

PERSONALISED PRICING IN THE DIGITAL ERA

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– Note by Portugal –

1. Introduction

The digitalization of the economy has meant that firms are increasingly able to gather data about their customers and potential customers, especially with the emergence of big data technologies. This represents an important shift in the way of doing business because not only firms can gather more information on the same variables (e.g. increased frequency, better quality data or more varied sources) but they are directly observing behaviour that previously was unfeasible to observe, such as how consumers shop around (e.g. browsing history).

These developments have brought about new avenues for firms to decide on the pricing strategy to adopt, so as to optimize their profits. As a result, several questions have arisen regarding the impact of these trends on consumer welfare and competition, as well as a debate on the overlaps and the frontiers between consumer protection and pure competition policy matters.

Digitalization has also brought about online markets, where the interaction between firms and consumers is markedly different relative to offline markets, namely:

- a. **There are little to no menu costs or time delays in price adjustments.** The aspects that keep firms from adjusting prices in a continuous fashion are 1) the degree of information available and 2) possible negative reactions from the demand side to high price volatility. In order to streamline the price setting process, firms can also use pricing and monitoring algorithms of varied levels of sophistication.
- b. **There tends to be a higher degree of privacy of information in online prices in comparison to offline prices.** Offline retail is a notorious example, where price tags ensure prices are highly visible and apply to all customers. In contrast, in online retail, consumers have no guarantee that they are being charged similar prices, aside from possible

commitments from the seller¹. Private prices make price discrimination harder to perceive by customers, thus easing its application.

- c. **Goods and services sold in online markets are often tied to a single individual or group of individuals**², usually based on user accounts or encryption. This makes arbitrage more difficult, meaning that enforcing price discrimination is easier in many online markets.

Personalised pricing is a form of direct price discrimination. Under personalised pricing, firms segment customers into small groups and charge each group a value close to an estimated willingness to pay (WTP). Ultimately, as personalised pricing approaches imperfect first-degree price discrimination³, these groups approach size one. For this reason, there is a **sliding scale in the strength of price discrimination**, in which firms can move from third to first-degree price discrimination, according to their ability to segment the market.

As with any form of price discrimination, personalised pricing requires 1) firms to have some degree of market power, 2) that there is heterogeneity among consumers that firms can identify, 3) that firms can fine tune prices according to this heterogeneity and 4) that there is no arbitrage among buyers.

Therefore, the combination of big data, costless price adjustments and the greater ease of enforcing price discrimination in digital settings has made personalised pricing more feasible.

Even though there is no evidence of widespread use of personalised pricing, this form of price discrimination has come under the spotlight. On the one hand, personalised pricing means firms may have greater ability to extract surplus from consumers – **extent of appropriation**. On the other hand, there is a fear that personalised pricing might structurally change how firms compete relative to uniform pricing or more traditional forms of price discrimination – **extent of competition**.

Consumers typically find personalised pricing to be unfair. For this reason, personalised prices may also raise consumer protection, fairness and trust concerns. Nonetheless, and despite the gap that may exist between expectations of the civil society regarding competition authorities, these issues, when unrelated to competition concerns, are outside of the scope of action of the Portuguese Competition Authority (Autoridade da Concorrência – AdC). The

¹ In both cases, prices are partly public and partly private. For instance, online consumers, if they are able to anonymize themselves, could still detect whether they are being charged different prices but not the exact price differences. In addition, even in offline retail, there might be customer-specific discounts, such as coupons.

² E.g., audio and video streaming services, videogames, tickets, newspapers and highly differentiated goods.

³ It must be noted that personalised pricing has always existed. Indeed, prices set in bilateral negotiations are an example of personalised pricing.

AdC's enforcement powers relate only to competition, and the AdC has no pure consumer protection powers other than those that follow from competition matters.

A *sine qua non* condition for firms to engage in price discrimination – and thus personalised pricing – is that they are able to identify heterogeneity amongst consumers. This is dealt with in section 2. In turn, the effects of personalised pricing in terms of consumer surplus and producer surplus are ambiguous. However, economic theory provides some priors regarding the effects of personalised pricing according to a combination of market characteristics. This is dealt with in section 3. Finally, building on sections 2 and 3, section 4 discusses the implications of personalised pricing for competition policy.

2. Identifying consumer heterogeneity

Personalised pricing requires firms to either identify individual customers or, at least, small customer groups. In order to do this, firms may ask users to identify themselves or resort to cues to infer their identity.

Firms can get users to self-identify if they demand account registrations to use their website or application. The registration forms often request information that, in most cases, identifies individual customers, e.g. through e-mail or address.

Even if users do not identify themselves, firms can use cues that may individually identify them. The most common technique is the use of cookies, i.e. pieces of text stored in the device which identify individual users and may be accessed later by the website or application.

