The Welfare and Allocative Impact of Targeted Advertising

Research-in-Progress

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Abstract

We investigate the welfare implications and the allocative effects of different consumer data-handling regimes in online targeted advertising. We develop a three-players model that includes firms, consumers, and an intermediary - the ad exchange – and analyze three scenarios that differ in the type of consumers’ data available during the targeting: a case in which only the horizontal information (consumers’ brand preferences) is available; a case in which only vertical information (consumers’ purchasing power) is available; a case in which both pieces of information are available. We find that there exist conditions under which the intermediary obtains the highest proportion of benefits from targeting and, in general, the intermediary’s incentives regarding the type of consumer information to be used for targeting are misaligned with the incentives of firms and/or consumers. Furthermore, consumers’ surplus from targeting is higher when only specific types of personal information are made available during the targeting process.

Keywords: Targeted Advertising, Online Auctions, Economics and Value of IS

Introduction

In both research and policy circles, a spirited debate has emerged over developments in Internet technologies that allow the collection, fusion, and analysis of large amounts of consumer information in real time. On the one hand, the aggregation of large databases of individuals’ data, and the application of increasingly sophisticated inferential techniques to those data, may be used to make services and transactions more efficient and even address societal problems (McAfee and Brynjolfsson, 2012). This so-called “data economy” (and the related notion of “big data”) may become a source of innovation, growth, and welfare increases for firms and consumers alike. On the other hand, some scholars have observed that more data available to firms and decision makers may not always translate to more social progress, economic efficiency, or equality (Crawford et al., 2014). In fact, economic imbalances between consumers and organizations may increase due to the exacerbation of information asymmetries between data “subjects” and data “holders” (The White House Report, 2015). In this paper, we contribute to this debate by investigating the extent to which the data economy may increase overall economic welfare, and the extent to which it may merely change the allocation of welfare between different stakeholders. We focus on the case of online targeted advertising --- one of the natural applications of the market for personal data (Tucker, 2012) and a focus of the current debate between regulators, industry, and privacy advocates.

Thirty Sixth International Conference on Information Systems, Fort Worth 2015 1
Specifically, we use economic modeling to investigate how the sharing of consumer data may differentially affect the welfare of firms (advertisers), consumers (online users), and an intermediary (the ad exchanges) that facilitates the matching between firms and consumers.

One of the potential advantages of big data consists in the ability for marketers and advertising firms to create detailed profiles of consumers, predict their preferences, and serve them the right products or services. Industry representatives have emphasized the benefits that both advertisers and consumers can derive from the digital ecosystem. According to Unanimis Consulting Limited, “targeting is not only good for consumers it’s a rare win for everyone. [...] it ensures that ad placements display content that you might be interested in rather than ads that are irrelevant and uninteresting. [...] Advertisers hope to find consumers who are interested in their product more often than by placing random adverts. They achieve higher brand awareness and a greater chance of selling the product. Publishers also win as being able to offer behavioral targeting increases the value of the ad placements and therefore their revenues.” According to Chad Little, CEO of Fetchback, Ebay Enterprise: “Behavioral tracking shouldn’t be feared, but instead, embraced. Tracking can simplify and improve a consumer’s online experience. By utilizing gathered behavioral data in a strategic manner, online retailers can put the power of the online tracking to work for their consumers”.

Consumers’ surveys that seem to confirm this view. A poll commissioned by the Digital Advertising Alliance (DAA) in 2013 showed that Americans understand and appreciate the importance of the ad-supported Internet. Nearly 70 percent of respondents indicated that they would like at least some ads tailored directly to their interests, compared to only 16 percent who preferred to only see generic ads for products and services. To summarize, different players in the digital ecosystem seem to agree that data tracking and the targeting that derives from it are beneficial for everyone. The question we address in this manuscript is the extent to which targeted advertising is really such an economic win win.

