition between two-sided intermediaries and resellers occurs. Thirdly, we chose Amazon for its economic strength and value.[30] If Amazon belongs to the same relevant market as Google then Google's dominant position is at the very least shaky.

Amazon.com (and its national equivalents) is a vertical search engine specialized in online shopping. There are roughly two types of products sold by Amazon.[31] The first kind is products that Amazon sells directly to con-

[29]On the anecdotic side, Google has explicitly identified Amazon as one of its main competitors. Eric Schmidt, *The New Gründergeist*, available at `http://googlepolicyeurope.blogspot.be/2014/10/the-new-grundergeist`. *"But, really, our biggest search competitor is Amazon"*. Amazon has also identified firms operating both web search engines and comparison-shopping websites as its competitors. "*The international marketplace in which we compete is evolving rapidly and intensely competitive, and we face a broad array of competitors from many different industry sectors around the world. Our current and potential competitors include: [...] web search engines, comparison shopping websites, social networks, web portals, and other online and app-based means of discovering, using, or acquiring goods and services, either directly or in collaboration with other retailers*". Amazon.com, Inc, "Annual Report Pursuant to Section 13 Or 15(D) of the Securities Exchange Act of 1934" December 31, 2015.

[30]In 2014 Amazon's global revenue was about 89 billion dollars, `http://finance.yahoo.com/q/is?s=AMZN&annual`.

[31]There is actually a third type of product: ads. The analysis we perform can also be

sumers and Amazon acts as a reseller: it buys goods from producers, sets prices and sells to consumers. We call this "Amazon Reseller". The second kind of products are those owned by third-party sellers but displayed and sold through Amazon. This service is called "Amazon Marketplace". Depending on the size of the seller, it either pays a fixed fee and a commission or only a commission. Importantly, it is the sellers who set the prices of their products. When Amazon operates under the Amazon Marketplace business model, we categorize it as a two-sided intermediary. There is a clear interaction in the form of an observable purchase and both sides are affiliated to the intermediary: consumers browse and buy on Amazon while sellers decide to sell their goods there.

On the other hand, Amazon Reseller is *not* a two-sided intermediary. While the affiliation requirement is satisfied for the same reasons as for Marketplace, there is no direct interaction: sellers and buyers do not interact with each other but only with Amazon. Indeed, in this case it is Amazon that controls the most important variables: it sets a price and decides on the marketing strategy on the Amazon website (e.g. should it be placed on the homepage of Amazon? Should it be the first result of a particular search? Etc.). Figure 3.3 displays a screenshot of a product search on Amazon.

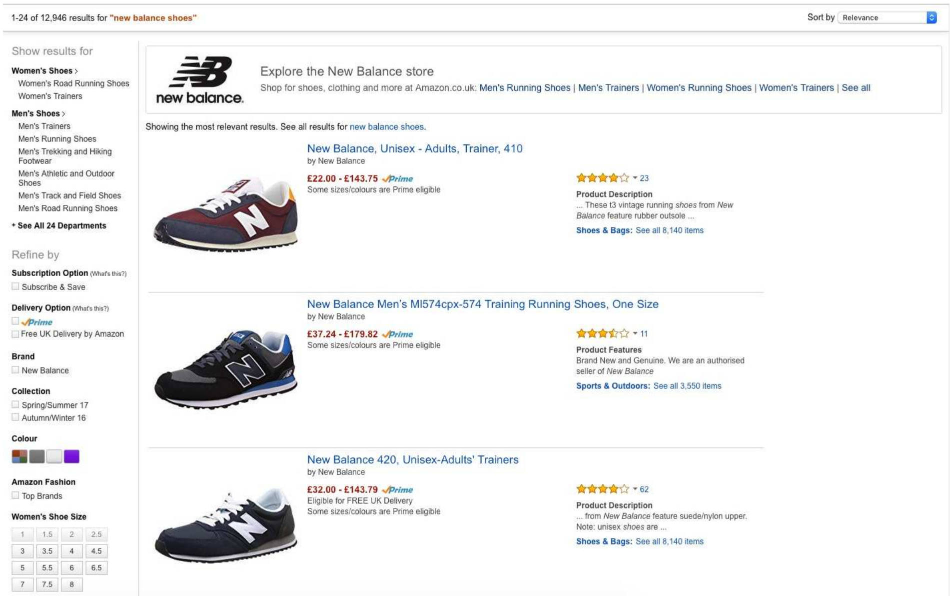
Application 1. *Google Search, Google Shopping and Amazon Marketplace are two-sided intermediaries. Amazon Reseller is a reseller.*

5.3 The market definition for two-sided intermediaries

As we discussed above, not all two-sided intermediaries operate in a market defined as encompassing both sides. Thus, the first question to answer is whether the market(s) in which Google Search, Google Shopping and Amazon Marketplace operate should encompass both sides of their respective platforms. Secondly, we must determine whether these two-sided intermediaries compete in the same relevant market.

applied to this side of Amazon's business. As of now, this is not a very important part of Amazon's revenues and we ignore it. However, it would not affect our main conclusions.

Figure 3.3: Screenshot of the results from a query on amazon.co.uk



5.3.1 A single market encompassing both sides

If firms cannot *feasibly* serve one side only, then it must be that what the firm sells is a particular interaction. This is in fact the core business of Google Search, Google Shopping and Amazon Marketplace. The service that they offer and are paid for is the intermediation that they provide between consumers and manufacturers.

That said, while Amazon does not satisfy our necessary condition for two markets to be defined –users would not derive any utility from Amazon in the absence of sellers –Google does –many queries lead to organic-only results. Hence, it would theoretically be possible for Google to sell the access to its search results and to stop showing ads. We are however not aware of a single search engine that uses or has used this business model. It is difficult to believe that Google would be able to make users pay when other search engines are all free and ads are not overly intrusive.

In our case study, this implies that it is unsound to refer to a "search market" or an "advertising market". What Google provides is a link between buyers and sellers. The same is true of Amazon Marketplace: it sells a link between buyers and sellers. It follows that, unlike what the Commission has stated, the market in which Google Search operates is therefore not "general online search".

Application 2. *The market(s) where Google Search, Google Shopping and Amazon Marketplace operate require defining a single market that encompasses both sides of their respective platforms.*

5.3.2 Google Search, Google Shopping and Amazon Marketplace belong to the same relevant market

Now that is clear that Google Search, Google Shopping and Amazon Marketplace are two-sided intermediaries selling an interaction between the two-sides of their respective platforms, the next step in the analysis is to corroborate whether the transaction they offer belongs to the same relevant market.

The Notice on Market Definition of the EU Commission states that "*a relevant product market comprises all those products and/or services which are regarded as interchangeable or substitutable by the consumer by reason of the products' characteristics, their prices and their intended use*". Thus, to corroborate whether Search, Shopping and Marketplace compete in the same market we must analyse whether customers on each side, be they consumers, advertisers or retailers, see them as effective substitutes. These are the questions that we try to answer in this subsection following the price, characteristic and intended use framework.

In the age of "big data", this return to qualitative analysis may surprise the reader. However, traditional tools such as the SSNIP test suffer, in this case, from insurmountable difficulties. Indeed, besides traditional issues with the SSNIP test (Filistrucchi et al., 2014; Filistrucchi, 2008; Evans and Noel, 2008) in two-sided markets, two other issues make it complicated to use in this particular setting. First, one side, consumers, does not pay anything (to the intermediary) and firms have to compete on other attributes which are less quantifiable, such as quality. There is no way for the SSNIP test to capture that aspect. Second, in the case of Google and Google Shopping, there are millions of prices, one for each keyword paid by advertisers, and they are constantly changing. Millions of prices mean millions of different situations. It is difficult to appreciate how using the SSNIP test on such a large scale, and with such fast-moving prices, would result in meaningful conclusions. Moreover, because each keyword is sold through an auction, using the SSNIP might lead to the extreme conclusion that each keyword auction is a market in itself (Parr et al., 2005).

Google Shopping and Google Search are not always in the same relevant market. Indeed, in many instances, while sponsored ads are displayed, Shopping ads are not. It must therefore be that in these cases Google considers that Shopping links are not useful to consumers. Either they would not click and the limited available space on the page would be wasted, or they would and results would be irrelevant, leading to displeased consumers and advertisers. The reason why they do not appear does not matter, the important point is that if Shopping ads are not displayed, there is, by definition, no scope to degrade anyone. It is therefore only worth considering those instances in which both sponsored ads and Shopping ads appear together.

That Google Search and Google Shopping results are substitutes is easy to see: Google itself knows that the *intended use* of consumers will lead them to click on both types of ads. Otherwise, it would be economically unsound to display both kinds and lose advertising space that Google could sell to other advertisers. The nature of both types of ads is that they answer the same intrinsic need of consumers: the search for a website selling a particular good. Consumers clicking on a sponsored ad or a Shopping ad expect the same result: a good that corresponds to his search.