If using cookies is not possible, firms may opt for other identification techniques. Common cues include IP and location⁴, which are often paired with fingerprinting techniques. These may gather information on the device, browser, screen resolution, language or installed fonts. Some of the most sophisticated techniques will make the user's browser render images which are specific to the graphics card model, graphics card driver and browser – canvas fingerprinting⁵.

When using fingerprinting, it is unlikely that a single variable identifies an individual customer. The observed characteristics of a customer will be either rare or common. As the number of rare characteristics increases (e.g. odd resolution, many custom fonts, outdated browser or OS), it becomes increasingly easier to identify an individual customer.

⁴ This may be either IP location, actual location (e.g. GPS, WPS or other multilateration techniques) or both.

⁵ [Panoptick's website](#) has many examples of fingerprinting. It is part of a research project by the Electronic Frontier Foundation, an international non-profit digital rights group.

The identification of users may be carried out by third parties present in multiple channels simultaneously. That is, while navigating both websites A and B, for instance, users may be identified and tracked by the same third party, C. This may be done using a combination of the three techniques explained *supra* – user accounts, cookies and fingerprinting. The use of web tags (or tracking pixels) made by a third party are a possible example of this third-party monitoring. These are pieces of code that track specific events on a website (e.g. page visits or purchases). Web tags are very common in digital advertising, as they allow firms to assess whether an ad on the third-party's platform led to a purchase on a given website.

In addition to identifying users, firms also want to estimate the WTP of potential customers. For this, firms may, for instance:

- d. Gather personal data provided by the user in account registrations, such as age, gender or location;
- e. Record their users' browsing behaviour: when and how many times they visit their pages, what they search, where they come from, how long they stay and how they leave. They may also track mouse movements and clicks (frequency and location), whether the window is active or inactive, maximized or not, among other behaviours⁶;
- f. Keep a history of previous purchases, as well as previous discounts;
- g. In multi-sided markets, record all the interactions within and between sides, which will include, for example, lists of contacts and messages or comments between users;
- h. Acquire data from firms specialized in tracking users. This may allow firms to merge datasets from different sources, even while keeping data in pseudonymised form ⁷, if firms are using common fingerprinting algorithms.

It is important to note that a single customer's data is not *per se* helpful in reducing the firm's uncertainty about the type of customer it faces. However, as the number of observed individuals increases, the value of the information in the dataset will, at least initially, grow more than proportionally – i.e., there are network effects to data gathering.

⁶ This website shows interactively what websites may be able to measure: <https://clickclickclick.click>.

⁷ According to the [European General Data Protection Regulation](#), pseudonymisation refers to “the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person” (Article 4).

Lastly, this data *may* be used for personalised pricing but it is mostly used for other purposes within the commercial policy of the firm. The most common uses include recommendation algorithms (e.g. product suggestions, targeted and tailored advertising), as well as customised goods and services.

3. The effects of personalised pricing in consumer markets

The effects of personalised pricing on market outcomes are highly dependent on the characteristics of the markets under analysis. In order to discuss these effects, we conduct a stylised exercise, generally applicable to all markets. We focus, therefore, on the effects of personalised pricing on market outcomes under:

- i. Different types of market structures;
- j. Varying degrees of uncertainty about consumer types;
- k. Pricing algorithms.

The effects of personalised pricing according to market structure

In a monopoly setting, if the monopolist produces a single undifferentiated good, first-degree price discrimination allows it to increase output and profits. However, consumer surplus is fully appropriated by the monopolist.

Third-degree price discrimination, on the other hand, would result in output expansion. The effect on consumer surplus, nonetheless, would be ambiguous, as the monopolist would appropriate part of the consumer surplus of each group but also expand the market to include low WTP groups. Indeed, consumer surplus is larger the more the market expands to low WTP groups, and would decrease if the monopolist simply kept the market size while targeting very high WTP groups.

Personalised pricing stands in the sliding scale between first-degree and third-degree price discrimination. As long as group sizes are not too small, the effects of personalised pricing on consumer surplus range from the – ambiguous – typical third-degree price discrimination effect to the first-degree price discrimination effect – elimination of consumer surplus. Therefore, as firms move along the identification sliding scale towards being able to identify each individual customers⁸ – **perfect segmentation** –, the output enhancing effect is dominated by the appropriation effect.

If a monopoly produces differentiated goods, the results would be similar. Under uniform pricing, there could be a diversion of customers between its goods as

⁸ I.e. as group sizes tend towards 1.

relative prices change – cannibalization –, which would make the analysis more complex. However, there can only be cannibalization if the monopolist is constrained to uniform pricing, otherwise it could treat each group of consumers as a whole separate market.