We scrutinize the claim that targeted advertising is beneficial for advertisers and consumers alike using formal economic modeling. Our modeling approach advances current theoretical work in this area because, unlike previous models of online advertising (see Related Work), our model 1) simultaneously considers three players: firms, consumers, and ad exchanges; and 2) focuses on how the surplus produced by targeting is allocated to the different parties. The model we develop is based on Real-Time bidding, a technology recently introduced that allows the allocation of online display advertisement spaces at real-time through online platforms called Ad Exchanges. Specifically, we focus on the interaction among three players: firms (the advertisers, who compete with each other for consumers’ attention), consumers (the online users, who visit websites, are shown targeted ads, and purchase products online), and a monopoly intermediary (the ad exchange). We assume that consumers are characterized by two dimensions (or, analogously, two pieces of information): horizontal information, that captures consumers' preferences for specific products; and vertical information, that captures differences in consumers' purchase power. Advertisers are firms that produce products and want to advertise them to consumers. Firms buy advertisements by participating in real-time auctions run by the intermediary ad exchange. When a consumer arrives to a website, a signal containing information about that user is sent to the ad exchange; the ad exchange, in turns, sends the signal to the advertiser firms along with some or all pieces of consumers’ information. Advertisers, on the basis of the information that they can receive about the user, decide how much to bid. The winner of the auction shows the advertisement to the consumer and pays the second-highest bid. We consider three possible scenarios that differ in the amount and/or type of information that is available to the Ad Exchange and (through the Ad Exchange) to the advertising firms during the bidding process. First, we consider the case in which only the horizontal information, that is which product a consumer prefers, is available. Second, we consider the case in which only the vertical information (whether the consumer is high valuation or low valuation) is available. Finally, we consider the case in which both the horizontal and the vertical information about consumers can be observed. For each of the four scenarios we consider, we use backward induction and Nash equilibrium strategies to first derive each advertisers' bidding strategy and pricing strategy; we then determine the winner of the auction and the final outcome of the game in terms of advertisers' profit, Ad Exchange's revenues and consumers' welfare. Our results can be summarized as follows. First, we find that consumers welfare is higher when only specific type of information are exchanged (horizontal information) and, generally, when less information is exchanged. Furthermore, there exists situations in which the incentives of the Intermediary are misaligned with respect to consumers’ interest; stated differently, the intermediary that acts as a profit-maximizing agent may decide to adopt strategies that lead to higher revenue for itself, while making consumers and/or advertisers worse off. Our findings have policy implications, because they show how the commerce in consumer data can differentially affect the welfare of data holders and
data subjects. Thus, particular, they contribute to the ongoing industry and regulatory debate over the economic and social implications of the adoption of tracking and advertising systems that are more sophisticated in terms of using consumer data.

Related Work

This paper is related to different strands of economic literature. First, it is related to the early work on the economics of advertising that look at the impact of advertising on product information and pricing (Grossman and Shapiro, 1984; Soberman, 2004; Iyer et al., 2005). Those works have analyzed the competitive effects of targeting in specific market structures by looking at the traditional interaction between firms and consumers. In those models, firms are usually assumed to be able to target consumers directly. Recently, authors in the information system field have offered a more complete analysis of the targeted advertising ecosystem by taking into consideration the fact that the targeting process is an intermediated process (Zhang and Catona, 2012) or by considering the important role played by publishers in the targeting process (Chen et al., 2014). In this paper, we explicitly model the existence of an independent, profit-maximizing online platform that facilitates the selling and buying of advertisement space and implements the targeting technology and analyze how this may affect the outcome of the game and the allocation of benefits among the different players. Furthermore, we explicitly model consumers' decision and we introduce the possibility that consumers differ along two dimensions: a horizontal one, that captures consumers' products preference; and a vertical one, that captures differences in consumers' reservation prices, as some individuals may have higher purchase power than others. Secondly, our work is related to the IS literature on online auctions and search-advertising (Bapna et al., 2003; Pinker et al., 2003; Katona and Sarvary, 2010; Liu et al., 2010; Chen and He, 2011). Those works study the features that characterize online auctions and, some of those, have specifically focused on the equilibrium properties of the generalized second-price auction, commonly used to place search-advertisements. In this paper, we rely on existing results from auction theory and focus on the Real-Time bidding technology that, introduced in 2007, has been growing really fast and it is expected to take over the market for the allocation of display advertising. Finally, our work is related to the literature on information congestion and consumers' privacy (Hann et al., 2008; Anderson-De Palma, 2009; Casadesus-Masanell and Hervas-Drane, 2015). Those works specifically model the possibility that consumers suffer a privacy harm when their information is being used for targeting purposes and analyze which strategy individuals may use to avoid marketing messages. Similarly to these works, we focus on the effects of targeted advertising on consumers' welfare. Differently, we assume that consumers do not use any blocking mechanism but they are always exposed to one advertisement.