The same is true for Amazon Marketplace. Whether consumers visit Amazon or Google, they search for a particular good and see an ordered list of items that link to retailers' goods. These items usually display some descriptive information (price, rating, availability, etc.) and a picture. While we do not contend that Google Shopping and Google Search are *always* substitutes, for retailers the two types of ads are as well substitutes. The same is true of Marketplace. If the group of consumers that advertisers can reach have the same intent in both cases, a retailer willing to sell should is targeting the same consumer base.

A caveat to this might be that Shopping ads and Amazon Marketplace links are, in terms of characteristics, superior to Search ads. In more economic terms: they are vertically differentiated. Indeed, Shopping ads and Amazon Marketplace links display a picture, provide more information, are more expensive and have better click-through rates. Nevertheless, these characteristics do not necessarily put them in different relevant markets because they are targeting the same set of consumers.[32] Also, virtually all economics textbooks, for instance Tirole (1988), show that vertically differentiated goods impose competitive constraints on each other.

Recent data seems to show that retailers acting as advertisers are indeed substituting. According to a report by Adobe, sponsored search spending among retailers has declined by 6% between December 2013 and December 2014 while Shopping ads spending has increased by 47%[33] during the same period.[34] Simultaneously, total search engine marketing spending by retailers increased by 7%.[35]

But this is not sufficient. A more important point is that the sequence of actions that consumers perform on Amazon and Google is exactly the same. A consumer searches for a good, sees a list, clicks (and does not pay for that click), moves to another webpage, buys and leaves the website. This is a particularly important point because it helps us distinguish the market of Amazon and Google from others'. For instance, "display ads" do not fit in this framework because there is a lack of willingness to buy on consumers' part and there is no ordered list. Offline shopping does not fit in this framework

[32] Adrian Majumdar and Richard Murgatroyd, *"Looking beyond market shares: the theory, evidence and meaning of closeness of competition in the manufacture, wholesale and retail of fast-moving consumer goods in South Africa and Europe"*, RBB Economics, 2009.

[33] The big difference in the numbers is simply due to differences in absolute values of spending.

[34] Global Digital Advertising Report, Adobe Digital Index Q4 2014, available at `http://offers.adobe.com/en/na/marketing/landings/_64058_q414_digital_advertising_report.html`

[35] Idem. This data is for the US but we cannot however come up with a reason why advertisers would behave differently in the EU. The Commission in particular has not further subsegmented the online advertising industry. Cases COMP/M.7217 - *Facebook/Whatsapp*, at §79 and COMP/M.7023 - *Publicis/Omnicom*.

either.[36]

Empirical evidence also points in the direction of consumers seeing the two intermediaries as substitutes and answers to the same need.[37] According to different studies, nearly half of consumers start their product searches at Amazon while only a third do so on a general search engine.[38] Other studies have lower figures but also show that Amazon is the leader for product searches.[39]

For online retailers, it does not make a difference whether the consumer comes through advertising put on Google or a link on Amazon, as long a sale occurs. The only distinction in use is the payment system. On Marketplace, sellers have the benefit of being able to use Amazon's payment system while if they use Google, they have to develop their own.[40] It is noteworthy that retailers face the same price whether it is based on a per transaction fee or per sale basis. On Amazon Marketplace, retailers pay a fixed fee and a variable fee each time a consumer buys. On Google, they pay each time their ad is clicked without certainty that this will turn into a sale. But they are indifferent between different ways of selling. If a retailer believes that one in a hundred clicks leads to a sale, then it must be that the price of an ad is a hundred times smaller than the variable fee on Amazon. In other words, yes, observed prices are different but prices per sale should be the same. Suppose

[36] This does not mean that offline shopping is necessarily out of the relevant market. More simply, we do not know. However, usage does not point in that direction.

[37] We could only find one apparent major difference between the two websites. Whilst on Amazon, consumers pay via Amazon, but consumers on Google have to pay via the retailer's system. There might thus be a risk issue with some consumers not willing to provide payment information to the retailers present on Google. However, the auction system mitigates that concern because to be displayed on Google, retailers have to win the keyword auction. This implies, that, except for exotic goods, most retailers are sizeable and well-known companies with whom consumers are used to transact and trust issues should remain marginal. In fact, Google's auction system is not solely price-based but incorporates other variables such as reputation and reliability of the retailer.

[38] Bloomreach, "*Amazon Commands Nearly Half of Consumers' First Product Search*", `http://bloomreach.com/2015/10/amazon-commands-nearly-half-of-consumers-first-product-search/`

[39] Interestingly, they also show that half of consumers who start at a search engine will click on a Shopping link while 41% will go to Amazon or a retailer. PowerReviews, "*New Study Finds that Retailers and Brands can Leverage Reviews to Compete with Amazon and Search*", available at `http://www.powerreviews.com/?p=7367`

[40] They can also use a third-party system such as PayPal.

for instance a 1/100 sale rate for an ad again and that an ad costs 0.01 euro. Then, it must be that the variable fee of Amazon is 1 euro. Prices are different (0.01 v. 1 euro) but prices per sale are the same (1 euro).[41]

We therefore conclude that there is strong evidence that Amazon Marketplace, Google Shopping and Google Search are substitutes and hence, belong to the same relevant market.

5.4 When resellers and two-sided intermediaries belong to the same relevant market

A major conceptual difficulty of the case, as already noted, is that Amazon Reseller and Google Search, Google Shopping and Amazon Marketplace have different business models. That said, market definition is not a static or given assumption and should thrive to incorporate dynamic arguments. A business model is an endogenous choice of firms, not a feature of a market. Therefore, the existence of firms operating under different models ought not to define different markets.

If we considered Amazon Reseller *ex nihilo*, we would have to define two separate markets, one for consumers and one for retailers. In each market, there would be a price, a transaction and profits. But Amazon reseller faces a double-sided competitive constraint and the market definition should take this constraint into account. That is, even though two separate markets may be defined if this business model was considered on its own, the presence of two-sided competitors forces the inclusion of some form of linkage between the two "independent" sides. How this would be achieved in practice is beyond the scope of this paper.

The only important question is therefore whether consumers and retailers see the different businesses as answering the same need.

For consumers, there is very little difference between buying via Amazon reseller and Amazon Marketplace. For retailers there is an important difference. Whereas on Google Search, Google Shopping and Amazon Marketplace

[41] Including the variable fee does not change the result; it just makes the point less clear. The computation is only valid for risk-neutral firms. Otherwise, prices per sale will be different but "perceived prices" will be the same. This does not change the result.

they interact both with the intermediary and the consumers, on Amazon Reseller, they only interact with the intermediary that buys their goods. Is this a sufficiently strong difference to make Amazon reseller a different market? While this will depend on the specificities of the case, to which we do not have access, it does not seem to be a very influential factor. As has been shown, whether through Google or Amazon the goal of retailers is simply to sell and the identity of the buyer should not matter.[42] In equilibrium, all options should yield the same returns.

Application 3. *Where Google has the technical ability to degrade rivals, i.e. when Shopping ads appear, Amazon and Google seem to be part of the same relevant market. In that case, it is a priori unclear that Google enjoys a dominant position.*

6 Conclusion

The incorporation of business dynamics into competition analysis should not deter antitrust agencies. In this paper we have highlighted three conceptual difficulties that antitrust enforcers and policy makers should be aware of. First, it is not always easy to determine the business model of a firm. Second, if a firm is two-sided, there are two possible types of relevant markets in which the firm might operate. There could either be two separate but interlinked markets (one for each side) or just one market relating the two sides. Third and most important, we have shown that the presence of firms with different business models does not imply that these firms operate in different markets. Rather, it may be that opting for different business strategies is a way for these firms to differentiate their offerings in very competitive markets.

Despite not having access to the facts of the case, by applying these concepts to the Google Shopping investigation, we have shown that they lead to surprising and relevant conclusions.

That said, we do not purport to have solved all problems related to intermediaries, competing business models and competition policy. For one, we

[42]This may not be true for luxury goods and other products and services that have a strong reputation to maintain.

have used a qualitative framework. This is of course partly due to the fact that we do not have access to the facts of the case. But even if we had this access, it is not clear how a quantitative analysis should be performed. For instance, notwithstanding the problems highlighted in the text concerning auctions, SSNIP tests are difficult to perform when two-sided intermediaries are present. With different business models, new issues may arise. For example, a reseller can, by definition, only raise its price on one side. But then, it is not clear how the test should be modified to take into account that two-sided competitors may change their price on another side. To the best of our knowledge, there is no literature on SSNIP tests and business model competition.

From the point of view of competition policy, the analysis also implies that if resellers (or other one-sided models) compete with two-sided intermediaries, competition authorities ought to focus also on supply side substitution in defining the boundaries of the relevant market. The supply side should not only play the role of "potential competition" once market shares have been calculated on the basis of demand-consumer substitution. Otherwise, the character of convergence of both models could be lost and lead to excessively narrow market definitions.

