

The intricate tale of demand and supply of personal data

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ABSTRACT

In this article, we develop some of the economics of the intricate relationship between the demand and the supply of personalized data. We first focus on one heavily debated use of personal data: differential pricing (price discrimination). This allows us to highlight the role played by privacy protection, the impact on consumer welfare and the incentives of data brokers to share their data with firms competing on the product market, thereby articulating some of the forces that can influence the supply of and demand for digital personal data. We then touch upon broader questions regarding the supply and the demand for personal data and conclude by arguing that we are currently not yet in a world of ‘real’ data ‘markets’: personal data are transacted most of the time relying on hybrid contracts.

I. INTRODUCTION

It is nowadays ever so common to share personal information with the companies and institutions we interact with. We indeed leave, consciously or not, a digital trace when interacting through social networks, when purchasing goods and services online or simply when browsing websites for our own entertainment.

Thanks to continuously decreasing costs of processing data and also to improved data algorithms, firms (and other institutions) can combine sets of digital data to know more about each one of us. Firms can then use this knowledge to improve their value proposition to their customers with the ultimate purpose to enhance their revenue base. The latter can happen through product and service customization, personalized advertising or targeted pricing. Depending on the market situation, firms and consumers can gain or lose from the increased availability and treatment of data. Think about (algorithmic) targeted pricing. In a more (less) competitive environment, this can lead to lower (higher) individual prices.

In addition, the vast amount of data creates indirect benefits for firms and consumers. On the one hand, more data availability could lead to algorithmic learning, decreasing data treatment costs even further. On the other hand, massive data availability allows consumers to benefit from informational externalities (the social benefits from information sharing are higher than the private benefits). Think about LinkedIn allowing jobseekers to gain information about how many other jobseekers (with a LinkedIn account) applied for a certain position, what the skills of these other jobseekers are, how the jobseeker ranks compared to the other applicants for this given position.

Personal data also have an important public good feature. Once someone releases personal information then the use of this information is clearly non rival: it can be used or (voluntarily?) transferred over and over again. We may want to post a picture portraying the consumption of a serious quantity of meat and French fries (accompanied by good beers) on Facebook to share our fun moments with our friends, but we may not want the same picture to end up in the hands of our health insurer. The recent Facebook scandal illustrates this point rather neatly. When we are able to decide on whether to share some personal information, we may (or may not) take into account the secondary use of our personal data.

We conclude from the above discussion that there are both direct and indirect benefits and costs attached to sharing personal data. In addition, the supply of data also seems to affect the demand side in important ways, from generating scale effects in the cost of data analysis to gaining information about consumers' preferences.

The purpose of this article is to flesh out some of the economics of the intricate relationship between the demand and the supply of personalized data. We do so by first zeroing in on one particular and heavily debated use of personal data: personalized pricing (price discrimination). By doing so, we will be able to highlight the role played by privacy protection, the impact on consumer welfare and the incentives of data brokers to share their data with firms competing on the product market, thereby articulating some of the forces that can influence the supply of and demand for digital personal data. We then touch upon broader questions regarding the supply and the demand for personal data and conclude by arguing that we are currently not yet in a world of 'real' data 'markets': personal data are transacted most of the time relying on hybrid contracts.

II. BIG DATA, PRICE DISCRIMINATION AND PRIVACY

In this section, we want to give a brief primer on the economics of price discrimination, and to relate this rather old concept¹ to the recent emergence of big data and the topical debate on consumer privacy. We start by describing the different forms of price discrimination and explaining how big data influence them (Section II.1). We then discuss how the effects of price discrimination depend on the degree of competition among sellers, as well as related issues regarding information sharing and competition policy (Section II.2). Finally, we focus on consumers' reactions in the face of improved price discrimination and the associated reduction of privacy (Section III.2).

II.1. WHAT IS PRICE DISCRIMINATION AND WHAT IS ITS LINK WITH BIG DATA?

Googling the search terms “Big data” and “price discrimination” (or “differential pricing” or “dynamic pricing”) presents the internet user with a plethora of links to very recent newspaper and magazine articles, business cases, governmental and inter-governmental white or green papers, antitrust agencies, scholarly articles by marketing academics, legal scholars and ... economists.