The Model

Real-Time Bidding

Real-time bidding (RTB) is a novel paradigm of serving ads with the aim of bringing more liquidity to the online advertising market. Specifically, RTB allows advertisers to buy online display advertisement spaces at real-time through Ad Exchanges. The mechanism works as follows: when a user visits a publisher's website belonging to an Ad Exchange's network, a request is sent to the Ad Exchange which subsequently broadcasts it along with user data (user's IP address, geo-location, user's cookies, information about browsing behaviors and others) to ad buyers and holds an auction. Bidders analyze the impression and submit their bid responses. As most of the Ad Exchange encourage truthful bidding through the use of second-price auctions, the best strategy for buyers is to bid in accordance with their true valuation for the consumer. The winning party is allowed to serve the advertisement to the user and pays the second-highest bid. The model developed in this paper focuses on three players: i) Advertisers. We assume that companies that wish to target specific consumers buy advertisements by participating to online auctions. For the rest of the paper we will use advertisers, companies and firms interchangeably. ii) Ad Exchange. We take into consideration the existence of one platform through which RTB and targeting can be implemented. For the rest of the paper, we will refer to this player as the Intermediary. iii) Consumers. They are the users of the website where the ad is displayed and they are the "object" of the auction. In other words, advertisers bid for a given consumer, represented by the collection of information that are exchanged and/or made available during the bidding process.
Basic Setting

Our initial model consider the existence of two firms, \( i = 1, 2 \) that produce two different products at a constant marginal cost of production, assumed to be zero without loss of generality. The market consists of a unit mass of consumers. Each consumer has a demand for at most one unit of the product. Consumers differ along two dimensions. Each consumer can take one of two horizontal positions, capturing the consumer’s natural preference for either one of the products. This means that each firm has a segment of consumers who have high preference for its product in the sense that, everything else equal, their willingness to pay is higher for that product. We denote by \( v \) a consumer’s reservation price for his favorite product. Stated differently, \( v \) represents the maximum amount of money that the consumer is willing to pay for the product he likes the most. Similarly, we denote by \( w \) a consumer’s reservation price for the other product. In other words, \( w \) represents the maximum amount of money that the consumer is willing to pay for a product that is not his favorite. We assume that \( v \geq w \). Put simply, the amount of money that a consumer is willing to pay for his favorite product is greater than the amount he is willing to pay for a different product.

We assume that a proportion \( \alpha_i \) of consumers prefers Firm 1 and a proportion \( \alpha_2 \) prefers Firm 2, with \( \alpha_1 + \alpha_2 = 1 \) and \( 0 \leq \alpha \leq 1 \). Those proportions are known to the firms. Differently, a firm does not know whether a specific consumer likes its product better than the other without any extra information. In other words, the only piece of information that a firm has is the probability of observing a consumer with a preference for its product; probability that is captured by the proportion \( \alpha_i \).