Finally, this paper has shown that the extant literature on business model competition is rather scarce. Economists have only started to analyse two-sided intermediaries roughly fifteen years ago and they have not, to the best of our knowledge, developed full-fledged models of "competition in business models" yet. We leave this avenue for future research.

Chapter 4

Cartels in the EU: Who Appeals and Who Wins?

Sébastien Broos, Axel Gautier

Abstract

With 65 cartels sanctioned between 2004 and 2014 amounting to a total fine of more than 16 billion euros, the European Commission has made the fight against cartels its top priority. To that end, the EU has developed new enforcement tools either to facilitate collaboration between parties (leniency, settlement) or to make the enforcement process more transparent (the 2006 Guidelines on Fines). This paper studies the determinants of appeals and their success in cartel cases. We show that collaboration tools such as leniency work well, in that they either reduce litigation or success. Second, clearer rules seem to make enforcement easier. Finally, there may be a disproportion between the high number of appeals and the fine reduction that can be expected.

Keywords: competition policy, cartels, appeals

JEL classification: K21, L40

1 Introduction

During the 2004-2014 period, the European Commission ("the Commission") sanctioned 65 cartels involving 375 undertakings[1] for infringement of Article 101 TFEU. Cartel participants were heavily fined by the Commission, with an average fine of more than 43 million euros per undertaking. Sanctioned cartel participants have the possibility to appeal the Commission's decision before the General Court ("the GC"); the GC's decision can subsequently be appealed before the European Court of Justice ("the ECJ"). The number of litigations in front of the courts is impressive. Among the 375 infringers sanctioned by the Commission, 162 (43.2%) have appealed and there is at least one firm appealing in 77% of the cartels. The GC has so far examined 149 of these 162 appeals and decided in a majority (63%) of the cases to leave the fine inflicted by the Commission unchanged. The fine was reduced (but not cancelled) for 28.9% of the appealing undertakings and cancelled for 6.8% of them. 78 decisions have been subsequently appealed before the ECJ, mostly at the initiative of the undertakings (77 appeals) and only 6 have been appealed by the Commission. So far, 65 have been examined by the Court. For the firms, few appeals have been successful in front of the ECJ with only 3 fine reductions when the appellant is the firm –which corresponds to a success rate of 4%. The appeals filed by the Commission succeeded in 1 case but even then, the fine remained lower than that set initially by the Commission. These figures suggest that undertakings have a limited probability of winning in appeal but the average fine of successful appellants (be it at the GC or the ECJ) is substantially reduced from 98.67 to 57.03 million euros.

The high appeal rate and the relatively low success rate –though fine levels are impressive– represent a significant cost both for the Commission and the undertakings. Therefore and unsurprisingly, the Commission has developed new enforcement tools either to facilitate collaboration between parties (le-

[1]"For the purpose of EU antitrust law, any entity engaged in an economic activity, that is an activity consisting in offering goods or services on a given market, regardless of its legal status and the way in which it is financed, is considered an undertaking.", *Glossary of Competition Terms*, available at `http://www.concurrences.com/en/droit-de-la-concurrence/glossary-of-competition-terms/Undertaking`.

niency, settlement) or to make the enforcement process more transparent (the 2006 Guidelines on Fines). This paper studies the determinants of the probability to appeal and to win an appeal in cartel cases with a special interest for these new enforcement tools. For that purpose we build an original dataset containing all cartel decisions for the period $2004 - 2014$ and their follow-on appeals before the GC and the ECJ. We estimate the determinants of the decision to appeal and the success of that appeal, using a robust econometric specification: an OLS with clustered standard errors. As cartel members belong (by definition) to the same cartel and they share similar unobservable characteristics, it is of prime importance to take these cartel-specific effects into account. The appropriate econometric tool for that is the clustering of standard errors at the cartel level. But this cannot be done in a Probit model[2] as, in this case, the clustering will only change the standard errors but not the estimated coefficients which will remain biased (see Greene (2007) p.780 for more details). We instead use an OLS model that allows us to correctly cluster standard errors at the level of the Commission's decision and estimates unbiased coefficients. With this methodology, we provide new and robust estimate of the impact of the new enforcement tools on the likelihood to appeal and to win.

To summarize our results briefly and contrast them with the literature, we show that leniency recipients, which are numerous and who collaborate with the Commission by providing evidence against the cartel, do not appeal less often than others, a result which is in sharp contrast with Hüschelrath and Smuda (2016) who found that leniency applicants appeal significantly less. Indeed, as the leniency is almost never challenged by the GC, there is no reason for leniency applicants to appeal less. However, appeals filed by leniency recipients are less successful. Leniency is considered (Brenner, 2009) as a major tool for collecting information against cartels and firms who provide valuable information are rewarded with a fine reduction. Leniency thus has two effects: a reduced fine and additional information provided to the authority. In our model, the first effect is captured by the fine variable which is negative and significant while the second effect, captured by the

[2] As it is done in Hüschelrath and Smuda (2016).

variable "leniency recipient", does not seem to affect strongly the probability to appeal. It has however an impact on the probability to win an appeal, which is lower for leniency recipients.

This might support the hypothesis that the leniency procedure is a source of information for the Commission who is then able to construct stronger decisions. On the contrary, those who settle and thereby explicitly acknowledge their implication in a cartel, are filing appeals less often, a confirmation of Hellwig et al. (2016). Finally, the 2006 Guidelines on fines have not reduced the probability to appeal but are correlated with less successful appeals. Again a result in sharp contrast with Hüschelrath and Smuda (2016), who found a significant impact on the probability to appeal but no impact on the success rate. The new Guidelines make the Commission's decisions legally stronger and, as appellants mainly challenge the determination of the fine (Camesasca et al., 2013), a greater legal certainty makes appeals in court less successful.

Based on our econometric analysis, we reach three conclusions. First, collaboration seems to work well: leniency tools are correlated with lower success rates and the settlement procedure is negatively correlated with a lower appeal rate. Second, clearer rules such as the 2006 Guidelines of Fines are positively correlated with a lower rate of success. Finally, there seems to be a disproportionate number of appeals compared to the fine reduction that undertakings can expect to obtain.

The rest of this article is organized as follows. We first review the literature related to the statistical analysis of cartel cases. We present briefly in Section 3 the cartel enforcement and the appeal procedure. In Section 4, we describe our data and the variables we use in the econometric model. In Section 5, we motivate our econometric specification and then turn to the empirical analysis. Finally, Section 6 concludes.

2 Related literature

Academics and practitioners have devoted a lot of attention to the quantitative analysis of cartel cases. We distinguish four main research approaches in this field. The first consists in providing comprehensive and detailed statistics on the characteristics of cartels cases and the enforcement process (Combe and Monnier, 2012; Broos et al., 2016; Hellwig and Hüschelrath, 2016). These statistics provide extremely useful information both on the structure of cartels[3] and on the tools used by competition authorities to fight cartels.

The second strand examines the determinants of cartel fines. Geradin and Henry (2005) review the parameters used by the Commission to determine the fine imposed on an undertaking. Carree et al. (2010) perform an econometric analysis to explain the fine level. Setting the appropriate fine level is of major importance as fines are supposed to be the main tool to deter future anticompetitive behaviour. The results of this literature on optimal fines are contrasted. While Combe and Monnier (2011) find that fines are not severe enough to deter future illegal behaviour, Allain et al. (2015) report that most fines could be considered as optimal.

The third research approach estimates the impact of specific enforcement tools such as the leniency procedure, introduced in the EU in 1996 (Brenner, 2009)[4] and the settlement procedure introduced in 2008 (Hellwig et al., 2016). Brenner (2009) estimates that leniency programs are a substantial source of information for competition authorities, resulting in procedure lengths reduced by about 1.5 years. Hellwig et al. (2016) estimate that the settlement procedure, where firms obtain a lower fine in exchange for admitting their liability and waiving some of their procedural rights, reduces the probability of appeal by 22 points to 55%.

The last approach estimates the determinants of the decision to appeal the decision of the Commission and the outcome of these appeals. Carree et al. (2010) analyze the determinants of the appeal of the Commission's decisions in both cartel and abuse cases for the period 1957-2004. They find that the fine significantly affects the decision to appeal, a result that is robust in many specifications including ours. They also show that the complexity of the case (measured by the number of recitals in the decision) has a positive

[3]Some studies try to go a step further and estimate the cartel overcharge, see for instance Connor and Bolotova (2006).