When asked to explain price discrimination an economist might start by contrasting price discrimination to so called ‘linear pricing’, in which each consumer has access to a certain good/service at the same constant price per unit. If a firm has market power, or even more clear cut, is a monopoly in a market, then charging one and the same price for each unit it sells will generate profits, but the seller may be able to increase profits by using a different price structure, ultimately leading to a situation in which different consumers end up paying different prices for the same good and/or in which the price per unit depends on the quantity purchased. But in order to do so, more than market power is needed.² The seller should also have *information* about the consumers and be able to *prevent arbitrage*.

Information. In order to charge consumers a price/tariff that reflects their willingness to pay, a firm needs to *know*, or at least have a good idea about, each consumer's value for the good/service it sells. The consumer's value is also known as the willingness to pay or the ‘pain point’ of the consumer: it is the price above which the consumer would refuse to execute a trade. The recent surge of interest in price discrimination should then come as little surprise: big data enables firms to have a better idea of each of their customers' pain points. They can obtain this information *directly from the horse's mouth*, based on past purchase history and other information the firm obtains about their consumers (e.g. from their loyalty card application, ...) or *indirectly from secondary sources* by acquiring it from data brokers or public databases.

No arbitrage. Sellers should be able to prevent competition with their own customers. If this cannot be prevented, then anyone who can purchase at a ‘low’ price will have an incentive to purchase more than needed and resell the remainder to consumers who can

¹ Pigou proposed the first taxonomy of price discrimination practices (first-, second-, and third-degree price discrimination) in his book ‘*Economics of Welfare*’ in 1920.

² The seller needs to be able to charge different prices to different consumers, a feature which is incompatible with competitive markets in which the law of one price ‘rules’.

only purchase the good at a higher price. The internet has accelerated the sale of many ‘personalized’ goods and services, which either cannot be resold to others (e.g. plane ticket) or for which resale has a high transaction cost relative to the sales price (e.g. a book).

Economists tend to distinguish three types of price discrimination, which differ according to the information that the seller has about the willingness to pay of its customers. The most extreme case of price discrimination is *personalized pricing* (also known as ‘first degree price discrimination’). This happens when the seller knows the value that each consumer attaches to the product and charges then all consumers a (potentially) different price according to their personal valuation. When the seller does not know individual valuations, it may nevertheless segment its market into various groups of consumers, who share some observable characteristics that are indicative of their willingness to pay; each group is then charged a different price; this tactic is known as *group pricing* (or ‘third-degree price discrimination’). Student discounts (e.g., in movie theatres) are a typical example of this practice. Note that personalized pricing can be seen as the ultimate form of group pricing, as it corresponds to a segmentation of the market that is so fine that each group boils down to a single consumer. Finally, when it is not possible to infer the consumers’ valuations from some observable characteristics, the firm may still try to induce consumers to reveal their willingness to pay by letting them choose among various versions of the product that carry different price tags. This is called *menu pricing* (or ‘second-degree price discrimination’). Think for instance of airline tickets: business travelers, who are less price sensitive, choose the more expensive business class, whereas tourists, who are more price sensitive, choose the cheaper economy class; here, the base service (flying from point A to point B) is the same but it is proposed in different versions, whose ‘quality’/price ratio differ so as to induce a form of self-selection among consumers with different valuations.

The arrival of big data and targeted pricing has enabled firms to obtain fine-grained information that expedited all forms of price discrimination. Many argue that advances in digital tracking allow for more accurate consumer profiling, which in turn helps to facilitate first-degree price discrimination. One example is Ant Financial Services Group (the financing unit of Alibaba), which in 2015 announced the launch of Sesame Credit, a credit-scoring service that leverages big data and customer behavior analytics to calculate personalized interest rates for micro loans or personalized premiums for insurance services (Business Wire, 2015).

II.2. MONOPOLY VS. COMPETITION: WHY DOES IT MATTER?

