Google Economics

A model of leadership in search advertising

by Federico Etro*

JEL Code: L1. Key Words: Dominance, twosided markets, online advertising
November 2011

Abstract

We analyze the role of leadership in a multi-sided market with quantity competition. The model can be microfounded taking network effects to descrive the market for search advertising. We suggest that a platform that has reached dominance in search may have an incentive to limit services to consumers to be aggressive with the advertisers, may be more likely to exploit its scale in search to build barriers to entry and may adopt click-weighted auctions to manipulate the pricing of sponsored links.

*Department of Economics, University of Venice, Ca' Foscari. I am grateful to Paul Belleflamme, Stephen Behringer, Lapo Filistrucchi, Renato Gomes, William Kovacic, Martin Peitz, Anne Perrot, Michele Polo, Roberto Roson, Richard Schmalensee, Emanuele Tarantino and other participants to the IV and V Intertic Conferences, to the III Conference on Recent Developments in Antitrust Policy and to the 2011 Cresse Conference for useful discussion on the topic. *E-mail*: federico.etro@unive.it.

The theoretical analysis of market leadership is crucial to understand abuse of dominance issues in imperfectly competitive markets. This article provides a first exploration of the role of leaders in multisided markets, that is markets where firms compete by charging (or offering different services to) multiple sides at the same time, as in the case of the market for online advertising. The economics of multisided markets has recently attracted a lot of attention between economists (Rochet and Tirole, 2003; Caillaud and Jullien, 2003; Armstrong, 2006; Weyl, 2010; Athey and Ellison, 2011) because it characterizes a number of important markets of the New Economy and generates a number of new intriguing antitrust issues. In particular, a wide interest has been focused on the market for search advertising, whose dominant firm at the global level, Google, is currently being investigated by a number of antitrust authorities. Analyzing this market, it emerges that possible abuses may concern manipulation of the opaque bidding system for sponsored links leading to exploitative prices on advertisers, preferential treatment for Google's own services in its free ('universal') search and exclusivity clauses for advertisers leading to exclusion of competing platforms. However, the theoretical debate on the role of market leaders in multi-sided markets is still limited: most of the literature on multi-sided markets is focused on monopolistic pricing and symmetric competition between platforms, not on competition between a potentially dominant platform and its followers.

In this article, building on the literature on strategic commitments under different entry conditions (Fudenberg and Tirole, 1984; Etro, 2006) and its recent applications to antitrust and contract theory (Etro, 2010, 2011), we advance some preliminary insights on modeling leadership in multi-sided markets. As usual, the incentives to adopt different strategies or pre-commitments depend on the nature of competition, on the entry conditions and on the impact of those strategies or pre-commitments on marginal profitability. First of all, we argue that a model of quantity competition between platforms better characterizes the market for search advertising. Second, we argue that online advertising can be realistically characterized by a fixed number of players in the short-medium run. And finally we examine the impact of different pre-commitments on the equilibrium of this multi-sided market. Our analysis suggests that a platform that has reached dominance in search advertising can have an incentive to limit services to consumers to be more aggressive in the competition for advertisers (a "lean and hungry look" strategy in the classic terminology of Fudenberg

and Tirole, 1984), or to exploit its scale in search to build barriers to entry and to adopt price discrimination through opaque click-weighted auctions to manipulate pricing for sponsored links (a "top dog" strategy in the mentioned terminology). As far as we know, this is the first analysis of asymmetric competition between leaders and followers in multi-sided markets, even if it belongs to a growing body of literature on antitrust issues in multisided markets (Evans, 2003a,b; Behringer and Filistrucchi, 2010).

The paper is organized as follows. Section 1 motivates our analysis describing the multi-sided market of search advertising and introducing details of the Google case. Section 2 shows a simplified version of a model of search advertising. Section 3 generalizes it in many dimensions. Section 5 concludes.

1 The market for search advertising

The motivation for this paper derives from recent attention of the leading antitrust authorities on a prominent multi-sided market, the one for online advertising, which is dominated by Google at the global level. In November 2010 the European Commission has started an investigation on potential abuses concerning the preferential treatment for Google services in its free search engine, the manipulation of the pricing system for the sponsored links, and exclusivity clauses or other restrictions for advertisers using Google services. In particular, the potential abuse is about 1) "allegedly lowering the ranking of unpaid search results of competing services which are specialised in providing users with specific online content such as price comparisons (so-called vertical search services) and by according preferential placement to the results of its own vertical search services in order to shut out competing service", 2) lowering the 'Quality Score' for sponsored links of competing vertical search services, 3) imposing "exclusivity obligations on advertising partners, preventing them from placing certain types of competing ads on their web sites, as well as on computer and software vendors, with the aim of shutting out competing search tools", and 4) imposing "suspected restrictions on the portability of online advertising campaign data to competing online advertising platforms". The investigation started with the complaints of some European companies in February 2010: a UK price comparison site (Foundem), a French legal search engine (eJustice) and a comparison

shopping site (Ciao!).[1]

1.1 Market definition

Online advertising is a multisided market in which platforms as Google, Yahoo! and others attract at the same time Internet users and companies willing to advertise their products to these users. The more Internet users reach a platform, the more effective is an advertising campaign on the same platform. Since Internet users often join the platform with a commercial purpose in mind and use it to find information on products and offers, advertising can be tailored on them in a much more effective way than with other means. Moreover, continuous technological innovations open new ways for advertisers to be always more effective on a platform online. This generates a very limited substitutability between online and traditional advertising, implying the existence of separate markets, which is confirmed by the outcome of multiple investigations.[2] In spite of this, Ratliff and Rubinfield (2010) have advanced the hypothesis that some substitutability between online and traditional advertising could exist because they both serve broad advertising goals. However they have not provided any empirical argument in support of such a view and have neglected a key difference: traditional advertising is aimed at building a general brand-awareness usually without a specific target audience, while online advertising (especially search advertising) is largely aimed at generating market transactions online. From this perspective, traditional and online advertising are almost always complements rather than substitutes,[3] and should be considered separate markets. Goldfarb and

[1] Other complaints have been also filed in front of the US, German and Italian authorities, mainly regarding unfair competition with publishers and other content providers. The French competition authority has also carried out a consultation, concluding in December 2010 that Google holds a dominant position both in search-related advertising and contextual advertising and that "competition law can apply limits to Google's actions and provide a response to the competitive stakes brought to light by the actors, without the need to implement sector-wide regulations." Some constraints to the activity of Google have been decided also in Italy in January 2011, but the main antitrust debate will take place at the EU level.

[2] See the Google/DoubleClick investigations by the European Commission and the U.S. Federal Trade Commission and the Microsoft/Yahoo! investigations by the European Commission, the U.S. Department of Justice and the Australian Competition Commission.