[4]Miller (2009) analyses the impact of the leniency procedure in the US.

impact on the appeal rate. The paper of Smuda et al. (2015) focuses on the duration of the appeal process, which is quite long in the EU. Broos et al. (2016) report an average duration of more than four years for the first-instance appeal with the GC. They show that cooperation between the parties and the Commission substantially reduces the duration of the appeal and that the new fine Guidelines released by the Commission in 2006 have also shortened the length of appeals. This should not be a surprise as the main motivation for appeal is related to fines (Camesasca et al., 2013). Distinguishing different reasons for filing an appeal related to procedural, factual and fining issues, Camesasca et al. (2013) show that pleas related to the fines are the most frequent and more likely to be received in appeal.

In this strand of the literature, the paper that is more closely related to ours is Hüschelrath and Smuda (2016). Sample periods differ slightly as we focus on the period after the entry into force of Regulation 1/2003 in 2004, which modernized antitrust enforcement and our econometric approach is also different, and we will argue that the methodology explains the differences in the results we provide. In their Probit specification, the introduction of the 2006 Guidelines on fines has a significant negative impact on the probability to appeal but does not influence the probability to win. Second, their Probit estimates show that leniency recipients are less likely to appeal. Finally, they do not only focus on the success rate of an appeal but also on the appellant's level of success measured by the fine reduction obtained by the firm after the appeal process.

3 Cartel Enforcement and Appeal Procedure

In cartel cases pursuant to Article 101, the Commission usually acts based on a leniency application, its own initiative or on complaints. Then, the Commission opens an investigation, which can last several years. If, after the investigation, it has serious doubts about a possible infringement, the Commission sends a Statement of Objections to the concerned undertakings. This Statement informs them about the charges they face and allows them to set-up a defence. At the end of the procedure, the Commission either adopts a prohibition Decision or closes the case. A prohibition decision is usually accompanied by fines. The fine is based on the values of sales in cartel-related activities but it cannot exceed 10% of the total turnover. The basic amount of the fine can be increased or decreased to take into account possible aggravating (ring leader, repeated offender, etc.) or mitigating circumstances such as leniency and settlement reductions. The Commission revised its fine guidelines in 2006.

There are two particularities of cartel enforcement which are especially relevant to this study. First, undertakings can apply for leniency, i.e. they provide information about the alleged cartel to the Commission in exchange for a possible reduction of their fine. The amount of the fine reduction depends (i) on the usefulness of the information provided and (ii) on whether other undertakings have already applied for leniency. That last criterion is especially important as the first to apply (and to provide useful information) obtains a 100% reduction of its fine while the second can only get up to 50%, the third 30% and the others up to 20%. The goal of this policy is to enhance cartel detection[5] and to reduce the cartels' stability.

The second particularity of cartel enforcement is the settlement procedure. Since 2008, an undertaking can decide to "settle" with the Commission in exchange for a 10% reduction in its fine. To obtain the reduction, the undertaking must admit liability for the infringement and waive some of its procedural rights. This allows the Commission to close cases faster. When the Commission takes an antitrust decision after a settlement, the infringer can still appeal the decision to the GC.

Undertakings can decide to file an appeal against the Commission's Decision. In a first stage, an appeal can be filed with the GC. The GC can not only increase, decrease or maintain the fine but can also review the Decision completely, i.e. it can fully repeat the assessment of the case. In the second stage, both the Commission and the undertaking can appeal the General Court's judgement with the ECJ. The ECJ can revise the fine but can not reassess the facts. It can only analyze questions of law. It can also decide to

[5] According to Combe and Monnier (2012), leniency application is the main tool for cartel detection.

send the case back to the GC.

4 Data and hypotheses

We construct a database of all cartel decisions taken by the European Commission between May 2004 and May 2014 and their follow-on appeals to the General Court and the European Court of Justice. Data was collected from the Commission's public decisions and, when not available, from press releases. Information about appeals was drawn from the CVRIA database.

We distinguish between three levels of aggregation: the cases, the cartels and the undertakings. A case is a Decision by the Commission which may concern one or multiple cartels, each composed of undertakings. For instance, "elevators and escalators" is a case that concerns four (geographically) different cartels, all of which had four undertakings, except one which had five. Typically, the cartels are grouped in one decision because they concern similar undertakings and/or close markets, be it geographically or in terms of product.

Our dataset contains 52 cases, concerning 65 cartels, and 375 undertakings. 162 (43.2%) of these undertakings appeal the decision of the Commission in front of the GC and 78 appeal in front of the ECJ. If the Commission's Decision imposes a strictly positive fine, we consider that an undertaking has "won" an appeal if the fine it has to pay after its appeal(s) is(are) over is smaller than that set by the Commission, i.e. if the fine is cancelled or reduced in appeal. If the undertaking had a fine of 0, it has "won" its appeal if the Commission's decision is annulled. Of the closed appeals, there are only two undertakings which appeal a fine of 0, one of which wins. The General Court has judged 149 of the 162 appeals. Of these 149 appeals, 54 (36.2%) were successful. There were 78 appeals in front of the ECJ, 65 of which were judged and 3 reduced or annulled the fine set by the GC. Overall, 52 of the 136 appeals which are closed both at the GC and the ECJ were successful.

We focus on six groups of variables to explain the probability to appeal: complexity, collaboration, fine, recidivism and legal environment. We add another variable to asses who wins appeals: single appeal. Summary statistics are presented in Tables 4.1, 4.2 and 4.3.

In typical cost-benefit fashion, an undertaking appeals a judgement when the expected benefits of doing so outweigh the expected costs (Shavell, 1995). The benefits of an appeal are a function of the expected reduction of the fine, which itself is a function of the probability that the Commission has made a mistake in its decision.[6] We analyse the following variables using this simple framework.

Complexity. The more complicated a cartel is, the more difficult it is for the Commission to avoid making mistakes, be it in establishing the liability of an undertaking or in setting the amount of fines. We would therefore expect more complex cases to be appealed more often and to be more successful. We use three variables to approximate complexity: the number of undertakings in the cartel ("*Number of Undertakings*"), the duration of the infringement ("*Duration of the Infringement*") and the duration of the procedure ("*Duration of the Procedure*" – starting at the issuance of the statement of objection and ending on the day of the decision). This last variable may be problematic in the sense that a longer procedure could be an indication that the Commission knows that the case is complicated and is willing to invest time to ensure its decision is error-proof. In that case, longer procedures should lead to less (successful) appeals.

Collaboration. We capture collaboration through two mechanisms: settlement ("*Settlement*") and leniency. An undertaking that settles must admit liability for the infringement and the grounds for appeal are therefore reduced. Hence, we expect firms which have settled to appeal less often. This hypothesis has been convincgly supported by Hellwig et al. (2016). There are two ways through which leniency should affect the probability to appeal and its subsequent success (Brenner, 2009). On the one hand, leniency recipients have a lower fine, which should decrease their probability to appeal. This should, at least partly, be captured by the amount of the fine. On the other

[6] In the case of an undertaking which appeals with a fine of zero, the benefits may be the absence of recidivism in future decisions, an aggravating circumstance which can lead to higher fines.

hand, being a leniency recipient implies having submitted helpful information about the infringement to the Commission. This should help the Commission establish a strong case and lead to less successful appeals. For the probability to appeal, we use three variables. In one regression, we distinguish between undertakings which are first leniency recipients and therefore obtain a 100% fine reduction (*"First Leniency Recipient"*), and those who are not (*"Other Leniency Recipient"*). In another, we pool the two cases (*"Leniency Recipient"*). Arguably, the information effect may be stronger for the first leniency recipient which should provide the bulk of the information to the Commission. For the probability to win, we use the "Leniency Recipient" variable because only one of the undertakings which have received full leniency and have appealed has had its appeal judged.

Fine. A higher fine implies a higher expected benefit from appealing and therefore should lead to more appeals. It may also be an incentive to invest more in the appeal, i.e. through higher spending on lawyers, which may raise the probability to win the appeal. We use the final fine of the Decision that is, the fine the undertaking has to pay after potential reductions and aggravating circumstances have been taken into account.

Recidivism. There are two effects to recidivism. First, a repeated infringement may be sanctioned by a higher fine. This should be picked up by the fine variable. Second, undertakings which have more experience with the litigation process may be abler to recognize the mistakes of the Commission. They may therefore appeal more often and more successfully. The Commission's definition of recidivism is that "an undertaking continues or repeats the same or a similar infringement after the Commission or a national competition authority has made a finding that the undertaking infringed Article 81 or 82".[7] This is slightly different from our variable because we only have data (i) about the 2004-2014 period and (ii) about the Commission's Decisions. We therefore do not have information about recidivists which were liable for infringements

[7]Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003.

prior to 2004 or were found liable by other competition authorities.