We now contrast the impacts of price discrimination (for sellers and consumers) depending on the market structure: we consider in turn situations in which there is a single seller or multiple sellers in the market. In the latter case, we examine whether sellers—or third parties—have an interest in trading information about consumers (a topic to which we return in the second part of this article). Finally, in light of the previous discussion, we discuss the potential role of competition policy regarding price discrimination.

II.2.1 Price discrimination by a monopolist

Compared to linear pricing (i.e., a uniform price charged to all consumers), price discrimination by a monopolist seller has two effects: surplus extraction and market expansion. The first effect means that, as a seller is able to set its price closer to the consumer's willingness to pay, (part of) the consumer's surplus is transferred to the seller. This is easy to understand: as consumers have no alternative product to substitute to, they are not in a position to refuse the terms that the seller imposes upon them. In particular, when a monopolist seller can obtain an estimate of a consumer's willingness to pay, then the seller can capture most, if not all, of the consumer's surplus through a take it or leave offer. This surplus extraction effect clearly becomes stronger the better the seller knows its consumers.

The market expansion effect indicates that a seller may find it profitable to sell its product or service to more consumers when it practices price discrimination than when it is restricted to linear pricing. The reason is that with linear pricing, selling to an additional consumer requires lowering the price not only for this consumer but also for all the other consumers (as everyone pays the same price); in contrast, price discrimination (i.e., the ability to charge different prices to different consumers) lifts this constraint and, thereby, increases the profitability of serving additional consumers.

While surplus extraction leaves total welfare unchanged (it is a transfer from consumers to the seller), market expansion has the potential to increase total welfare (as new gains from trade are realized). Yet, as the seller will capture most of these additional gains of trade, we may conclude from the previous analysis that consumers stand to suffer from a seller's improved ability to price discriminate (which may itself follow from an increased availability of data).³ However, as we now discuss, drawing this conclusion could turn out to be misguided for at least two reasons. First, when firms compete, more information may lead to lower prices instead. Second, consumers are not necessarily passive bystanders: they can take actions to prevent firms from obtaining their information.

II.2.2. When two dogs fight over a bone ... the bone runs away with it!⁴

Matters change considerably when firms compete over the same consumer, illustrated most dramatically by the Bertrand paradox, a situation in which firms end up competing away any profit by undercutting one another. This situation continues to hold in the case in which firms can price discriminate and hold the same information about the consumer's willingness to pay. In other words, when competing firms try to capture a consumer's surplus, they all fail and it is the consumer who stays to keep the highest possible surplus in case of a sale.

When competing over price, it may thus be in the interest of competing sellers to possess (potentially) different information about the willingness to pay of the consumer's willingness to pay. This is what Belleflamme, Lam and Vergote (2018) show in the case of pure price competition. They also show that when one seller is the only one holding precise information about the consumers, then again intense price competition ensues.

³ Such fears have lead the Council of Economic Advisers of the Whitehouse to release a study on big data and differential pricing in 2015 (see Executive Office of the President of the United States, 2015).

⁴ Paraphrased from a Dutch proverb.

Their conclusion is that from the sellers' point of view, it is best that each seller has some but different information. Other scholars have shown, in the spirit of Thisse and Vives (1988), that in the presence of switching costs, obtaining more information on consumers' pain points intensifies competition. On the other hand, when price discrimination is based on consumer search costs, then obtaining more information can weaken competition between oligopolists (see for instance Armstrong and Vickers, 2001).

II.2.3 Incentives for information sharing and data markets

The above discussion suggests that different factors influence the incentives for firms to share information about their consumers (assuming that such sharing is possible and legal). If firms purely compete on price, then they might have an incentive to share some information to soften price competition (Belleflamme, Lam and Vergote, 2018). In the case of consumer search, firms have an interest to share all the information they have about their customer base.