Consumers in this model do not differ only in their products’ preference. They also differ in their purchase power, as we allow them to take one of two different vertical positions: a consumer can be a low valuation consumer or a high valuation consumer. To better understand what we mean by vertical position, let us consider an example. Let us take two consumers, both with a preference for the product of Firm 1. According to our assumptions, this implies that both consumers are willing to spend more for product 1 than for product 2. Nevertheless, even though the two consumers have the same product’s preference, they may have different purchase powers in the sense that one can afford to pay more than the other for the product he likes. For instance, the consumer with higher purchase power (that we call high valuation) can afford to pay a maximum of 10\$; differently, the consumer with lower purchase power (that we call low valuation consumer) can only afford to pay a maximum of 8\$. Note that this has consequences on the amount that the consumers are willing to pay for product 2. By definition, both consumers will be willing to spend less on product 2 because that is not their favorite product. Nevertheless, following the example, the high valuation consumer can pay a maximum of 7\$ for product 2 while the low valuation consumer can pay a maximum of 5\$ for product 2.

From a notational point of view, we denote by \( v_h \) the amount that a high valuation consumer is willing to pay for his favorite product and we denote by \( v_l \) the amount he is willing to pay for the other product. Similarly, we denote by \( w_l \) the amount that a low valuation consumer is willing to pay for his favorite product and we denote by \( w_l \) the amount he is willing to pay for the other product is. We assume that a proportion \( \beta \) of consumers is a high valuation consumer and a proportion \( 1-\beta \) is a low valuation consumer, with \( 0 \leq \beta \leq 1 \). As before, firms have information about \( \beta \). Differently, without any extra information, a firm does not know whether a specific consumer is high valuation or low valuation. In other words, the only piece of information that a firm has, a priori, is the probability of observing a high valuation consumer; probability that is captured by the proportion \( \beta \).

In this model, consumers have preferences over products, but without advertising do not know which company sells which product and at what price. In this sense, advertising plays an informative role as it informs consumers of the existing firms and prices. Given the market’s structure, the firm’ objective is to target consumers that have a preference for its product and have a high reservation price. Nevertheless, as mentioned before, companies cannot target consumers directly as they cannot “identified” consumers without extra information; remember that the only pieces of information they have are the proportions \( \alpha \) and \( \beta \). As a consequence, they have to rely on an intermediary (online platform) that possess the targeting technology and runs a second-price auction to allocate consumers between companies. Importantly, during the auction, the Ad Exchange may make available to the firms additional pieces of information about the consumers. Firms, after observing the set of information about the consumer, decide how much to bid for the advertisement and the pricing strategy for their product. The highest bidder wins and pay the bid of the second company.
In the following sections, we consider and then compare three cases that differ in the amount and type of information that companies see about the consumer before submitting the bid: i) Only Horizontal Information. Firms are able to observe which product a consumer prefers but they do not observe the vertical position (purchase power). ii) Only Vertical Information. Firms are able to observe whether the consumer is a high valuation or low valuation consumer but they do not observe his horizontal position (product’s preference). iii) Both Horizontal and Vertical information. Firms obtain all the information about the consumer, that is his product’s preference and purchase power. In the analysis that follows we consider those three different scenarios and we derive each firm’s bidding strategy and pricing strategy and we analyze how the outcome of the game changes in terms of firms’ profits, Ad Exchange profit and consumers’ welfare. Before proceeding with the analysis, let us clarify those variables. Since we assume a marginal cost of production equal to zero, a firm’s profits are simply given by revenues (if the consumer buys the product) minus the amount paid by the company if she wins the online auction for the advertisement (amount equal to the second-highest bid). As for the Ad Exchange, we do not consider any cost of running the auction. Hence, Ad Exchange’s profits are simply equal to the amount paid by the firm that wins the online auction. Finally, we conservatively define consumer’s welfare as the difference between the maximum amount a consumer is willing to pay for a product and the price he actually pays for it.