Legal Environment. We consider the effects of two changes in the legal environment: the introduction of the 2006 Guidelines on the method of setting of fines and the 2008 Settlement Notice. The new Guidelines on fines reduced the discretionary power of the Commission regarding the setting of fines (Wils, 2007). The effect of this on the probability to appeal is ambiguous. On the one hand, the Guidelines reduce the probability of an error on the Commission's part and we should therefore expect less appeals. On the other hand, it is easier for undertakings to detect when an error is indeed made and this increases the probability to appeal. If this last effect is dominant, appeals should be more successful. We do not expect any effect of the Settlement Notice on the probability to appeal because the variable "settlement" should capture the bulk of the effects of the ability to settle. However, only one undertaking has appealed the Commission's decision and this changes the composition of the appellants. This effect should influence the probability to win an appeal although it is unclear in what way exactly.

Single Appeal If only a single undertaking within a cartel appeals, it may be a sign that other cartel members have deemed the Decision as legally strong with regards to the part of the Decision which is about them but also with regards to cartel-specific issues. Therefore, we expect "single appeals" to be less successful than others.

Table 4.1: Summary Statistics, all undertakings

Variable	Mean	S.D.	Min.	Max.	Obs.
Nb. of Undertakings, all	7.88	4.24	2	17	375
Nb. of Undertakings, appellants	8.01	4.26	2	10	162
Nb. of Undertakings, successful app.	7.84	3.75	2	17	52
Dur. of the Procedure (months), all	18.96	11.58	0	63	375
Dur. of the Procedure (months), appellants	18.87	9.32	7	38	162
Dur. of the Procedure (months), successful app.	17.43	8.95	7	38	52
Dur. of the Infringement (months), all	86.63	65.33	0	419	375
Dur. of the Infringement (months), appellants	94.73	62.74	3	309	162
Dur. of the Infringement (months), successful app.	96.23	70.52	3	309	52
First Leniency Recipient (1=Yes), all	0.125	0.33	0	1	375
First Leniency Recipient (1=Yes), appellants	0.03	0.17	0	1	162
First Leniency Recipient (1=Yes), successful app.	0	0	0	0	52
Other Leniency Recipient (1=Yes), all	0.34	0.47	0	1	375
Other Leniency Recipient (1=Yes), appellants	0.36	0.48	0	1	162
Other Leniency Recipient (1=Yes), successful app.	0.196	0.4	0	1	52
Leniency Recipient (1=Yes), all	0.46	0.5	0	1	375
Leniency Recipient (1=Yes), appellants	0.39	0.49	0	1	162
Leniency Recipient (1=Yes), successful app.	0.19	0.4	0	1	52
Settlement (1=Yes), all	0.125	0.33	0	1	375
Settlement (1=Yes), appellants	0.02	0.16	0	1	162
Settlement (1=Yes), successful app.	0	0	0	0	52
Initial fine (million euros), all	43.01	90.26	0	896	375
Initial fine (million euros), appellants	66.68	114.51	0	896	162
Initial fine (million euros), successful app.	98.67	174.26	0	896	52
Recidivist (1=Yes), all	0.16	0.37	0	1	375
Recidivist (1=Yes), appellants	0.13	0.34	0	1	162
Recidivist (1=Yes), successful app.	0.12	0.32	0	1	52
2006 Guidelines on Fines (1=Yes), all	0.57	0.49	0	1	375
2006 Guidelines on Fines (1=Yes), appellants	0.395	0.49	0	1	162
2006 Guidelines on Fines (1=Yes), successful app.	0.33	0.48	0	1	52
2008 Settlement Notice (1=Yes), all	0.49	0.5	0	1	375
2008 Settlement Notice (1=Yes), appellants	0.33	0.47	0	1	162
2008 Settlement Notice (1=Yes), successful app.	0.29	0.46	0	1	52
Single Appeal (1=Yes), app. and closed	0.59	0.24	0	1	136
Single Appeal (1=Yes), successful app.	0.58	0.24	0	1	52

Notes: statistics regarding "appellants" concern undertakings which have appealed, even if their appeal is still ongoing.

Table 4.2: Number of observations at the different stages

Stage	Number of Undertakings
Commission Decision	375
GC Appeals	162
GC Appeals Closed	149
GC Appeals Success	54
ECJ Appeals	78
ECJ Appeals Closed	65
ECJ Appeals Success	3
Appeals Fully Closed	136
Appeals Fully Closed Success	52

Note: "Fully closed" means first and/or second stage appeal closed.

Table 4.3: Duration and Fine Impacts of Closed Appeals

	GC	ECJ
Fine Maintained[1]	93(63.3%)	61(95.3%)
Cancelled	10(6.8%)	1(1.6%)
Modified	54(36.7%)	3(4.7%)
Average Fine before appeal[2]	66.25 million euros	58.9 million euros
Average Fine after appeal[2]	56.59 million euros	49.29 million euros
Average Duration of the appeal	50.67 months	74.72 months

Notes: (1) Modified fines includes cancelled fines. We exclude the two appeals with a Commission fine of 0. The comparison point is the fine set by the Commission in the case of an appeal with the GC and that set by the GC in case of an appeal with the ECJ. There is only a single case of an upward modification of the fine. (2) In the case of an appeal in front of the GC, fines before the appeal refer to those set by the Commission and fines after the appeal to those set by the GC. In the case of fines in front of the ECJ, fines before the appeal refer to those set by the GC and fines after the appeal to those set by the ECJ.

5 Empirical Analysis

We run two sets of regression. In the first (Table 4.4), we regress the dummy variable appeal (1 if yes, 0 if no) on the variables highlighted above and year dummies.[8] In the second (Table 4.5), we regress the success of an undertaking (whose appeal(s) is(are) closed) on the variables highlighted above and year dummies. We first look at econometric issues and then comment the results for each group of variables.

We use two econometric models: OLS and Probit. The use of the OLS model in a setting with a dummy dependent variable may be surprising. However, we believe it likely that heteroskedasticy is present in this situation if only for the fact that undertakings are grouped by cartels. In that case, OLS is still consistent and standard-errors are incorrect but can be easily corrected.[9] On the other hand, a Probit (or a Logit) model that suffers from a heteroskedasticity problem is *not* consistent and there is no easy fix for this. In particular, using a robust covariance matrix does not make sense: it would be like "providing an appropriate asymptotic covariance matrix for an estimator that is biased in an unknown direction" (Greene (2007), p.780).[10] We therefore estimate both an OLS and a Probit model for completeness but focus our discussion on the former.

Our first result is to show that the econometric specification matters. Switching from a Probit model to an OLS specification with clustered standard errors[11] has important consequences. As predicted in the literature (Cameron and Miller, 2015), not correcting the standard errors can bias them upwards or downwards. In the regression on the appeal, the legal environ-

[8]Note that we only include year dummies which are not 100% predictive of the outcome because this is problematic in the estimation of non-linear models (Albert and Anderson, 1984; Zorn, 2005). Out of consistency, we use the same year dummies in OLS. Regarding the appeal, we drop the dummy for 2014 and, for the success, the dummy on 2011. Our OLS estimates are robust to adding these dummy variables.

[9]To be clear, OLS is not devoid of problems in this case. For instance, it may lead to nonsense probabilities (negative or bigger than 1). Yet, advantages seem to outweigh disadvantages.

[10]See also Johnston and DiNardo (1997).

[11]Clustering standard errors in the Probit model leads to the same conclusion, and so does OLS without clustered standard-errors, see Appendix 7.1.

ment variables become insignificant when OLS with clustered standard-errors is used. Being a leniency recipient is also less significant (or even insignificant) in the OLS specification. With regards to the success, the 2006 guidelines on fines are highly significant in the OLS specification but insignificant in the Probit.

Complexity. A higher number of undertakings is correlated with a lower rate of appeal. The duration of the infringement seems to be correlated neither with the appeal nor with the success. Interestingly, the duration of the procedure does not affect the appeal but is negatively correlated with the success. This may be a sign that a longer procedure should be interpreted as a heavier investment by the Commission in the case.

Collaboration. First, we confirm the result of Hellwig et al. (2016): having settled is highly correlated with a lower probability to appeal. Second, being a leniency recipient does not seem to be correlated with a lower probability to appeal. In the OLS specification, if we separate leniency recipients which have a 100% fine reduction from the others, neither coefficient is significant at the 10% level. If we pool the two cases, the coefficient's p-value is only 0.099. Finally, being a leniency recipient is negatively correlated with the probability to win the appeal. The two results may be a confirmation of the information story of Brenner (2009): being a leniency recipient implies transmitting information to the Commission, which it can then use against the undertaking.

Fine. As expected, a higher fine is correlated with a higher probability to appeal, probably because of the higher expected return from appealing, but is not correlated with a higher or lower probability of success.

Recidivism. Recidivism seems to play no role in the probability to appeal or to win. This may be due to our restricted sample which does not cover undertakings which were liable for pre-2004 infringements.