[3] Analogously, Amazon may compete with traditional bookstores, but does not compete with traditional advertisers of books (whose services actually promote the business of Amazon rather than being substitutes for it). For a theoretical investigation on the relation between traditional and online advertising see Athey, Calvano and Gans (2011) and Blasco, Pin and Sobbrio (2011).

Tucker (2011) have provided an interesting analysis of susbtitutability between search advertising and a very particular form of offline advertising, marketing through mail and email. They used data on prices paid by U.S. personal injury lawyers in search advertising (on the Google platform) comparing states where they can and they cannot directly contact potential clients by mail or email. Their econometric analysis convincingly argues that advertising prices per click are 5-7% higher when state regulations forbid this form of offline advertising, suggesting that online and offline advertising would be substitutes. However, this conclusion can be criticized on multiple grounds:

- it does not really apply to the substitutability between online search advertising and traditional offline advertising, but mainly to the substitutability between search advertising and a marginal part of online advertising which is e-mail advertising;

- it is not clear how to evaluate such a limited percentage change of prices in search advertising as a response to a huge change of the price of mail advertising (since forbidding snail-mail marketing is equivalent to a prohibitive increase of its price): the traditional test of market definition of a reaction to a small price increase would probably give raise to a smaller or an insignificant change in price for search advertising, suggesting that the markets would be separate;

- this natural experiment is very specific to U.S. legal marketing and hardly extends to other countries or markets (there are no similar studies for the European Union).

Within online advertising, one can also distinguish two markets, search and display advertising. Search advertising is aimed at direct demand fullfillment, as witnessed by the "text-only" composition and the payments on a *Cost per click* (CPC) basis;[4] moreover, platforms compete to conquer the largest number of visitors (that is they compete in quantities) and charge advertisers for the clicks they receive on their ads. Display advertising is mainly aimed at brand awareness and directed to a targeted audience (always more so with new technologies allowing for forms of behavioral advertising that are impossible with traditional media): this is witnessed by the advanced graphic/video composition of the ads and the payments on a *Cost per thousand impression* (CPM)

[4]The first successfull pay-per-click auction based model was introduced in 1998 by Overture, adopted only in 2002 by Google (not without a legal issue for infringement of the patents of Overture), which exploited it better than other search engines thanks to the increasing scale of its natural search engine.

basis.[5] Since firms pay exactly for what they value, an impression which gives general brand awareness to the web visitor (and not for a click which may, or may not, lead to a market transaction, as in search advertising), platforms can directly compete in prices for display advertising. In these two markets advertisers not only face different forms of pricing, but they actually buy different goods: clicks leading to market transactions with a certain probability on one side, and impressions that promote a brand on a targeted audience on the other side. To verify that the markets are distinct, one should evaluate the impact of a hypothetical small increase in the price of search advertising: given the technological advantage that a search platform obtains from a large market size in free search, it is unlikely that display advertisers or other non-search advertisers could exploit this change and even less likely that they could profitably enter the search advertising market in the short or medium run. Besides this, not much is known on substitutability between different services and more research on market definition is welcome.[6] The focus of the rest of the paper will be on the most relevant of the two markets, the one for search advertising.

1.2 Market structure

As well known, Google is the leading search engine in the world, with a global share of search traffic around 85 %, against 7 % for Yahoo! and 4 % for Bing, but with even higher market shares in Europe.[7] Google reached this position through constant innovations that have improved the search experience (think of Google Instant, Place Search, Real-time Search, Social Search and the Universal Search of course) and provided a wide array of services to Internet users. Beyond this, Google dominates the lucrative business of placing text ads next to search engine results. Google AdWords accounts for more than 70 % of search advertising revenue worldwide, leaving Yahoo! and Microsoft far behind. All these platforms choose a number of advertisements to be made available in a specific order for any search query. Given the space allocated to these sponsored links, an auction pins down the market clearing price for these advertisements. More precisely, payments are based on so-called Vickrey auctions between ad-

[5] However, behavioral advertising is likely to push also this form of advertising toward something directly aimed at demand fullfillment in the near future.

[6] For one of the first theoretical analysis on market definition see Filistrucchi (2010).

[7] Google is the leader in search in every European country except for the Czech Republic, where the local engine Seznam is the leader. The leaders in Japan and China have been traditionally Yahoo! and Baidu.

vertisers on the keywords that match the content of the webpages or searches: charges are typically for each click on the ad, and the highest bid for each keyword association wins, with the price given by the second highest bid: as shown by Vickrey (1961), this tends to force bidders to reveal their true evaluation of the click,[8] which allows the auctioneer to choose the profit maximizing auction mechanism. Contrary what is usually claimed (see, for instance, Ratliff and Rubinfleld, 2010) these auctions do not necessarily add a competitive element to online advertising, but allow a dominant firm to adopt complex forms of price discrimination aimed at excluding competitors in search advertising or at extracting all the surplus from the bidders (or even both aims at the same time).

The auction process for search advertising is made more complex by the different places where the ad can appear on the search page (on these *position auctions* see Edelman *et al.*, 2007, Varian, 2007, Agarwal *et al.*, 2009, and Athey and Ellison, 2011), and remains largely obscure to advertisers and competitors. More recently, most platforms have introduced forms of *click-weighted auctions* that weight bids to give priority to advertisements with a larger chance to be clicked on: this mechanism is aimed at increasing the effective willingness to pay (see Athey and Ellison, 2011, for the most complete theoretical treatment of this issue). The lack of transparency of this pricing and ranking scheme could easily hide abusive forms of exclusionary behaviour, predatory strategies against competing services specialized in providing users with specific online content (price comparisons), price discrimination or even exploitative pricing toward selected advertisers. For instance, an exclusionary behaviour was identified by the French national competition authority when Google suspended the AdWords account of a French company providing online services (Navx); Google was subsequently forced by the competition authority to re-establish the account.

The structure of the market for search advertising depends on a particular form of network externality which is quite different from the one emerging in other markets of the New Economy. This is due to two main reasons, one related to technological issues and one related to the role of multihoming by advertisers.

1.3 Scale in search

First of all, network effects in search are combined with a form of learning by doing (or learning by searching). This is due to technological reasons: search engines find more relevant results for each query when there are more queries

[8] More recent contributions include Hansen (1988) or Maskin and Riley (2000).

and the subsequent clicks of the users provide information on what were the most relevant websites associated with particular keywords (see also Tarantino, 2011). Through this feedback mechanism, the same users improve the algorithms that govern the search engine, and the impact is relatively bigger on tail queries (compared to the most common queries on which all search engines reach a relatively large scale of queries). Therefore, not only more search generates more demand for advertising (as in any market with network effects), but more search generates also the scale needed to improve the search technology and provide more relevant results and ads, which in turn generates more search. This is a key difference compared to other markets with network externalities, as those of other software platforms: on one side in traditional platforms the number of consumers determines the demand of application developers but does not affect the quality of the software platform for a given number of applications, on the other side the number of visitors of a search engine determines not only the demand of advertisers but also the (future) quality of the search engine (in terms of ability to reach the most relevant results). This combination of network effects and learning by doing induces initial increasing returns to scale in this market, that are reflected in the pattern of the "*revenue per search*" (RPS), which has a typical S shape in the size of the web visitors - the RPS is always increasing in the size of search but in a convex way at a small scale and in a concave way at a larger scale.