The sharing of consumer information takes another form when, instead of collecting data by themselves, firms acquire information from secondary sources. It is then the secondary providers of information, in particular **data brokers**, that determine the extent to which the same information can be 'shared', i.e., used by several firms. This issue is particularly relevant when the potential users of some information are firms competing on the same market. If some information confers a competitive advantage to its buyer (because, e.g., it facilitates price discrimination), then it is likely that a data broker will find it profitable to grant an exclusive access to this information (as no buyer will attach any value to an information that its competitors can also use). This intuition is confirmed by Montes et al. (2018), who investigate a duopoly in which firms can price discriminate if consumers do not pay a privacy cost. They find that data owners would prefer to sell all their data to one firm, because this scenario "maximizes the stakes for rival buyers". The policy relevant conclusion they draw is that policy makers should try to prevent data exclusivity.

However, as discussed in Belleflamme, Lam and Vergote (2018), there are also situations in which a competitor that lacks any ability to price discriminate is bound to compete so fiercely that no competitive advantage would result any longer from acquiring information about consumers. The firms' willingness to pay for data (for price discrimination purposes) heavily depends on the quality of this data and, more importantly, on how much data competitors can access. As a consequence, data owners/brokers have incentives to provide several firms with data, as long as the quality of the data is different; that is, vertical data differentiation arises. According to this argument, exclusivity contracts offered by data brokers do not necessarily harm consumers. Hence, the jury's still out on whether data exclusivity deals are harmful for consumers.

II.2.4 If competition matters, is there a role for competition policy?

Price discrimination has never been considered, per se, as an issue for competition policy. We explained the reason above: from a welfare perspective, price discrimination

is either neutral (as it transfers surplus from consumers to sellers) or positive (when it expands the market or exacerbates price competition). The fact that big data makes price discrimination easier does not challenge this conclusion. As a result, both policy makers and economists tend to argue that more price discrimination should not immediately raise a red flag from a competition policy point of view. The Federal Trade Commission of the United States summarizes the only word of caution as follows: “In certain limited circumstances, price discrimination might feature as an aspect of an exclusionary strategy meant to enhance or protect market power. Intervention should be limited to preventing these exclusionary abuses.” (Note by the United States, OECD round table on price discrimination, 2016, p. 6).

However, there are two reasons to qualify the previous conclusion. First, big data affects pricing through other means than improved price discrimination: it also gives rise to *algorithmic pricing*, i.e., the automated and dynamic adjustment of a firm’s prices, based on personal and statistical information on currently active and potential buyers and other important market variables such as the prices of competitors.⁵ One concern with algorithmic pricing in terms of competition policy is that it may contribute to explicit collusion and facilitate tacit collusion.⁶

Second, many have recognized that when firms use pricing algorithms from the same ‘upstream’ provider, the latter may adjust its pricing algorithm in such a way as to increase prices for all ‘downstream’ firms using their pricing algorithm, even if these firms are unaware of this collusive effect.⁷ Third party algorithm providers are then claimed to act as the hub in a **hub and spoke cartel**.

We would like to highlight that not only the pricing algorithms but the data transactions themselves can play the exact same role when sellers compete by using price discrimination based on data they obtain from a **data broker**. It is in the data broker’s best interest to provide the data in such a way that it maximizes producer surplus of the price competing sellers (the ‘spokes’) in the product market. The data broker (the ‘hub’) then maximizes her own profits by capturing (an important part of) the product market producer surplus.

II.3. EXOGENOUS VS ENDOGENOUS PRIVACY

So far, we have assumed that it is not possible for consumers to escape being identified by the firms when profiling technologies are effective. In reality, consumers may resort to obfuscation strategies that make profiling technologies inoperative; for instance, consumers may delete cookies, use tools to browse the web anonymously, or purchase ad blockers. This interaction between price discrimination and the consumer’s privacy choice leads to an *endogenous demand for privacy*.⁸ In parallel, consumers enjoy some legal protection that makes it illegal for sellers to obtain/use information about the consumers without his or her consent. We call this form of privacy *exogenous privacy*.

⁵ Of course, algorithms can also be used to price discriminate and then we speak of algorithmic price discrimination.

⁶ A discussion of this possibility goes beyond the scope of this article. We refer the interested reader to, e.g., Ezrachi and Stucke (2017) or Ittoo and Petit (2017).