Legal Environment. The 2006 Guidelines on fines do not seem to have an effect on the probability to appeal –the coefficient is negative but not significant at the 10% level– but they are negatively correlated with the probability to win. We take this as an indication that the Guidelines have decreased the possibility of a mistake on the part of the Commission. The 2008 Settlement Notice does not have an impact on the probability to appeal –possibly because the settlement variable already captures the impact of the notice– but is positively correlated with the probability to win. One explanation for this is that the Settlement Notice changes the composition of the appellants because settling firms nearly never appeal. These results may imply that, absent the Leniency Notice, some of the undertakings which have settled would have appealed and lost. This conclusion is only tentative however as a definitive answer would require a causal framework.

Single Appeal. Although positive, the coefficient of this variable is statistically insignificant. Most likely, this is due to the fact that the fine is most common ground of appeal (Carree et al., 2010) and that fines are undertaking-specific. We also ran a robustness check by replacing the variable "Single Appeal" by a dummy which is equal to 1 if all undertakings within a cartel appeal and 0 otherwise. This was also insignificant.

Table 4.4: Regression on the Appeal

	Dependant Variable: Appeal			
	OLS	OLS	Probit	Probit
Complexity				
Number of Undertakings	-0.019^{*}	-0.019^{**}	-0.07^{**}	-0.067^{*}
	(0.009)	(0.009)	(0.035)	(0.035)
Duration of the Procedure (log)	0.092	0.092	0.302	0.316
	(0.068)	(0.068)	(0.247)	(0.247)
Duration of the Infringement (log)	0.032	0.031	0.111	0.101
	(0.03)	(0.029)	(0.106)	(0.105)
Collaboration				
First Leniency Recipient (1=Yes)	-0.082		-0.599	
	(0.086)		(0.38)	
Other Leniency Recipient (1=Yes)	-0.076		-0.333^{*}	
	(0.03)		(0.191)	
Leniency recipient(1=Yes)		-0.077^{*}		-0.38^{**}
		(0.046)		(0.177)
Settlement	-0.403^{***}	-0.401^{***}	-1.963^{***}	-1.871^{***}
	(0.07)	(0.068)	(0.475)	(0.448)
Fine (log)	0.13^{***}	0.131^{***}	0.48^{***}	0.505^{***}
	(0.02)	(0.015)	(0.071)	(0.06)
Recidivist (1=yes)	-0.083	-0.083	-0.318	-0.332
	(0.073)	(0.073)	(0.246)	(0.244)
Legal Environment				
2006 Guidelines on Fines (1=Yes)	-0.194	-0.194	-1.237^{**}	-1.249^{**}
	(0.162)	(0.162)	(0.554)	(0.552)
2008 Settlement Notice (1=Yes)	-0.234	-0.236	-1.297^{***}	-1.349^{***}
	(0.182)	(0.176)	(0.482)	(0.475)
Constant	0.152	0.15	-1.229^{*}	-1.289^{***}
	(0.214)	(0.213)	(0.736)	(0.74)
Observations	375	375	375	375
(pseudo) R^2	0.365	0.365	0.323	0.342

Notes: For OLS regressions, we cluster standard errors at the decision level. Standard errors are in parentheses. P-values: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. Year dummies are not shown.

Table 4.5: Regression on the Success of an Appeal

	Dependant Variable: Success	
	OLS	Probit
Number of Undertakings	0.021	0.062
	(0.017)	(0.047)
Duration of the Procedure (log)	-0.217^{*}	-0.595
	(0.149)	(0.377)
Duration of the Infringement (log)	-0.07	-0.194
	(0.075)	(0.179)
Leniency Recipient (1=Yes)	-0.194^{*}	-0.602^{**}
	(0.096)	(0.287)
Fine (log)	0.039	0.117
	(0.032)	(0.098)
Recidivist (1=yes)	-0.085	-0.323
	(0.122)	(0.415)
2006 Guidelines on Fines (1=Yes)	-0.43^{***}	-1.596
	(0.156)	(1.114)
2008 Settlement Notice (1=Yes)	0.573^{**}	1.653^{**}
	(0.218)	(0.823)
Single Appeal	0.073	0.337
	(0.163)	(0.958)
Constant	1.289^{**}	2.18
	(0.518)	(1.31)
Observations	136	136
(pseudo) R^2	0.159	0.128

Notes: for OLS regressions, we cluster standard errors at the decision level. Standard errors are in parentheses. P-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Year dummies are not shown.

6 Conclusion

We have investigated the determinants of (successful) appeals in cartel cases and there are three major conclusions to take from this study. First, policies that aim at increasing collaboration between the Commission and undertaking work relatively well. While it is unclear that being a leniency recipient has any impact on the probability to appeal, it is strongly correlated with a lower probability of success. This may imply that the information the Commission receives through leniency makes its decisions legally stronger. Moreover, the Settlement Notice has reduced the number of appeals brought before the GC and may have avoided some useless appeals.

Second, clearer rules make enforcement easier: the 2006 Guidelines on fines are strongly correlated with a lower rate of success in appeal. There is nothing we can say about the optimal discretionary power to be given to the Commission but it appears that these guidelines improved competition enforcement.

Third, as shown by Table 4.3, there seems to be a disproportion between the number of appeals and the fine reduction that can be expected. Appeals are long and costly procedures which often yield no result and yet, they are numerous. It would be an interesting avenue for further research to estimate the precise costs of appeals rather than only focus on the potential benefits.

7 Appendix

7.1 Additional regressions

In this Appendix, we present the same regressions as in the main text, but with different robust standard errors. Table 4.6 displays the result of the regression on the appeal in two situations: (i) if we only use heteroskedasticity-robust standard errors in the OLS setting (and no clustering) (ii) if, in the Probit regression, standard-errors are clustered at the case level. In Table 4.7, we display the results of the regression on the the success with the same changes in the computation of standard-errors.

Table 4.6: Regression on the Appeal

	Dependant Variable: Appeal			
	Robust S-E		Clustered S-E	
	OLS	OLS	Probit	Probit
Complexity				
Number of Undertakings	-0.019^{**}	-0.019^{**}	-0.07^{*}	-0.067^{**}
	(0.008)	(0.008)	(0.036)	(0.034)
Duration of the Procedure (log)	0.092^{*}	0.092^{**}	0.302	0.316
	(0.047)	(0.047)	(0.304)	(0.299)
Duration of the Infringement (log)	0.032	0.031	0.111	0.101
	(0.027)	(0.026)	(0.107)	(0.104)
Collaboration				
First Leniency Recipient (1=Yes)	−0.082		−0.599	
	(0.082)		(0.396)	
Other Leniency Recipient (1=Yes)	−0.076		-0.333^{*}	
	(0.048)		(0.179)	
Leniency recipient(1=Yes)		-0.077^{*}		-0.38^{**}
		(0.045)		(0.169)
Settlement	-0.403^{***}	-0.401^{***}	-1.963^{***}	-1.871^{***}
	(0.076)	(0.073)	(0.374)	(0.386)
Fine (log)	0.13^{***}	0.131^{***}	0.48^{***}	0.505^{***}
	(0.016)	(0.012)	(0.079)	(0.068)
Recidivist (1=yes)	−0.083	−0.083	−0.318	−0.332
	(0.055)	(0.055)	(0.285)	(0.283)
Legal Environment				
2006 Guidelines on Fines (1=Yes)	−0.194	−0.194	-1.237^{*}	-1.249^{*}
	(0.122)	(0.122)	(0.726)	(0.737)
2008 Settlement Notice (1=Yes)	-0.234^{*}	-0.236^{*}	-1.297^{**}	-1.349^{**}
	(0.138)	(0.135)	(0.645)	(0.632)
Constant	0.152	0.15	−1.229	−1.289
	(0.167)	(0.165)	(0.895)	(0.88)
Observations	375	375	375	375
(pseudo) R^2	0.365	0.365	0.323	0.342

Notes: P-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Year dummies are not shown.

Table 4.7: Regression on the Success of an Appeal

	Dependant Variable: Success	
	Robust S-E	Clustered S-E
	OLS	Probit
Number of Undertakings	0.022	0.071
	(0.017)	(0.049)
Duration of the Procedure (log)	-0.225^{*}	-0.683
	(0.124)	(0.486)
Duration of the Infringement (log)	-0.084	-0.249
	(0.063)	(0.229)
Leniency Recipient (1=Yes)	-0.258^{***}	-0.869^{**}
	(0.085)	(0.354)
Fine (log)	0.035	0.113
	(0.036)	(0.103)
Recidivist (1=yes)	-0.031	-0.149
	(0.117)	(0.415)
2006 Guidelines on Fines (1=Yes)	-0.365^{***}	-1.206^{**}
	(0.133)	(0.639)
2008 Settlement Notice (1=Yes)	0.581^{**}	1.733^{**}
	(0.247)	(0.79)
Single Appeal	-0.04	-0.332
	(0.102)	(0.439)
Constant	1.411^{***}	2.78^{*}
	(0.413)	(1.57)
Observations	136	136
(pseudo) R^2	0.2075	0.1752

Notes: P-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Year dummies are not shown.