As a consequence of the importance of scale in search, for a platform to enter the search advertising market (or increase its market share) and compete with the leader it is crucial to rapidly gain scale and close the technological and information gap on the search queries (to provide more relevant results and conquer more visitors and advertisers). At the same time, for a leading platform to maintain its market power it is crucial to protect the information gained through searches and limit the scale of the rivals and their learning by doing. Any exclusivity agreement between the dominant firm and hardware or software distributors to install only its search-related product and services or between the dominant firm and advertisers to rely only on its platform may jeopardize any hope of the competitors to gain scale and compete on the merit (see Argenton and Prufer, 2011, for a recent theoretical work emphasizing this point). This may be the case of the exclusivity agreements on the Google toolbar or on the search default settings between Google and software vendors as Adobe, hardware vendors as Apple for the iPhone (and others adopting the Android

operating system) or browser distributors as Firefox, Safari and Opera.

Moroever, scale requires that any search engine must be able to have full access to all websites and "crawl" them to find new informations to be provided in search queries. Clearly, if the dominant platform obtains a privileged access to some relevant websites and limits the access of competitors, competition is penalized because raising rivals' costs may exclude some of these competitors (or accommodate market outcomes with high prices that are detrimental to advertisers). In this case, innovation by the followers is penalized as well. This is what may have happened since the acquisition by Google of YouTube, the main website for video contents, whose access for competing search engines does not appear to be as direct and immediate as for Google.

1.4 Multihoming on both sides

The second reason for which network effects in search are different from the network effects of many other markets is that multihoming on both sides (by web visitors and advertisers) can easily spread their benefits between different providers. Of course, multihoming by consumers is key to drive the accumulation of information needed to build scale for a minor search engine. The fact that search engines are free and, most of all, are always "one click away" on the Internet plays a double role in this context. On one side, it allows consumers starting from the dominant search engine to easily try alternative ones to test their capabilities or to perform additional investigations whenever the intial search was not fully satisfactory (which, hwoever, may be too little to enhance the chances for minor search engines to gain scale and take off). On the other side, multihoming by consumers allows those who are experimenting a minor search engine to quickly revert to the dominant one jeopardizing the chances of the former to develop and protecting the advantage of the latter.

Equally important is multihoming on the advertisers' side. Since advertisers are uniquely interested in the effectiveness of their spending in search advertising, they have good reasons to diversify their investment between alternative platforms in such a way that the marginal returns are equalized. Multihoming guarantees that different Internet users can be reached with different search engines, typically with a higher budget destined to the leading channel (currently Google AdWord) and a smaller budget shared across the others (as Yahoo! Panama or Microsoft AdCenter). Moreover, data analysis can easily allow for a comparison of the return on investment in each channel to optimize spending.

It is clear that multihoming by many advertisers would contribute to the development of scale and efficiency of minor search platforms.[9] As a consequence, any policy aimed at limiting multihoming in search advertising (or simply at raising its costs) is going to create obstacles to the creation of network effects. This may be the case for the contracts with which Google prohibits advertisers from using competing platforms, and for the exclusive use by Google of the data on its clients which prevents them from performing data analysis to compare the return on investment of different advertising channels.

1.5 Vertical search and search intermediation

Besides general search engines, some search platforms focus on specific issues, as news, travel information, academic works, finance, videos, maps, and more: since these services offer a deeper information within particular fields, they are usually referred to as *vertical search services*. To be reached and used (as for any website) these vertical services rely on general search engines as Google. In the last years Google has also introduced new services, some of which raise serious concerns not only about antitrust, but also about copyright protection (Google Books) and privacy (Youtube and Google Maps with Street View, which emerged ignoring any privacy regulation). This is particularly evident in terms of predatory pricing or free riding against content providers, whose information is freely aggregated and displayed by Google News. On this front, the Italian and French competition authorities have obliged Google to guarantee that press publishers will be able to request and obtain exclusion from Google News, but without being de-listed from the general search. On the antitrust front, the new services of Google have rapidly gained success over competing vertical search services, but possibly with the help of manipulated ranking in the natural search of Google, which ends up marginalizing any competing vertical engine (Tarantino, 2011).[10] As long as a dominant search platform gives prior-

[9] Notice that this is quite different from what emerges in some of the other software platforms where multihoming on both sides is often not necessary (think of the market for video games, where consumers do not multihome and choose a single platform, but multihoming by game developers guarantees the process of development of network effects for all competing platforms).

[10] Clearly there is a trade-off between gains from additional business due to the manipulation of organic search and losses from lost visitors realizing the same manipulation, but a leader would have some gains to manipulate against the followers. As the founders of Google have explicitly noticed (Brin and Page, 1998): "A search engine could add a small factor to search

ity to its own vertical services and diverts traffic away from its competitors, it is destined to reach leadership in any service provided, hurting competition on the merit. Moreover, alternative specialized search engines are the only entry constraints that Google could face in the short and medium run, and protecting their viability is crucial to protect competition.

A separate submarket in search concern the agreements between search platforms and leading publishers to offer search services on their websites. This form of "*search intermediation*" is becoming quite relevant because an increasing amount of search is done within popular websites (not only to search in the same websites but also in the entire Internet). The deals usually generate a division of the ad revenues between the platform and the publisher, and the remuneration of the publishers, the so-called "*traffic acquisition cost*" (TAC), can often reach percentages of revenues well above 50 % plus fixed fees. Given the size of some websites, some of these deals guarantee a search platform with a large number of search queries that can power the mentioned process of learning by doing. Nevertheless, also the market for search intermediation is dominated by Google. Of course, multihoming by websites is possible and there are no deep reasons to commit to long term contracts. Therefore, any long term exclusive dealing arrangement between a dominant search platform can again jeopardize the chances of the competing platforms to gain scale and compete on the merit. Agreements of this kind between Google and many famous websites (as Amazon, eBay, Ask, AOL, CNN, Friendster, MySpace and others) could be of this nature (of course Bing is doing the same with Facebook, but Bing is a far follower in the market for search advertising).