Sequence of Events

The sequence of events in the model is as follows:
1) At any given point in time, a consumer arrives to a website. The consumer is characterized by two pieces of information: horizontal and vertical.
2) The Ad Exchange receives a signal that the specific consumer is online and turns the signal to advertisers that wish to show advertisements to that consumer.
3) The Ad Exchange runs a second-price auction to allocate the advertisement space. During the auction, it may make visible to the advertisers all or part of the information about the consumer (only the horizontal information, only the vertical information, or both).
4) On the bases of the information observed, advertisers decide how much to bid and set the price of the product.
5) The firm that submits the highest bid wins the auction, pays the second-highest bid and shows the ad to the consumer.
6) The consumer sees the ad and decide whether or not to buy the product. The consumer buys as long as the price is lower than his reservation price.

Figure 1 offers a visual representation of the sequence of the events.

Analysis

We start by considering the case in which only the consumer’ horizontal information is available to firms during the auction. Let us assume companies observe a consumer of type 1. Firm 1 can decide to adopt one
of two strategies: it can choose to capture any consumer coming from its segment, by setting \( p_i = v_h \). In this case, the bid would be \( b_i = v_i \). Alternatively, if \( \beta \) is large enough, that is the probability of observing a high valuation consumer is high enough, the company can choose to capture, inside its segment, only the high valuation consumers by setting \( p_i = v_h \). In this case, the bidding strategy would be \( b_i = \beta^* v_h \).

In summary, Firm 1 bidding strategy is \( b_i = \max (\beta^* v_h, v_l) \). Note that also Firm 2 submits a positive bid. Indeed, since the consumer does have a positive valuation for its product too, it will follow a bidding strategy similar to company 1, by bidding \( b_2 = \max (\beta^* w_h, w_l) \). Those results are summarized in Lemma 1.

**LEMMA 1.** When companies observe a consumer of type \( i \), firm \( i \) bids \( b_i = \max (\beta^* v_h, v_l) \) and sets a price equal to \( p_i = v_h \) if \( \beta^* v_h \geq v_l \) and \( p_i = v_l \) otherwise. Firm \( j \) (with \( i,j = 1,2 \) and \( i \neq j \)) bids \( b_j = \max (\beta^* w_h, w_l) \) and sets a price equal to \( p_j = w_h \) if \( \beta^* w_h \geq v_l \) and \( p_j = w_l \) otherwise. Since \( b_i = \max (\beta^* v_h, v_l) \) is always greater than \( b_j = \max (\beta^* w_h, w_l) \), company \( i \) always wins the auction for consumer of type \( i \). The Intermediary revenue is \( \max (\beta^* w_h, w_l) \).

When only the Horizontal Information is available, even though both companies submit a positive bid, company \( i \) that observes a consumer of type \( i \) always wins the auction. Consequently, consumers are always shown with the advertisement for their favorite product. Since in this case also the other company submits a positive bid, the Intermediary revenue is not zero.

The next scenario we consider is the case in which only the vertical information is available to companies during the auction, that is firms can distinguish between high valuation and low valuation consumers, but they do not know consumer’s preferences. Let us assume the consumer is high valuation. Firms know that the consumer will be willing to pay \( v_h \) for his favorite product and \( w_h \) for the other. They also know the respective probability of getting a consumer from a specific segment, that is \( \alpha \). Hence, they can decide to adopt one of two strategies: i) company \( i \) can decide to capture any consumer that is high valuation by setting a price equal to \( w_h \); ii) it can decide to capture any consumer coming from its segment and that is high valuation, by setting a price equal to \( v_h \). The same reasoning can be applied to low valuation consumers. Lemma 2 summarizes the result.

**LEMMA 2.** When only consumers’ vertical position is available, both companies submit a positive bid. If consumer is high valuation, company \( i \) sets \( p_i = v_l \) and bid \( b_i = \alpha^* v_l \) if \( \alpha^* v_l \geq w_h \) the company sets \( p_i = w_h \) and bid \( b_i = w_h \) otherwise. If consumer is low valuation, company \( i \) sets \( p_i = v_l \) and bid \( b_i = \alpha^* v_l \) if \( \alpha^* v_l \geq w_l \) the company sets \( p_i = w_l \) and bid \( b_i = w_l \) otherwise.