⁷ The issue is not just theoretical and came up in the 2016 Eturas case (Case C-74/14, judgment of 21 January 2016)

⁸ See, e.g., Belleflamme and Vergote (2016), Conitzer et al (2012), Montes et. al (2018), or Taylor and Wagman (2014).

As privacy matters for consumers, the question is to which extent privacy should be protected. In other words, what is the optimal scope of privacy regulation? This is a huge and very difficult debate and it is not our intention to comprehensively address it here. Instead, we just wish to call the reader's attention to the policy implications of altering legal privacy provisions. First, not all consumers will necessarily benefit or suffer from such a policy change. Take, for instance, the impact of less protective rules: on the one hand, some consumers will obtain a lower surplus because firms are better at profiling them. On the other hand, thanks to the possibility to price discriminate, some low value consumers will actually end up transacting and obtaining positive surplus compared to a situation where firms could not profile them and offer a 'reasonable' price.

The complex interplay between these forces may explain why the United States and the European Union have contrasting consumer privacy regulations. In particular, the European Union has enacted a stricter privacy law that, according to the New York Times (May 24, 2018) "makes Europe world's leading tech watchdog". The European Union General Data Protection Regulation (GDPR) that came into effect on May 25, 2018 provides unprecedented control over and protection of personal data. Data collectors now need to obtain explicit permission to collect and use (within the EU) our data, exemplified by the no doubt many kind e-mails you have received from companies and institutions, asking for permission to (continue to) use your data, mostly explicitly stating how beneficial this permission will be for you. Besides explicit consent, it imposes severe restrictions on the use of algorithms on personal data in order to target individuals, gives right to individuals to change and delete their data and allows people to transfer their personal data from one data collector to another (data portability). The introduction of the GDPR is expected to make it harder for firms to target consumers with a personalized price. On top of that, the strategic and exclusive value of controlling and using a set of personal data will erode. One would thus expect this to have a negative impact on the demand for personal data. Ghosh (2018) argues that this may lead firms to switch to contextual targeting: 'real time targeted' offers sent to a consumer based on the contents of the website he or she is visiting but not on his or her personal information.

III. PERSONAL DATA: SUPPLY AND DEMAND

Our previous discussion on big data and price discrimination sets the stage for some broader questions that relate to the supply and the demand for personal data. In what follows, we examine where the demand for personal data comes from (Section III.1), we make a cost-benefit analysis of supplying personal data (Section III.2), and we analyze to which extent and how the demand and supply of personal data meet (Section III.3).⁹

As a preliminary, it is probably useful to briefly discuss what is meant by personal data. Since many definitions can be given and have been given, we prefer to rely on a legal definition. The European Commission defines personal data as any information that relates "*an identified or identifiable living individual*". Article 4 of the EU GDPR further specifies that an individual is "*An identifiable natural person is one who can be identified,*

⁹ This section partly draws on Belleflamme (2018).

directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.” We note that even data that has been anonymized remains personal data as long as the anonymization process is reversible.

III.1. DEMAND FOR PERSONAL DATA

On the demand side of (consumers’) personal data, we find both commercial and non-commercial organizations. For the latter, personal data can be seen as a factor of production. This is also the case for the former but on top, personal data can also be considered as a strategic variable. We examine the two motivations in turn.

III.1.1 Personal data as a factor of production

As we have learned from our discussion on price discrimination, firms desire to identify their consumers’ willingness to pay. But personal data have other, commercial or non-commercial, uses. When mobile data, for instance, allow governments to improve their mapping of morning and evening commuting habits, they will be able to devise better—and often real-time—strategies to fight traffic problems and pollution. The same data can help advertisers to target their ads better (e.g., send a message knowing that the person, or at least the phone of the person, has entered in a certain area).

In short, more data improves the effectiveness of decision making of firms and institutions. It is then not hard to understand that the demand for data has increased exponentially during only the last 10 to 15 years. Indeed, only recently has it been made possible to track and store an enormous amount of data. In addition, recent advances in technology and computer science has generated more efficient methods and algorithms to collect, treat and interpret the data.