1.6 Entry conditions

Google controls at least 80 % of the worldwide market for online advertising, and, as confirmed by the sector inquiry by the French antitrust authority, is protected by high barriers to entry. As mentioned, a first source of barriers to entry is related to the importance of scale in search, and the huge lead time that the dominant player has because of the massive amount of data it can draw on to improve its organic search, which is due to the high volume of the search queries that are made and to the fact that Google is a laggard in the

results from "friendly" companies, and subtract a factor from results from competitors. This type of bias is very difficult to detect but could still have a significant effect on the market."

industry with respect to the anonymization of user data.[11] A second source of barriers to entry derives from the fact that alternatives to Google can be hardly offered to publishers using Google's services: switching to a different publisher tool involves high sunk costs in terms of substantial investments in software, in training the staff, coding all of the data about keywords' association and returns for search advertising, managing novel datasets, transferring ad campaigns to the system and so on, with all the associated business risk.

This leaves space for multiple potential abuses by the dominant firm, including exploitative pricing on advertisers (with negative indirect consequences on all sectors depending on advertising) made possible through aggressive strategies on the other side (free services to consumers and free distribution of content produced by third parties), exclusivity clauses for advertisers using Google services and restrictions that Google can place on advertisers that wish to use the services of competing platforms. The clarification of these mechanisms requires a wide theoretical work on the role of leaders in multi-sided markets. In the rest of the paper we provide some preliminary thoughts on this aspect, focusing on fully fledged multi-sided markets with and without a dominant platform.

2 A model of two-sided competition

In this section we will examine a simple model where a platform, as an online advertising platform (say Google or Yahoo!), charges for each interaction (*pay per click*). Denoting with c_i the marginal cost of an interaction for platform i, the profit of platform i is:

$$\Pi^i = (p_{ai} - p_{ci} - c_i) \cdot A_i \cdot C_i \tag{1}$$

where p_{ai} is the price charged on advertisers per interaction, p_{ci} can be seen as the cost per interaction to attract consumers, i.e.: the cost of the services freely provided to consumers (in search advertising), A_i is the number of ads available through platform i, C_i is the number of consumers reached by these

[11] In this spirit, Argenton and Prufer (2011) have argued that the market for Internet search is characterized by data-driven indirect network externalities and have built a simple model of search engine competition delivering gradual monopolization by Google. Therefore, they have proposed to require search engines to share their data on previous searches and have shown that their proposal would increase the rate of innovation, search quality, consumer surplus, and total welfare.

ads through platform i, and their product represents (or is proportional to) the number of interactions.

The number of consumers C_i reached by an ad for each platform i is increasing in p_{ci}, with $C_i = C(p_{ci})$. The supply of consumers can also be inverted to obtain $p_{ci} = p^i(C_i)$, which is increasing in the number of consumers. On the other side, an advertiser can choose between different platforms on the basis of their prices. We will adopt a reduced form for the number of ads offered to each platform i: $A_i = A^i(\mathbf{p}_a)$, where $\mathbf{p}_a = (p_{a1}, p_{a2}, ..)$ is the vector of prices of different platforms, decreasing in p_{ai} and increasing in p_{aj} for any $j \neq i$. Analogously we can define the inverse demand of advertising as $p_{ai} = p^i(\mathbf{A})$ where $\mathbf{A} = [A_1, A_2, ..]$ is the vector of advertsement choices, with $\partial p^i(\mathbf{A})/\partial A_j < 0$ for any j. In general these relations should depend also on the size of the potential consumers because of network effects, but we leave a full derivation of a microfounded model to a following section.

The profit of platform i can be written as a function of the quantity of advertisements and consumers:

$$\Pi^i = \left[p^i(\mathbf{A}) - p^i(C_i) - c_i\right] A_i C_i \tag{2}$$

Symmetric forms of competition have been analyzed by Armstrong (2006), Chakravorti and Roson (2006), Rochet and Tirole (2006) and others mainly in models of price competition. However, search advertising can be interpreted in terms of quantity competition. On one side, each platform decides how many consumers will join the platform, typically providing free services that deliver utility for consumers and can be seen as a price paid to them. Natural search results and a vast array of free applications attract visitors on a search engine, making them available for sponsored search as well. Of course, the number of visitors is constrained by the technology available to the search engine and the exploitation of network effects built over time, but a larger number of visitors can be always obtained at a larger cost. A microfoundation is provided in the next section.

On the other side, each platform decides how many ads will be made available on the search engine (typically above or on the right hand side of the natural search results for each query) and an auction pins down the market clearing price $p_{ai} = p^i(\mathbf{A})$ for these advertisements. More recently, most platforms have introduced forms of *click-weighted auctions* that weight bids to give priority to advertisements with a larger chance to be clicked on (see Athey and

Ellison, 2011): this amounts to a sophisticated mechanism aimed at increasing the effective willingness to pay, and therefore the total revenues.

Finally, notice that search advertising is characterized by barriers to entry due to the importance of scale in search, and the huge lead time that the dominant player has because of the massive amount of data it can draw on to improve its organic search (which is due to the high volume of the search queries that are made). For this reason, a focus on exogenous rather than endogenous entry appears proper. In our model, quantity competition between an exogenous number of platforms leads to a symmetric Cournot equilibrium satisfying the first order conditions:

$$\begin{aligned} A_i &: \; p^i(\mathbf{A}) - p^i(C_i) - c_i + \frac{\partial p^i(\mathbf{A})}{\partial A_i} A_i = 0 \\ C_i &: \; p^i(\mathbf{A}) - p^i(C_i) - c_i - \frac{\partial p^i(C_i)}{\partial C_i} C_i = 0 \end{aligned}$$

which can be rewritten in terms of a Rochet-Tirole (2003) rule:

$$p_{ai} - p_{ci} - c_i = \frac{p_{ai}}{\epsilon^i(\mathbf{A})} = \frac{p_{ci}}{\epsilon^i(C_i)} \tag{3}$$

where $\epsilon^i(\mathbf{A}) = -p^i(\mathbf{A})/A_i \left[\partial p^i(\mathbf{A})/\partial A_i\right] > 0$ is the elasticity of demand of advertising and $\epsilon^i(C_i) = p^i(C_i)/C_i \left[\partial p^i(C_i)/\partial C_i\right] > 0$ is the elasticity of supply of consumers. The equilibrium markups for each platform are decreasing in the relevant elasticities and in the marginal cost per interaction, but the relative charge on advertisers increases in the elasticity of demand of advertising and decreases in the elasticity of supply of consumers. Moreover, under regularity conditions, the elasticity of demand of advertising increases with the number of competing platforms, which leads to reduced markups: competition between symmetric platforms tends to reduce profitability.[12]

[12]The details of this model provide some help in defining the relevant market for antitrust purposes in such a complex two-sided market as search advertising. First, under our assumptions, more efficient platforms (here with lower cost per interaction) end up with more consumers and more advertising, determining a direct relation between the sizes of the two sides of the market. Second, the number of consumers of each platform does not affect directly the number of consumers of the other platforms or their advertising choices, and the strategic interactions take place entirely on one side, the advertising side, with the purpose of conquering advertisements to be used with the pool of consumers. Moreover, there is little or no substitutability between an online platform and a traditional platform including advertisements (as a newspaper) because only the former can directly lead to market transactions and can be used for the direct purpose of concluding these transactions rather than receiving