In this case, it is not immediately clear which company is going to win the auction; the final outcome depends on the value of the parameters. Let us consider a high valuation consumer. If the market is asymmetric (\( \alpha > 0.5 \)) and the difference between \( v_h \) and \( w_h \) is large enough, company \( i \) with the largest segment of consumers bids \( \alpha^* v_h \) and wins the auction, with \( i = 1,2 \). There are two main cases in which both companies submit the same bid and the consumer is randomly assigned: i) the market is symmetric and both submits \( \alpha^* v_h \); ii) the difference between \( v_h \) and \( w_h \) is not large enough and both submit \( w_h \). The same reasoning is valid for a low valuation consumer. In the last case we consider, both the horizontal and the vertical information about the consumer is available to companies during the auction. Let as assume firms observe a high valuation consumer of type 1. Then we have \( b_1 = v_h \) and \( p_1 = v_h \), for firm 1. For firm 2, we have \( b_2 = w_h \) and \( p_2 = w_h \). Similarly, if the consumer is low valuation we have that that \( b_1 = v_l \) and \( p_1 = v_l \), for firm 1; for firm 2 we have \( b_2 = w_l \) and \( p_2 = w_l \).

**LEMMA 3.** When companies can observe both horizontal and vertical information, firm \( i \) always wins the auction for consumer \( i \). The Intermediary revenue is \( w_h \) if the consumer is high valuation and \( w_l \) if the consumer is low valuation.

In this last scenario, companies are able to observe both a consumer’s product preference and purchase power. Consequently, firm 1 that observe, for instance, a high valuation consumer of type 1 can set the product’s price to be exactly equal the consumer’s reservation price, \( v_h \), and it also submits a bid equal to \( v_h \) as he knows that the consumer will buy its product for sure at that price. Similarly, firm 2 knows that the consumer is only willing to pay \( w_h \) for its product; hence, it sets the price of product and the bid for the advertisement accordingly. Since by assumption we have that \( v_h \geq w_h \), firm 1 that bids \( v_h \) always wins the auction for the consumer. The same reasoning applies to a consumer that is low valuation.
Welfare Analysis

In this section, we analyze how the size and allocation of the players’ benefits (defined as firms’ profits, intermediary’s profit and consumer’s welfare) changes across three different scenarios. To exemplify our reasoning, we consider the case of a consumer that is high valuation of type $i$ and we examine how his surplus changes when different pieces of information about him are made available. When only the horizontal information is available, we found before that company $i$ is always going to win the auction for consumer $i$. In other words, the consumer sees the advertisement for his favorite product and, consequently, he always buys his favorite product. If company $i$ sets a price equal to $v_h$, the consumer surplus is $\phi_i$; if company $i$ sets a price equal to $v_l$, the consumer surplus is positive and equal to $v_h - v_l$. Company $i$ is always left with a positive profit. If it sets a price equal to $v_h$, its profit is going to be $v_h - \max(\beta*w_h, w_l)$; analogously, if it sets a price equal to $v_l$, its profit is going to be $v_l - \max(\beta*w_h, w_l)$. The Intermediary profit is always going to be $\max(\beta*w_h, w_l)$. When only the Vertical information is available, which company is going to win the auction mostly depends on the value of the parameters. In the previous section, we derived that if the market is asymmetric and the difference between $v_h$ and $w_l$ is large enough, the company with the largest segment of consumer wins the auction.