In business terms, the value of data depends on the ‘4 V’s of Big Data’: Volume (suggesting that there are scale economies), Variety (suggesting economies of scope), Velocity (speed of treatment) and Veracity (precision). An economist would quickly add that the 4 V’s can be seen as a factor of production and that the value of the data is a function of these factors and the state of the technology. Yet, firms acquire data not for their intrinsic value but rather to enhance the value propositions to their customers, to improve their production processes and to better target their consumers through advertising and pricing strategies.

In other words, the demand for data is a derived demand from the seller’s perspective.

III.1.2 Personal data as a strategic variable.

When firms compete, this naturally leads to a situation in which they will try to obtain more data in order to be able to stay ahead of or to leapfrog ahead of competition. As illustrated by the impact of consumer data on price competition, it is often important to obtain personal data to keep a competitive edge. This can lead to a situation where firms compete for information. When the ability to price discriminate depends on the amount and precision of information firms have, it could imply that while each firm has an incentive to obtain more information, it may be detrimental that all firms obtain more precise information about their (potential) consumers, as it will lead to more cut-throat

competition. When this happens, firms demand more personal data but cannot avoid ending up in a prisoner's dilemma (i.e., in a situation in which they would be collectively better off if they did not invest so much in obtaining information).

III.2. SUPPLY SIDE: BENEFITS AND COSTS OF PROVIDING PERSONAL DATA

Let us now turn to the supply side, where the providers of personal data are individuals acting as consumers, users of social networks and digital platforms or, simply, as citizens. Before examining the extent to which individuals control their 'supply' of personal data, we list a number of benefits that individuals can draw from firms using their personal data.

III.2.1 What is to be gained from having one's personal data used?

In Section II, when describing the market expansion effect of price discrimination, we highlighted a first potential benefit for consumers of having their personal data accessible to sellers. Recall that if firms cannot price discriminate, some consumers will decide not to purchase certain products or services, even if they are willing to pay more than what it costs the seller to produce them. Price discrimination alleviates this problem. When sellers have more information, they can tailor their prices such that more people purchase the product. As a result, more people will have a net benefit from market participation, a positive side effect of the availability of their personal data.

Another benefit can stem from firms using data to customize their value propositions. Firms are indeed able to offer more personalized products and services to someone when they have a better idea of whom that person is. When consumers value improved and personalized products, then they are better off when firms can have access to personal data.

In other situations, individuals benefit not so much from their own data but from other individuals' data being accessible to firms. This is so in the LinkedIn example that we gave in the introduction. In such situations, an individual that provides his/her personal data generates a positive externality on the other users. Free riding may then lead to an insufficient provision of personal data. To overcome this problem, data driven platforms need to design incentive mechanisms to induce their patrons to provide their data; for instance, they may condition (enhanced) access to their services to an initial provision of personal information.

III.2.2 Opt-out vs opt-in: Coase in theory but not in practice?

When can one truly talk about the supply of (personal) data? In order to be able to exchange data, data providers must be able to set the terms of the transaction. But can they? Even if offered the possibility to refuse data collection ('opt out') by the websites they visit, individuals find it most of the time way too cumbersome to go over the data exchange provisions, written in complicated legal jargon. In addition, if a benefit is attached to agreeing to the terms of data exchange, such as cheaper products (often free), or services better suited to our needs and potentially better (like targeted offers), then people will not quickly opt out. That is to say that we associate a 'virtual price' to our data and therefore to our private life.

Sometimes this virtual price becomes a real price. This is the case when companies (e.g., Internet Service Providers) differentiate their services by charging consumers a higher price when they refuse to have their data collected or receive targeted advertising. By choosing to opt out, consumers reveal their willingness to pay to protect their privacy.

What would happen if, on the contrary, it is up to companies to pay consumers to open access to their data or if firms need to incur a cost to ask for explicit consent as is the case under the GDPR (opt-in system)? In the spirit of the Coase Theorem, we would be tempted to think that in principle, the privacy decision should not change if the firm now pays (or incur a cost) to obtain access to your personal data. Studies show, however, that, in general, consumers demand a higher price in order to give up their privacy than what they are willing to pay to protect their privacy to the same extent (Acquisti, John and Loewenstein, 2013). Consumers seem therefore to attach greater value to their personal data in the case of an 'opt in' system than an 'opt out' system. The introduction of the GDPR could serve an interesting natural experiment to test this hypothesis.