2.1 Market leadership

Consider now a situation in which one platform can act as a leader in the choice of a strategic variable and, therefore, precommit to it before competition with the other platforms takes place. As long as the number of platforms is exogenous, we are in the situation characterized by Fudenberg and Tirole (1984) under the assumption of strategic substitutability. More precisely, imagine that the dominant platform 1 can anticipate the choice of how many consumers to attract on the platform, C_1. In other words, in a first stage firm 1 chooses C_1 and in a second stage firms 1 and 2 choose C_2, A_1 and A_2. To verify the incentives of the leader to invest in attracting consumers, we need to look at the equilibrium cross-effect:

$$\frac{\partial^2 \Pi^1}{\partial A_1 \partial C_1} = -\frac{\partial p^1(C_1)}{\partial C_1} < 0 \tag{4}$$

In the terminology of Fudenberg and Tirole (1984), this implies that we are in a "*lean and hungry look*" case: a leader has a strategic incentive to restrict or bias the size and quality of services made available on the platform, so as to decrease the utility of the consumers per interaction with the purpose of being more aggressive against the other platforms in the competition for advertisements. Examples of this may include underinvestment in new services once dominance has been reached, preferential treatments for the services offered by the platform in the search engine (with limitations on the use of other services) and manipulation of the natural search results to promote objectives of interest for the dominant firm (as promoting its own services or excluding competitors in particular services). The consequence is that the dominant platform reduces the gains of the consumers but conquers a larger share of total advertisements.

As an example, assume that there are two platforms and the cost per interaction is the same, c. The optimality conditions derive from the first order conditions for C_2, A_1 and A_2, which implicitly determine how these variables depend on C_1, and from the optimality condition for the precommitment variable, which is simplified because C_2 does not affect directly the profitability of the leader, and the impact of A_1 disappears by the envelope theorem. After

information. Finally, profits for each platform are proportional to the number of consumers using the platform. For these reasons, a relevant measure of the size of a platform is given by the share consumers using it, and therefore a relevant definition of market size and market dominance in search advertising must start from the numbers of consumers using search engines and using each search engine.

straightforward manipulation, the equilibrium conditions can be expressed as:

$$p_{a1} - p_{c1} - c = \frac{p_{a1}}{\epsilon^1(\mathbf{A})} = \frac{p_{c1}}{\epsilon^1(C_1)} + \frac{\eta p_{a1}}{\zeta} \quad (5)$$

$$p_{a2} - p_{c2} - c = \frac{p_{a2}}{\epsilon^2(\mathbf{A})} = \frac{p_{c2}}{\epsilon^2(C_2)} \quad (6)$$

where $\zeta = -p_{a1}/A_2 \left[\partial p_{a1}/\partial A_2\right] > 0$ and $\eta = (\partial A_2/\partial C_1)C_1/A_2 > 0$. This implies the modified Rochet-Tirole rule:

$$\frac{p_{a1}}{\epsilon^1(\mathbf{A})} = \frac{p_{c1}}{\epsilon^1(C_1)\left[1 - \frac{\eta\epsilon^1(\mathbf{A})}{\zeta}\right]} \quad (7)$$

under the regularity condition $\epsilon^1(\mathbf{A}) \in (0, \zeta/\eta)$. A simple comparison of the equilibrium conditions under symmetric and asymmetric competition shows that the dominant platform manages to increase its profits through an increase of the effective markup $p_{a1} - p_{c1}$, which requires a reduction of the reward of the consumers in terms of both services per interaction (p_{c1}) and size of the market (C_1) and generates an increase of its share of advertising $A_1/(A_1 + A_2)$. Clearly, this is going to reduce consumer surplus compared to the case of symmetric competition. The impact on the advertisers is more complex but the price reduction is likely to end up in gains for this side of the market.[13]

2.2 Scale in search

Consider now a different precommitment of the leader. Suppose that the dominant platform can reduce its marginal cost per interaction through direct investments and through a process of learning by doing in service provision: in search advertising this happens because of the importance of scale in search and because of the huge lead time that a dominant player has because of the massive amount of data it can draw on to improve its organic search. Suppose that the number of visitors improves the search algorithms and reduces the cost of obtaining each click $c(C_i)$, with $c'(C_i) < 0$. As shown by Fudenberg and Tirole

[13]Notice that dominance in this case leads to a change in the gains of the two sides interacting on the platform and of the competing platforms, and, for the same nature of online advertising, which leads to online market transactions (while traditional advertising only leads to a promotion of market transactions), it does not affect the firms engaged in advertising on traditional media. Therefore, this suggests that a proper definition of the relevant market should take in consideration all (and only) the platforms matching content providers and advertisers online.

(1984) in the presence of barriers to entry, the nature of the incentives depends simply on the equilibrium cross-effect:

$$\frac{\partial^2 \Pi^1}{\partial A_1 \partial C_1} = -\frac{\partial p^1(C_1)}{\partial C_1} - c'(C_1) \tag{8}$$

which is now ambiguous: the first factor is negative as before, but the second is positive because of the gains from scale. If the latter prevails, the dominant firm has an incentive to overinvest to create scale in search ad reduce its cost per interaction. Moreover, the leadership is going to strengthen itself automatically as long as it leads to a quicker learning by doing process which reduces costs per interaction and provides an advantage in the conquest of larger market shares in advertising. The first mover advantage can easily lead to conquer the entire market: if it takes time to conquer visitors and improve the search algorithms, this can lock in the market into a monopolistic situation (as in Argenton and Prufer, 2011).

2.3 Click-weighted auctions

Most search platforms have introduced forms of click-weighted auctions that weight bids to give priority to ads with a larger chance to be clicked on (see Athey and Ellison, 2011): this amounts to a sophisticated mechanism aimed at increasing the effective willingness to pay, and therefore the total revenues. Similar systems have been introduced by Google and then by other platforms and represent crucial commercial secrets for this business.