Let us assume $\alpha_i > \alpha_l$. Then company $i$ wins the auction, the consumer sees an advertisement for its favorite product and pays $v_h$. Consumer’s surplus is going to be zero while company $i$ makes positive profit equal to $v_h - \max(\alpha_i*v_h, w_l)$. Nevertheless, when $\alpha_i > \alpha_l$, company $j$ wins the auction and the consumer (that we assumed at the beginning is of type $i$) does not buy the product. Consequently, there is a company -consumer mismatch, and the company makes negative profit as it still has to pay the bid equal to $\max(\alpha_i*v_h, w_l)$. Similarily, when the market tends to be symmetric and companies submit the same bid, the consumer is randomly assigned. This implies that there will be situations in which the consumer sees the advertisement for its favorite product, pays $v_l$ and he gets zero surplus (or he pays $w_l$ and gets a positive surplus equal to $v_h - w_l$); company $i$ will make a positive profit when it sets $v_h$ and zero profit when it sets $w_l$. Similarly, there will be situations in which the consumer sees the advertisement for the other product and does not buy it, when price is $v_h$; or he does buy it when price is $w_l$; company $j$ either ends up with a negative profit (when it wins the auction but consumer does not buy) or with a zero profit.

The Intermediary profit will always be positive and equal to $\max(\alpha_i*v_h, w_l)$, where $\alpha_i$ is equal to smallest segment of consumers. When complete information about consumers is available, consumer of type $i$ is always going to see the advertisement for its favorite product and it always ends up with zero surplus. Company $i$ that wins the auction for consumer $i$ is always going to make positive profit. In the example we are considering, it will set a price equal to $v_h$, pay a bid equal to $w_l$ and make a profit equal to $v_h - w_l$. The Intermediary revenue is also going to be always positive; in this particular case, it will be equal to $w_h$.

To understand how the welfare and allocation of benefits change under the different scenarios, we run computational simulations of the model. We fix the values for $v_h, v_l, w_l$ and $\alpha$. We let $\beta$ and $\alpha$ vary. What we find is that, in the great majority of cases, consumers’ surplus is higher when only the horizontal information is available on the market. Only for specific combination of the parameters, that is when $w_l$ is high and greater than $v_h$, and when $\beta \geq 0.5$, consumers maximize their surplus when only the vertical information is available. This last result is mostly driven by high valuation consumers: indeed, when $\beta$ is high, under horizontal information firms will prefer to capture any consumer that is high valuation as, in expectation, the revenue company can gained from them is higher than from low valuation consumers. Differently, for all the different combinations of the parameters, the intermediary’s revenues are higher when only the vertical information is available on the market. The intuition behind the result is as follows: in the vertical information case firms do not know the consumer’s segment and, consequently, they tend to bid more aggressively. Finally, for advertisers, profits are generally higher when complete information about consumers is available. This is driven by the fact that, in other scenarios, and specifically when only the vertical information is available, the winning company can make negative profit if the consumer does not buy the product due to a mismatch. Differently, in the complete information case, companies always make a positive profit as they can observe perfectly the consumer and he will always buy the product.

To offer a visual representation of the findings, we use the results from the simulation to compute the proportion of (expected) benefits that each player would obtain under the three different scenarios. We normalized the results so to make them comparable. Note that, for the combination of parameters used in the simulation, the total amount of benefits (that is the sum of consumers’ surplus, advertisers and intermediary surplus) is the same in the three cases. What changes is the allocation of those benefits.
among the different players. Figure 2, composed by three sub-figures, shows the results for the three cases.

![Diagram showing allocation of benefits under three scenarios: Complete Information (2.a), Horizontal Information (2.b) and Vertical Information (2.c).](image)

Under the complete information case (left quadrant), advertisers and intermediary obtain the same proportion of benefits while the consumers’ surplus is zero, confirming the analytical results of the model. In the horizontal information case (middle quadrant) all the players obtain a positive proportion of the benefits even though the allocation is unbalanced and favors advertisers and the intermediary. Finally, in the vertical information case (right quadrant), the intermediary captures the highest proportion of benefits. In conclusion, the results highlight a misalignment between the different players’ interest: consumers’ surplus is, in expectation, higher when only the horizontal information is available to the other players; on the contrary, the Intermediary usually prefers only the vertical information about consumers to be available. Advertisers, instead, prefer the complete information case when the consumer can be perfectly identified.