III.3. WHEN SUPPLY AND DEMAND MEET

Williamson (1991) distinguishes three ways of organizing economic transactions. The first, called 'hierarchy', organizes transactions within an integrated firm; the second, the 'market', uses the price mechanism to coordinate supply and demand; finally, between these two extremes, are forms of hybrid governance, based on specific contracts.

Currently, personal data transactions are organized primarily through hybrid forms: they are based on opt-out contracts. To put it bluntly, companies are using these data as long as consumers do not stop them. We have also seen, as in the case of price discrimination, that companies may find it beneficial to share their data. Transactions are then based on multilateral long-term contracts. Another form of hybrid governance is that of specialized intermediaries in the collection and processing of data: so called 'data brokers'. Because of economies of scale and scope, the industry of data brokers is dominated by a few large companies, mostly Americans, which collect various data on hundreds of millions of consumers around the world; we can mention Acxiom (marketing), Equifax (insurance), Experian (credit), Corelogic (real estate), or Datalogix (finance).

To date, there do not exist personal 'data markets' per se. This is explained by the following paradox: as the information that can be extracted from data is strategic, the willingness to pay for non-proprietary data is generally weak or even nil; but because data is inherently non-rival (the consumption by one does not reduce the consumption possibilities for others), exclusivity is difficult to guarantee, especially in a decentralized exchange mechanism. Moreover, it is difficult to establish the veracity of data rigorously, as well as its value because of its uniqueness (absence of comparable data) or its complementarity (it is necessary to combine several databases to extract relevant information).

CONCLUSION

In this paper, we have highlighted some of the economic implications of the increase in both the availability of data and the ability to transform data into relevant information and knowledge. We have first focused on the use of data for differential pricing and the resulting reduction of consumers' privacy. We have argued that although consumers might rightly fear that firms will be able to capture a larger part of their surplus, they also have reasons to hope that the increased availability of data will sharpen competition among firms, thereby leading to lower prices for perhaps not all but at least some consumers. Consumers must also realize that they can use the developments of digital technologies to their advantage and counteract the firms' increased ability to profile them.

Our analysis of the links between big data and price discrimination allowed us to better understand the demand and the supply side of personal data. This led us to analyze the intricate relationship between supply and demand, and question the ways by which the two can meet. In this regard, we shed light on the roles played by intermediaries (in particular data brokers), as well as by regulation (stressing the lead exercised by the European Union in this matter).

Obviously, there are a number of important issues that we were not able to address in this short paper. For instance, an open question is the impact that the new European privacy law (the GDPR) will have on the exchange of data. On the one hand, the new regulation is likely to reduce the demand for data (because firms will find it more difficult to collect and use their consumers' personal data); on the other hand, by increasing transparency, this regulation could facilitate the organization of 'data marketplaces' where data can be exchanged at lower costs; if so, the European Union would then provide a more fertile ground for such markets than, e.g., the United States.

Another significant issue concerns the firms' reaction towards the new European Regulation (which applies to all firms, irrespective of their origin, as soon as they do business in the EU). Some firms, like Microsoft, have already committed to protect privacy even further than the GDPR requires (see, e.g., Ong, 2018).¹⁰ If expanded privacy protection appeals to consumers (which is a reasonable assumption in the aftermath of the Cambridge Analytica scandal), it may become a source of competitive advantage. Firms would then enter a race to the top, with each firm trying to outperform its competitors by better protecting personal data.

Finally, new technological developments will clearly shape the future of data demand and supply. If computing capacity continues to grow exponentially, then, given the public good nature of personal information, it might become very difficult for the individual to 'control' all (important) personal information, even if new tools, such as 'Personal Information Management Systems (PIMS)', may assist them in doing so.

¹⁰ At: <https://www.theverge.com/2018/5/24/17388206/microsoft-expand-data-privacy-tools-gdpr-eu>

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