Suppose that the dominant platform can introduce a mechanism of click-weighted auctions which increases the willingness to pay for advertisments on the platform. The mechanism is indexed by the parameter ϖ, which can be seen as the accuracy in discriminating between valuable and less valuable advertisers, or simply as the cost of development of the mechanism, which should be positively related to its accuracy. The profits of the leading platform are:

$$\Pi^1 = \left[p^1(\mathbf{A}, \varpi) - p^1(C_1) - c_1\right] A_1 C_1$$

A higher ϖ increases the inverse demand function for each interaction to $p^1(\mathbf{A}, \varpi)$, but this impact is likely to be reduced when the level of advertising on the platform is larger. Therefore, we assume that the elasticity of $\partial p^1(\mathbf{A}, \varpi)/\partial \varpi$ with respect to A_1 is less than unitary ϖ, which determines the sign of the following

marginal effect:

$$\frac{\partial^2 \Pi^1}{\partial A_1 \partial \varpi} = \left[\frac{\partial p^1(\mathbf{A}, \boldsymbol{\varpi})}{\partial \boldsymbol{\varpi}} + \frac{\partial^2 p^1(\mathbf{A}, \boldsymbol{\varpi})}{\partial A_1 \partial \boldsymbol{\varpi}} A_1 \right] C_1 > 0 \tag{9}$$

This cross effect suggests that we are in front of a classic "top dog" strategy in the terminology of Fudenberg and Tirole (1984): a dominant platform should overinvest in the development of a click-weighted auction mechanism. In case of two platforms, the equilibrium conditions would be given by the traditional Rochet and Tirole (2003) rules plus an optimality optimality condition for the choice of the strategic variable ϖ, which compares its marginal cost to the following marginal revenue:

$$\frac{\partial p^1(\mathbf{A}, \boldsymbol{\varpi})}{\partial \boldsymbol{\varpi}} + \frac{\partial p^1(\mathbf{A}, \boldsymbol{\varpi})}{\partial A_2} \frac{\partial A_2}{\partial \varpi}$$

The second positive term shows that there is a strategic incentive to overinvest in sophisticated pricing mechanism that manipulate the willingness to pay of the advertisers, because this shifts advertising from other platforms to the dominant one. The higher marginal revenues per click induce the dominant platform to expand both its services to consumers and its space for advertisement, while reducing their counterparts for the competing platforms. Nevertheless, the higher willingness to pay (bid) for advertising induced by the enhanced mechanism may even increase the price charged by the leading platform on advertisers. In this sense, these mechanisms may generate a non-transparent manipulation of the pricing system for the sponsored links which can limit competition.

3 Microfoundations, network effects and entry

Network effects[14] that induce an increase in the willingness to pay for ads on platforms with more visitors can be easily introduced. Under some additional restrictions, the tendency of market leaders to restrict the services provided to the web visitors (to be more aggressive in advertising) persists. A counteractive force, however, emerges because a larger base of web visitors increases the willingness to pay of the same advertisers on the platform. If network effects and scale in search effects are strong enough, as we would expect given their importance in the market for search advertising, they induce a tendency for the dominant firm to overinvest to conquer visitors and lock in the market into a

[14] See Katz and Shapiro (1985) for a classic analysis.

monopolistic outcome in which followers do not manage to catch up. To see this, we generalize the previous model with a solid microfoundation taking network effects into account.

Consider n platforms for search advertising $j = 1, ..., n$ serving advertisers on one side and web visitors on the other side. For simplicity, let us assume that there is a single advertising company, which pays a price per click p_{ai} for every interaction between its ads and a web visitor on platform i. Given its advertising A_i on the platform i with C_i web visitors, the number of times a web visitor faces an advertisment on this platform is $A_i C_i$ and the probability that this leads to an interaction is $\rho \in (0, 1]$. For every interaction, there is a probability that this leads to a market transaction with expected revenue V. It is reasonable to assume that the expected unitary revenue is increasing and possibly concave in the number of ads, for instance because the probability of a transaction increases with the number of advertisements but less than proportionally. Therefore, we assume:

$$V = V(A_i) \text{ with } V'(A_i) > 0 \text{ and } V''(A_i) \leq 0$$

Finally, all the ads have a cost $g(\mathbf{A})$, where $\mathbf{A} = [A_1, A_2, ..]$ is the vector of advertisement choices, and $g(\mathbf{A})$ satisfies $g_i(\mathbf{A}) > 0$ and $g_{ij}(\mathbf{A}) > 0$ for any i and j. The profit of the advertising company is therefore:

$$\pi^A = \sum_{j=1}^{n} V(A_j)\rho A_j C_j - \sum_{j=1}^{n} p_{aj}\rho A_j C_j - g(\mathbf{A}) \tag{10}$$

and is maximized under the conditions:

$$\rho V'(A_i)A_i C_i + \rho V(A_i)C_i - p_{ai}\rho C_i = g_i(\mathbf{A}) \quad i = 1, .., n$$

that equilize the return on investment in advertising on any platform.

Solving for the price, we obtain the inverse demand function of advertising on platform i:

$$p^i(\mathbf{A}) = V'(A_i)A_i + V(A_i) - \frac{g_i(\mathbf{A})}{\rho C_i} \tag{11}$$

which is always decreasing in A_i when the second order conditions are satisfied, and is always increasing in the number of visitors C_i. The last comparative statics follows from the presence of network effects: more visitors increase the willingness to pay of each advertiser because they increase the chances to reach a click.

To microfound the number of web visitors on the platform C_i, assume that platform i provides services whose cost per interaction is q_{ci}, and each web visitor k obtains utility:

$$U_k = \theta_k p_{ci} \varphi(C_i) - \bar{u} \tag{12}$$

from visiting the platform i, where θ_k is a preference parameter, distributed in the population according to the cumulative function $F(\theta_k)$ with density $f(\theta_k)$, $\bar{u}$ is a reserve utility (from visiting other websites) and $\varphi(C_i)$ is increasing in the number of visitors and represents the network effects. If total population is N_C, the number of visitors is

$$\begin{aligned} C(p_{ci}) &= N_C \left[1 - F\left(\frac{\bar{u}}{\varphi p_{ci}}\right)\right] \\ \text{with } C'(p_{ci}) &= N_C f(\bar{u}/\varphi p_{ci})(\bar{u}/\varphi p_{ci}^2) > 0 \end{aligned}$$

which can be inverted to obtain the function:

$$p^i(C_i) = \frac{\bar{u}}{\varphi F^{-1}\left(1 - \frac{C_i}{N_C}\right)} \tag{13}$$

This is increasing in the number of visitors and increasing in the reserve utility that must be reached to generate a visit. In the presence of network effects, regularity conditions insure the existence of a unique number of visitors which can be inverted to obtain the same kind of function, which we define as $p_{ci} = p^i(C_i)$. Notice that in the previous example we assumed for simplicity $\rho = \varphi = N_C = 1$.