### Limitations and Possible Extensions

The model we propose can be extended in various ways. First of all, some of the assumptions on consumers’ behavior may look simplistic and can be relaxed. We assume that consumers see only one advertisement at the time, either for firm 1 or for firm 2. We could extend the model by considering the existence of $n$ competing firms and by allowing the possibility that a consumer is displayed with more than one advertisement at the time. Furthermore, in the proposed version of the model, a consumer buys as long as the price of the advertised product is no greater than the consumer’s reservation price for that product. We could relax this assumption by including consumers’ search behavior to account for the fact that consumers may decide to shop around before buying. In addition, consumers are not able to block or avoid advertisements; introducing consumers’ ability to control the type and amount of information that is being collected online seems to be an interesting and relevant case, particularly nowadays that online users can rely to various privacy-enhancing technologies. Concerning the assumptions on the Ad Exchange, we currently consider the existence of a monopoly intermediary. We could allow some degree of competition also on the intermediary side and consider the possibility that companies decide to enter different Ad networks. Finally, the proposed model takes into consideration the interaction between three types of players: advertisers, intermediary and consumers. The online advertising ecosystem is more complex and includes additional subjects. For instance, companies that want to participate to auctions for online advertising usually rely on Demand Side Platform (DSP) that serves advertisers or ad agencies by bidding for their campaigns in multiple ad networks automatically. On the other side, Supply Side Platforms (SSP) serves publishers by registering their inventories (ads space) in different ad networks and accepting the most beneficial automatically. Taking into consideration the existence of those players may help offering a more complete analysis of the online advertising market.
Conclusions

In this paper, we analyzed the welfare and allocative impact of targeted advertising by developing an analytical model based on Real-Time Bidding. The model focused the attention on the interaction among three types of players: firms (the advertisers), consumers (the online users), and a monopoly intermediary (the ad exchange). We assumed that consumers are characterized by two dimensions (or, analogously, two pieces of information): horizontal information, that captures consumers’ preferences for specific products; and vertical information, that captures differences in consumers’ purchase power. Advertisers, firms that produce products and want to advertise them to consumers, buy advertisements by participating in real-time auctions run by the intermediary. We considered three scenarios that differed in the amount and/or type of information that is available on the market and that advertising firms have available during the bidding process: i) the case in which only the horizontal information, that is which product a consumer prefers, is available. ii) The case in which only the vertical information (whether the consumer is high valuation or low valuation) is available. iii) The case in which both the horizontal and the vertical information about consumers is available. For each scenario, we derived each advertisers' bidding strategy and pricing strategy; we then determined the winner of the auction and the final outcome of the game in terms of advertisers' profit, Ad Exchange's revenues and consumers' welfare. We found that consumers welfare is higher when only specific type of information are exchanged (horizontal information) and, generally, when less information is exchanged. Furthermore, under certain conditions, the intermediary obtains the highest proportion of benefits from the targeting process. This implies the existence of situations in which the incentives of the intermediary are misaligned with respect to consumers' interest; stated differently, the intermediary that acts as a profit-maximizing agent may decide to adopt strategies that lead to higher revenue for itself while making consumers and/or advertisers worse off. By illustrating how different degrees of consumer data tracking and sharing can differentially affect the welfare of data holders and data subjects, these findings can contribute to the ongoing industry and regulatory debate over the economic and social implications of the adoption of tracking and advertising systems.

Acknowledgements

This research was supported by the National Science Foundation under grant number 1012763 (Nudging users towards privacy). Acquisti also gratefully acknowledges support from the Carnegie Corporation of New York via an Andrew Carnegie Fellowship. The statements made and views expressed in this manuscript are solely the responsibility of the authors.
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