Avenues for further research

In three chapters of this thesis I have studied aspects of the digital economy. Its economic analysis is still young and, as such, open questions abound. Let met highlight three.

Chapter 3 has discussed the difficulties of the definition of the relevant market in the presence of two-sided intermediaries. Clearly, a model of the competitive interactions between different business models is needed. For instance, the way Google competes with Amazon has barely been studied. One especially interesting direction for research would be to study the reasons why some markets only contain two-sided or one-sided firms while others are mixed.

In Chapter 2, I have investigated the ability of firms to link valuation and information for advertising purposes. Beyond the obvious extension – competition in the product market– the analysis of the "competition" between the information provided by firms and the information available to consumers from other sources is another potentially interesting research area. In particular, what does it change if these outside sources are partially controlled by firms? For instance, consumers could search and firms could influence search costs. The interaction of search and advertising is a classical topic and would be worth exploring in the particular setting of Chapter 2.

Finally, let me mention a topic which has become common in fields such as computer science, philosophy and law, but has received scant attention in economics: artificial intelligence (AI). In particular, the question of the complementarity or substitutability of human labour and AI is of major importance. One may look at this issue from at least two angles. AI may first be a decrease in the *cost* of doing something, for instance providing predictions (Agrawal et al., 2016). On the other hand, AI may be a different *way* of performing a task. In that sense, it may be fruitful to consider the results of the behavioural economics literature and to examine how humans differ from AI exactly.

Bibliography

Agrawal, A., J. Gans, and A. Goldfarb (2016): "Exploring the Impact of Artificial Intelligence: Prediction versus Judgment," Mimeo.

Albert, A. and J. Anderson (1984): "On the Existence of Maximum Likelihood Estimates in Logistic Regression Models," *Biometrika*, 71, 1–10.

Allain, M.-L., M. Boyer, R. Kotchoni, and J.-P. Ponssard (2015): "Are Cartel Fines Optimal? Theory and Evidence from the European Union," *International Review of Law and Economics.*

Ambrus, A., E. Calvano, and M. Reisinger (2016): "Either or Both Competition: A" Two-Sided" Theory of Advertising with Overlapping Viewerships," *American Economic Journal: Microeconomics*, 8, 189–222.

Anderson, S. P. and J. J. Gabszewicz (2006): "The Media and Advertising: a Tale of Two-Sided Markets," in *Handbook of the Economics of Art and Culture*, ed. by V. Ginsburgh and D. Throsby, North-Holland, vol. 1, 567–614.

Argentesi, E. and L. Filistrucchi (2007): "Estimating market power in a two-sided market: The case of newspapers," *Journal of Applied Econometrics*, 22, 1247–1266.

Armstrong, M. (2002): "The Theory of Access Pricing and Interconnection," in *Handbook of Telecommunication Economics*, Citeseer.

——— (2006a): "Competition in Two-Sided Markets," *The RAND Journal of Economics*, 37, 668–691.

——— (2006b): "Competition in Two-Sided Markets," *The RAND Journal of Economics*, 37, 668–691.

Athey, S. and J. S. Gans (2010): "The Impact of Targeting Technology on Advertising Markets and Media Competition," *The American Economic Review*, 608–613.

Auer, D. and N. Petit (2015): "Two-Sided Markets and the Challenge of Turning Economic Theory into Antitrust Policy," *The Antitrust Bulletin*, 60, 426–461.

Bagnoli, M. and T. Bergstrom (2005): "Log-Concave Probability and its Applications," *Economic Theory*, 26, 445–469.

Bagwell, K. (2007): "The Economic Analysis of Advertising," in *Handbook of Industrial Organization*, ed. by M. Armstrong and R. Porter, Elsevier, vol. 3, 1701–1844.

BEREC (2012): "A View of Traffic Management and Other Practices Resulting in Restrictions to the Open Internet in Europe," .

Bergemann, D. and A. Bonatti (2011): "Targeting in Advertising Markets: Implications for Offline Versus Online Media," *The RAND Journal of Economics*, 42, 417–443.

Blake, T., C. Nosko, and S. Tadelis (2015): "Consumer Heterogeneity and Paid Search Effectiveness: a Large-Scale Field Experiment," *Econometrica*, 83, 155–174.

Bourreau, M., F. Kourandi, and T. Valletti (2015): "Net Neutrality with Competing Internet Platforms," *Journal of Industrial Economics*, 63, 30–73.

Brahim, N. B. E.-B., R. Lahmandi-Ayed, and D. Laussel (2011): "Is Targeted Advertising Always Beneficial?" *International Journal of Industrial Organization*, 29, 678–689.

Brenner, S. (2009): "An Empirical Study of the European Corporate Leniency Program," *International Journal of Industrial Organization*, 27, 639–645.

Brito, D., P. Pereira, and J. Vareda (2014): "On the Incentives of an Integrated ISP to Favor its Own Content," Mimeo.

Broos, S., A. Gautier, J. M. Ramos, and N. Petit (2016): "Analyse statistique des affaires d'ententes dans l'UE (2004-2014)," *Revue économique*, 67, 79–94.

Calvano, E. and M. Polo (2016): "Strategic Differentiation by Business Models: Free-to-Air and Pay-TV," Mimeo.

Cameron, A. C. and D. L. Miller (2015): "A Practitioner's Guide to Cluster-Robust Inference," *Journal of Human Resources*, 50, 317–372.

Camesasca, P., J. Ysewyn, T. Weck, and B. Bowman (2013): "Cartel Appeals to the Court of Justice: the Song of the Sirens?" *Journal of European Competition Law and Practice*, 215–233.

Carree, M., A. Günster, and M. P. Schinkel (2010): "European Antitrust Policy 1957–2004: an Analysis of Commission Decisions," *Review of Industrial Organization*, 36, 97–131.

Chen, M. K. and B. J. Nalebuff (2006): "One-Way Essential Complements," Cowles Foundation Discussion Papers 1588.

Choi, J. P., D.-S. Jeon, and B.-C. Kim (2015a): "Net neutrality, business models, and internet interconnection," *American Economic Journal: Microeconomics*, 7, 104–141.

——— (2015b): "Net Neutrality, Network Capacity, and Innovation at the Edges," Mimeo.

Choi, J. P. and B.-C. Kim (2010): "Net Neutrality and Investment Incentives," *RAND Journal of Economics*, 41, 446–471.

COMBE, E. AND C. MONNIER (2011): "Fines Against Hard Core Cartels in Europe: the Myth of Overenforcement," *Antitrust Bulletin*, 56, 235–275.

——— (2012): "Les cartels en Europe, une analyse empirique," *Revue française d'économie*, 27, 187–226.

CONNOR, J. M. AND Y. BOLOTOVA (2006): "Cartel Overcharges: Survey and Meta-analysis," *International Journal of Industrial Organization*, 24, 1109–1137.

D'ANNUNZIO, A. AND A. RUSSO (2015): "Net Neutrality and Internet Fragmentation: The Role of Online Advertising," *International Journal of Industrial Organization*, 43, 30–47.

DE BIJL, P. AND M. PEITZ (2004): "Unbundling the Local Loop: One-way access and Imperfect Competition," in *Access Pricing: Theory and Practice*, ed. by J. Haucap and R. Dewenter, Elsevier Science, 91–148.

——— (2009): "Access Regulation and the Adoption of VoIP," *Journal of Regulatory Economics*, 35, 111–134.

——— (2010): "Regulatory Legacy, VoIP adoption, and Investment Incentives," *Telecommunications Policy*, 34, 596–605.

DEWENTER, R. AND J. ROSCH (2016): "Net Neutrality and the Incentives (Not) to Exclude Competitors," *Review of Economics*, 67, 209–229.

ECONOMIDES, N. AND B. E. HERMALIN (2012): "The Economics of Network Neutrality," *RAND Journal of Economics*, 43, 602–629.

EDELMAN, B., M. OSTROVSKY, AND M. SCHWARZ (2007): "Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords," *The American Economic Review*, 97, 242–259.

ESTEBAN, L., A. GIL, AND J. M. HERNANDEZ (2001): "Informative Advertising and Optimal Targeting in a Monopoly," *The Journal of Industrial Economics*, 49, 161–180.

Esteves, R.-B. and J. Resende (2016): "Competitive Targeted Advertising with Price Discrimination," *Marketing Science*, 35, 576–587.

Evans, D. and R. Schmalensee (2007): "The Industrial Organization of Markets with Two-Sided Platforms," *Competition Policy International*, 3.

Evans, D. S. (2003): "The Antitrust Economics of Multi-Sided Platform Markets," *Yale Journal on Regulation*, 20, 325.

Evans, D. S. and M. D. Noel (2008): "The Analysis of Mergers that Involve Multisided Platform Businesses," *Journal of Competition Law & Economics*, 4, 663–695.