The profit of platform i is:

$$\begin{aligned} \Pi^i &= \left[p^i(\mathbf{A}) - p^i(C_i) - c_i\right] \rho A_i \left(C_i N_C\right) = \\ &= \left[V'(A_i)A_i + V(A_i) - \frac{g_i(\mathbf{A})}{\rho C_i} - \frac{\bar{u}}{\varphi F^{-1}(1 - C_i/N_C)} - c_i\right] \cdot \\ &\quad \cdot \rho A_i \left(C_i N_C\right) \end{aligned} \tag{14}$$

3.1 Symmetric competition

Quantity competition between an exogenous number of symmetric platforms would lead to a symmetric Cournot equilibrium satisfying the first order conditions:

$$\begin{aligned} A_i &: \; p^i(\mathbf{A}) - p^i(C_i) - c_i + 2V'(A_i) + V''(A_i)A_i - \frac{g_{ii}(\mathbf{A})}{\rho C_i} = 0 \\ C_i &: \; p^i(\mathbf{A}) - p^i(C_i) - c_i + \frac{g_i(\mathbf{A})}{\rho C_i} - \frac{\partial p^i(C_i)}{\partial C_i} C_i = 0 \end{aligned}$$

In the simpler case in which which $V'(A_i) = V$, these equilibrium conditions can be rewritten in terms of a modified Rochet-Tirole (2003) rule:

$$p_{ai} - p_{ci} - c_i = \frac{p_{ai}}{\epsilon_A^i(\mathbf{A})} = \frac{p_{ci}}{\epsilon^i(C_i)} + \frac{p_{ai}}{\epsilon_C^i(\mathbf{A})} \tag{15}$$

where $\epsilon_A^i(\mathbf{A}) = -p^i(\mathbf{A})/A_i \left[\partial p^i(\mathbf{A})/\partial A_i\right]$, $\epsilon_C^i(\mathbf{A}) = -p^i(\mathbf{A})/C_i \left[\partial p^i(\mathbf{A})/\partial C_i\right]$ and $\epsilon^i(C_i) = p^i(C_i)/C_i \left[\partial p^i(C_i)/\partial C_i\right]$. The rule differs from the one in the text only in the last term: because of the network effects, each platform tends to attract more web visitors (expanding the service offered) to attract more advertisers.

To endogenize the market structure, let us impose an additional assumption on the cost function of the advertisers:

$$g(\mathbf{A}) = g\left(\sum_{j=1}^{n} h(A_j)\right)$$

This implies that the inverse demand can be written as:

$$p^i(\mathbf{A}) = V'(A_i)A_i + V(A_i) - \frac{h'(A_i)g'\left(\sum_{j=1}^{n} h(A_j)\right)}{\rho C_i}$$

Let us assume also that there are a common cost per interaction between the platforms c and a common fixed cost F. Then, there is a symmetric equilibrium between all the platforms, characterized by the following symmetric first order conditions and endogenous entry conditions:

$$\begin{aligned} p(nA) - p(C) - c + 2V'(A) + V''(A)A - \frac{h''(A)g'\left(nh(A)\right) + h'(A)^2 g'(nh(A))}{\rho C} &= 0 \\ p(nA) - p(C) - c + \frac{h'(A)g'(nh(A))}{\rho C^2} - \frac{\partial p(C)}{\partial C}C &= 0 \\ \left[p(nA) - p(C) - c\right]\rho A C N_C &= F \end{aligned}$$

The endogenous market structure must satisfy:

$$\frac{p_a}{\epsilon_A(nA)} = \frac{p_c}{\epsilon(C)} + \frac{p_a}{\epsilon_C(nA)} = \frac{F}{\rho A C N_C} \tag{16}$$

3.2 Asymmetric competition

Let us finally move to the analysis of asymmetric competition between platforms due to some form of market leadership. To verify the role of leadership in this

market, notice that for a leading fim 1 we have:

$$\begin{aligned}\frac{\partial^2\Pi^1}{\partial A_1\partial C_1} &= -\frac{\partial p^1(C_1)}{\partial C_1}+g_1(\mathbf{A})\frac{1}{\rho C_1^2}+g_{11}(\mathbf{A})\frac{A_1}{\rho C_1}\\ &= -\frac{\partial p^1(C_1)}{\partial C_1}+\frac{V(A_1)-p^1(C_1)-c_1}{C_1} \qquad (17)\end{aligned}$$

which has an ambiguous sign. As long as the second term is small enough, this is negative and the same result of the previous section goes through as a consequence of the Fudenberg-Tirole (1984) taxonomy: a leader has an incentive to reduce the services provided to the web visitors to be more aggressive in the competition for the advertisers.

Under endogenous entry (see Etro, 2006, 2008), the advertising of the leader A_1 and of the other firms A, the number of visitors of the other firms C, and the number of firms n satisfy the following relations depending on the number of visitors of the leading platform C_1:

$$\begin{aligned}p^1(\mathbf{A})-p(C_1)-c+2V'(A_1)+V''(A_1)A_1-\frac{h''(A_1)g'(H)+h'(A_1)^2g'(H)}{\rho C_1} &= 0\\ p(\mathbf{A})-p(C)-c+2V'(A)+V''(A)A-\frac{h''(A)g'(H)+h'(A)^2g'(H)}{\rho C} &= 0\\ p(\mathbf{A})-p(C)-c+\frac{h'(A)g'(H)}{\rho C}-\frac{\partial p(C)}{\partial C}C &= 0\\ [p(\mathbf{A})-p(C)-c]\,\rho ACN_C &= F\end{aligned}$$

with $p(\mathbf{A})=V'(A)A+V(A)-h'(A)g'(H)/\rho C$, where $H=h(A_1)+(n-1)h(A)$. The last three equations determine A, C and H independently from C_1, while the first equation determines A_1 as a function of C_1. Therefore, the choice of the market leader on the size of consumers joining its platform does not affect the strategies of the other platforms, but simply affect their number and the advertising of the same leader. In the simpler case in which $V'(A_i)=V$, the profit of the leader is:

$$\Pi^1=\left[V-\frac{h'(A_1)g'(H)}{\rho C_1}-\frac{\bar{u}}{F^{-1}(1-C_1/N_C)}-c\right]\rho A_1C_1N_C$$

Taking into account that $\partial\Pi^1/\partial A_1=\partial H/\partial C_1=0$, the optimality condition for the precommitment on C_1 is:

$$p^1(\mathbf{A})-p(C_1)-c+\frac{h'(A_1)g'(H)}{\rho C_1}-\frac{\partial p(C_1)}{\partial C_1}C_1=-\frac{h'(A_1)^2g''(H)}{\rho C_1}\left(\frac{\partial A_1}{\partial C_1}\right)$$

The sign of the new term on the right and side determines weather it is optimal to over- or under-supply web visitors. As long as $\partial^2\Pi^1/\partial A_1\partial C_1 < 0$ we have an endogenous restriction of services to web visitors as in the example of the previous section. Summing up, the dominant firm increases advertising above the competing platforms and reduces their number.

The other results in the previous section go through without restrictions, because, when the cost oer transaction depends on the number of visitors, we have:

$$\frac{\partial^2\Pi^1}{\partial A_1\partial C_1} = -c'(C_1) < 0 \tag{18}$$

and, setting $V(\varpi)$ increasing in the accurcacy of the click-weighted mechanism, we also have:

$$\frac{\partial^2\Pi^1}{\partial A_1\partial \varpi} \propto V_\varpi > 0 \tag{19}$$

as in the previous section.

4 Conclusions

We have analyzed the role of leadership in multi-sided markets, with a particular emphasis on online advertising, which is characterized by a single dominant firm. We have shown that a platform that has reached dominance in search can have an incentive to limit services to consumers to be more aggressive in the competition for advertisers or to adopt click-weighted auctions to manipulate the pricing for sponsored links. Additional research on the implications of asymmetric models of competition in multisided markets appears fruitful to better understand the structure of these markets and the appropriate antitrust policies.

References

[1] Agarwal, Nikhil, Susan Athey and David Yang, 2009, Skewed Bidding in Pay-per-Action Auctions for Online Advertising, *American Economic Review, P&P*, 99, 2, 441–47

[2] Aloui, Chokri and Khaïreddine Jebsi, 2010, A Media-monopoly Products Innovation with Countervailing Cross-externalities, mimeo, University of Sousse, presented at the IV Intertic Conference

[3] Argentesi, Elena and Lapo Filistrucchi, 2011, Estimating Market Power in a Two-sided Market: the Case of Newspapers, presented at the IV Intertic Conference

[4] Armstrong, Mark, 2006, Competition in Two-Sided Markets, *The RAND Journal of Economics*, 37, 3, 668-91

[5] Argenton, Cedric and Jens Prufer, 2011, Search Engine Competition with Network Externalities, mimeo, Tilburg University

[6] Athey, Susan, Emilio Calvano and Joshua Gans, 2011, The Impact of the Internet on Advertising Markets for News Media, presented at the V Intertic Conference

[7] Athey, Susan and Glenn Ellison, 2011, Position Auctions with Consumer Search, in press, *Quarterly Journal of Economics*

[8] Behringer, Stephen, 2010, Equilibrium Market and Pricing Structures in Virtual Platform Duopoly, mimeo, Universität Bonn, presented at the 2010 Intertic Conference

[9] Behringer, Stephen and Lapo Filistrucchi, 2010, Price Wars in Two-Sided Markets: The case of the UK Quality Newspapers, mimeo, University of Bonn, presented at the IV Intertic Conference

[10] Belleflamme, Paul and Martin Peitz, 2010, Intermediation and Investment Incentives, presented at the IV Intertic Conference

[11] Blasco, Andrea, Paolo Pin and Francesco Sobbrio, 2011, Paying positive to go Negative: Advertisers' Competition and Media Reports, presented at the V Intertic Conference

[12] Brin, Sergey and Larry Page, 1998, The Anatomy of a Large-Scale Hypertextual Web Search Engine, Proceedings of the 7th International Conference on World Wide Web, Brisbane, 107-17

[13] Caillaud, Bernard and Bruno Jullien, 2003, Chicken and Egg: Competition among Intermediation Service Providers, *The RAND Journal of Economics*, 34, 2, 521-52

[14] Chakravorti, Sujit and Roberto Roson, 2006, Platform Competition in Two-Sided Markets: The Case of Payment Networks, *Review of Network Economics*, 5, 1, 118-142

[15] Edelman, Benjamin, Michael Ostrovsky and Michael Schwarz, 2007, Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords, *American Economic Review*, 97, 1, 242-59

[16] Etro, Federico, 2006, Aggressive Leaders, *The RAND Journal of Economics*, Vol. 37 (Spring), 146-54

[17] Etro, Federico, 2008, Stackelberg Competition with Endogenous Entry, *The Economic Journal*, 118, 1670-97

[18] Etro, Federico, 2010, Endogenous Market Structures and Antitrust Policy, *International Review of Economics*, 57, 1, 9-46

[19] Etro, Federico, 2011, Endogenous Market Structures and Contract Theory, *European Economic Review*, in press

[20] Evans, David, 2003a, Some Empirical Aspects of Multi-sided Platform Industries, *Review of Network Economics*, 2, 3, 191-209

[21] Evans, David, 2003b, The Antitrust Economics of Multi-Sided Platform Markets, *Yale Journal of Regulation*, 20, 325-81

[22] Evans, David, Andrei Hagiu and Richard Schmalensee, 2006, *Invisible Engines. How Software Platforms Drive Innovation and Transform Industries*, Cambridge, The MIT Press

[23] Filistrucchi, Lapo, 2010, A SSNIP Test for Two-Sided Markets: The Case of Media, mimeo, University of Tilburg, presented at the IV Intertic Conference

[24] Fudenberg, Drew and Jean Tirole, 1984, The Fat Cat Effect, the Puppy Dog Ploy and the Lean and Hungry Look, *The American Economic Review, Papers and Procedeengs*, 74 (2), 361-68

[25] Goldfarb, Avi and Catherin Tucker, 2011, Search Engine Advertising: Channel Substitution when Pricing Ads to Context, *Management Science*, in press

[26] Gomes, Renato, 2010, Mechanism Design in Two-sided Markets, mimeo, Toulouse School of Economics, presented at the IV Intertic Conference

[27] Hansen, Robert, 1988, Auctions with Endogenous Quantity, Rand Journal of Economics, 19, 1, 44-58

[28] Katz, Michael and Carl Shapiro, 1985, Network Externalities, Competition and Compatibility, *The American Economic Review*, 75, 424-40

[29] Maskin, Eric and John Riley, 2000, Asymmetric Auctions, *Review of Economic Studies*, 67, 3, 413-38

[30] Ratliff, James and Daniel Rubinfield, 2010, Online Advertising: Defining Relevant Markets, *Journal of Competition Law and Economics*, 1, 1-34

[31] Rochet, Jean-Charles and Jean Tirole, 2003, Platform Competition in Two-Sided Markets, *Journal of the European Economic Association*, 1 (4), 990-1029

[32] Rochet, Jean-Charles and Jean Tirole, 2006, Two-Sided Markets: A Progress Report, *The RAND Journal of Economics*, 37, 3, 645-67

[33] Schmalensee, Richard, 2010, Aspects of Multi-sided Platforms, mimeo, MIT, presented as the IV Stackelberg Lecture at the IV Intertic Conference

[34] Tarantino, Emanuele, 2011, A Note on Vertical Search Engines Foreclosure, presented at the V Intertic Conference

[35] Varian, Hal, 2007, Position auctions, *International Journal of Industrial Organization*, 25, 6, 1163-1178

[36] Vickrey, William, 1961, Counterspeculation, Auctions, and Competitive Sealed Tenders, *Journal of Finance*, 93, 675-89

[37] Weyl, E. Glen, 2010, A Price Theory of Multi-sided Platforms, *American Economic Review*, 100, 4, 1642-72