Faratin, P., D. Clark, B. Steven, W. H. Lehr, P. Gilmore, and A. Berger (2008): "The Growing Complexity of Internet Interconnection," *Communications & Strategies*, 1, 51–72.

Filistrucchi, L. (2008): "A SSNIP Test for Two-sided Markets: The Case of Media," Tech. rep., NET Institute Working Paper.

Filistrucchi, L., D. Geradin, E. Van Damme, and P. Affeldt (2014): "Market Definition in Two-Sided Markets: Theory and Practice," *Journal of Competition Law & Economics*, 10, 293–339.

Filistrucchi, L., D. Geradin, E. van Damme, S. Keunen, J. Wileu, J. Boone, T. Klein, and T. Michielsen (2010): "Mergers in Two-Sided Markets – A Report to the NMa," Tech. rep., Netherlands Competition Authority.

Fudickar, J. (2015): "Net Neutrality, Vertical Integration, and Competition Between Content Providers," Working Paper 2015-14, Berlin Doctoral Programme in Economics and Management Science.

Gans, J. S. (2015): "Weak Versus Strong Net Neutrality," *Journal of Regulatory Economics*, 47, 183–200.

Gans, J. S. and M. L. Katz (2016): "Weak Versus Strong Net Neutrality: Correction and Clarification," *Journal of Regulatory Economics*, 50, 99–110.

GERADIN, D. AND D. HENRY (2005): "The EC Fining Policy for Violations of Competition Law: An Empirical Review of the Commission Decisional Practice and the Community Courts' Judgments," *European Competition Journal*, 1, 401–473.

GREENE, W. (2007): *Econometric Analysis*, Pearson, 6th ed.

GREENSTEIN, S., M. PEITZ, AND T. VALLETTI (2016): "Net Neutrality: A Fast Lane to Understanding the Trade-offs," *The Journal of Economic Perspectives*, 30, 127–149.

GRUNDBERG, S. (2012): "TeliaSonera Backs Off Plan to Charge for VoIP," http://www.marketwatch.com/story/teliasonera-backs-off-plan-to-charge-for-voip-2012-09-24.

GUO, H., S. BANDYOPADHYAY, H. CHENG, AND Y.-C. YANG (2010): "Net Neutrality and Vertical Integration of Content and Broadband Services," *Journal of Management and Information Systems*, 27, 243–276.

HACKETT, S. C. (1992): "A Comparative Analysis of Merchant and Broker Intermediation," *Journal of Economic Behavior & Organization*, 18, 299–315.

HAGIU, A. (2007): "Merchant or Two-Sided Platform?" *Review of Network Economics*, 6.

HAGIU, A. AND R. LEE (2011): "Exclusivity and Control," *Journal of Economics & Management Strategy*, 20, 679–708.

HAGIU, A. AND J. WRIGHT (2014): "Marketplace or Reseller?" *Management Science*, 61, 184–203.

——— (2015): "Multi-Sided Platforms," *International Journal of Industrial Organization*, 43, 162–174.

HELLWIG, M. AND K. HÜSCHELRATH (2016): "Cartel Cases and the Cartel Enforcement Process in the European Union 2001–2015: A Quantitative Assessment," Mimeo.

Hellwig, M., K. Hüschelrath, and U. Laitenberger (2016): "Settlements and Appeals in the European Commission's Cartel Cases: an Empirical Assessment," Mimeo.

Hernandez-Garcia, J. M. (1997): "Informative Advertising, Imperfect targeting and Welfare," *Economics Letters*, 55, 131–137.

Hoppner, T. (2015): "Defining Markets for Multi-Sided Platforms: The Case of Search Engines," *World Competition*, 38, 349–366.

Hüschelrath, K. and F. Smuda (2016): "The Appeals Process in the European Commission's Cartel Cases: An Empirical Assessment," *Journal of Empirical Legal Studies*, 13, 330–357.

International Telecommunications Union (2012): "Net neutrality: A Regulatory Perspective," GSR 2012 Discussion Paper.

Iyer, G., D. Soberman, and J. M. Villas-Boas (2005): "The Targeting of Advertising," *Marketing Science*, 24, 461–476.

Johnson, J. P. and D. P. Myatt (2006): "On the Simple Economics of Advertising, Marketing, and Product Design," *The American Economic Review*, 96, 756–784.

Johnston, J. and J. DiNardo (1997): *Econometric Methods*, McGraw-Hill, 4th ed.

Jones, M. (2009): "Kumaraswamy's Distribution: A Beta-Type Distribution with some Tractability Advantages," *Statistical Methodology*, 6, 70–81.

Jullien, B. and W. Sand-Zantman (2016): "Internet Regulation, Two-Sided Pricing, and Sponsored Data," Mimeo.

Kaplow, L. (2010): "Why (Ever) Define Markets?" *Harvard Law Review*, 437–517.

——— (2015): "Market Definition, Market Power," *International Journal of Industrial Organization*, 43, 148–161.

Kourandi, F., J. Kramer, and T. Valletti (2015): "Net Neutrality, Exclusivity Contracts and Internet Fragmentation," *Information Systems Research*, 26, 320–338.

Krämer, J., L. Wiewiorra, and C. Weinhardt (2013): "Net Neutrality: A Progress Report," *Telecommunications Policy*, 37, 794–813.

Laffont, J.-J. and J. Tirole (1994): "Access pricing and competition," *European Economic Review*, 38, 1673–1710.

Lewis, T. and D. Sappington (1999): "Access Pricing with Unregulated Downstream Competition," *Information Economics and Policy*, 11, 73 – 100.

Luchetta, G. (2014): "Is the Google Platform a Two-Sided Market?" *Journal of Competition Law & Economics*, 10.

Manne, G. A. and J. D. Wright (2011): "Google and the Limits of Antitrust: the Case Against the Case Against Google," *Harvard Journal of Law & Public Policy*, 34.

Meurer, M. and D. O. Stahl (1994): "Informative Advertising and Product Match," *International Journal of Industrial Organization*, 12, 1–19.

Miller, N. H. (2009): "Strategic Leniency and Cartel Enforcement," *The American Economic Review*, 99, 750–768.

Parr, A. N., R. J. Finbow, and M. J. Hughes (2005): *UK Merger Control: Law and Practice*, Sweet & Maxwell.

Peitz, M. and F. Schuett (2016): "Net Neutrality and Inflation of Traffic," *International Journal of Industrial Organization*, 46, 16–62.

Ratliff, J. D. and D. L. Rubinfeld (2014): "Is There a Market for Organic Search Engine Results and Can Their Manipulation Give Rise to Antitrust Liability?" *Journal of Competition Law & Economics*, 10, 517–541.

Reggiani, C. and T. Valletti (2016): "Net Neutrality and Innovation at the Core and at the Edge," *International Journal of Industrial Organization.*

Renault, R. (2016): "Advertising in Markets," in *Handbook of Media Economics*, ed. by A. Simon, J. Waldfogel, and D. Stromberg, Elsevier, vol. 1A, 121–204.

Rey, P. and J. Tirole (2007): *A Primer on Foreclosure*, Elsevier, vol. 3 of *Handbook of Industrial Organization*, 2145–2220.

Rochet, J.-C. and J. Tirole (2006): "Two-Sided Markets: a Progress Report," *The RAND Journal of Economics*, 37, 645–667.

Rysman, M. (2009): "The Economics of Two-Sided Markets," *The Journal of Economic Perspectives*, 23, 125–143.

Schuett, F. (2010): "Network Neutrality: A Survey of the Economic Literature," *Review of Network Economics*, 9, 1–15.

Shapiro, C. (1980): "Advertising and Welfare: Comment," *The Bell Journal of Economics*, 749–752.

Shavell, S. (1995): "The Appeals Process as a Means of Error Correction," *The Journal of Legal Studies*, 24, 379–426.

Smuda, F., P. Bougette, and K. Hüschelrath (2015): "Determinants of the Duration of European Appellate Court Proceedings in Cartel Cases," *JCMS: Journal of Common Market Studies*, 53, 1352–1369.

Tirole, J. (1988): *The Theory of Industrial Organization*, The MIT Press.

Varian, H. R. (2007): "Position Auctions," *International Journal of Industrial Organization*, 25, 1163–1178.

Wiethaus, L. (2015): "Google's Favouring of Own Services: Comments from an Economic Perspective," *Journal of European Competition Law & Practice*, 506–512.

Wils, W. P. (2007): "The European Commission's 2006 Guidelines on Antitrust Fines: A Legal and Economic Analysis," *World Competition*, 30, 197.

Xu, L., J. Chen, and A. Whinston (2012): "Effects of the Presence of Organic Listing in Search Advertising," *Information Systems Research*, 23, 1284–1302.

Zorn, C. (2005): "A Solution to Separation in Binary Response Models," *Political Analysis*, 157–170.