In a setting with more than one firm results may be different, as the possibility of competition adds an extra layer of effects. Moving, on the one hand, from uniform pricing to price discrimination and, on the other hand, along the sliding scale from third- to first-degree price discrimination may significantly affect the extent of competition in the market.

Under differentiated goods, assuming a duopoly of differentiated goods, where firm A produces good A and firm B produces good B, and two types of consumers, 1 and 2⁹, the direction of price changes following the introduction of price discrimination will depend on 1) whether firms consider or not the same group of consumers to be strong or weak, 2) the relative size of the different consumer groups and 3) the strength of firms among their strong consumer groups¹⁰.

A group of consumers is strong *to a firm/product* if the WTP of its members is relatively higher than the WTP of members of other groups of consumers. On the other hand, a group of consumers is weak *to a firm/product* if the WTP of its members is relatively lower than the WTP of members of other groups of consumers. Note that one may only speak of strong or weak consumer groups in reference to a specific firm or product.

In the duopoly considered in this section, by construction, there are only two possible consumer groups. Thus, one group must be strong and the other must be weak for a given firm. For instance, the group of consumers of type 1 might have a high WTP towards firm A's product, good A. In that case, it is said that the group of consumers of type 1 is A's strong group, while the group of consumers of type 2 is A's weak group.

Firms, hence, rank their consumers according to the WTP towards their products. They may also rank consumer groups differently, which may alter the way competition is conducted in the market and from which different market outcomes may follow.

If firms rank groups equally – **best-response symmetry** –, A's strong group is the same as B's strong group and A's weak group is the same as B's weak group. This occurs, for example, if consumers are discriminated according to income level,

⁹ Following Corts (1998).

¹⁰ Firms will be stronger among their strong consumer groups the higher the WTP of their strong consumer groups relative to the WTP of their weak consumer groups. The less strong firms are among their strong groups, the more ambivalent all consumers will be. Conversely, the stronger firms are among their strong groups, the more loyal their strong groups will be.

where all else constant, high income groups always have a higher WTP. Hence, for any given price charged by B, A will always charge its strong group a higher price relative to its weak group (and B will do the same towards the same groups).

Under best-response symmetry, as both firms rank markets equally, results will be similar to the monopoly case: following the introduction of price discrimination, firms will charge their strong groups higher prices and charge their weak groups lower prices. Therefore, **there will be price decreases for low WTP customers and price increases for high WTP customers**. In the end, the **overall effect on consumer welfare is ambiguous**.

If firms rank groups differently – **best-response asymmetry** –, A’s strong group is B’s weak group and A’s weak group is B’s strong group. This will be the case if, for example, consumer groups have different brand preferences, where one group has a higher WTP towards A’s product and the other a higher WTP towards B’s product. Thus, for any given price charged by B, A will always charge its strong group a higher price (and B will charge A’s weak group a higher price relative to A’s strong group).

Under best-response asymmetry, following the introduction of price discrimination, it is possible that prices increase or decrease for some or all consumers:

- i. **If consumer group sizes are roughly equal**, assuming firms to be strong among their strong groups, under price discrimination, firms will take advantage of the fact they can decrease prices for ambivalent customers (in their weak consumer group) without reducing them for loyal ones (in the strong consumer group). When both firms do this, competition for ambivalent consumers will be intensified, as firms will try to poach customers from each other¹¹. Under uniform pricing, the market outcome is similar to that under market sharing, as firms focus on different consumer groups - each firm focuses on its strong group and prices out its weak group. Thus, since price discrimination breaks this market sharing like outcome by introducing poaching, **competition is intensified, prices decrease for all consumers, consumer surplus increases, and profits decrease for both firms**;
- m. **If consumer group sizes differ**, firms will tend to care more about the larger group, all other things considered. Therefore, under uniform

¹¹ This is the result in Thisses and Vives (1988). In their model, consumer preferences are distributed à la Hotelling, meaning there is an infinite number of consumer types. In that case, the “ambivalent consumers” will be the ones among a firm’s weak group and near the middle of the distribution. In Corts (1998), as there are only two types of consumers, the whole firm’s weak group is composed of ambivalent consumers, as they are the next supramarginal group.

pricing, there will be increased competition for the larger group, as the firm for which the larger consumer group is weak will decrease its uniform price so as not to price it out. This benefits the strong group as well. Moreover, the other firm, faced with increased competition for its strong group, will also decrease its price – feedback effect. Following the introduction of price discrimination, firms attach a lower weight to avoiding pricing out their weak but larger consumer group. Ultimately, the direction of price changes will depend on the price level before price discrimination, namely on how low uniform prices were as a result of consumer group size differences. Hence, under this scenario, **it is not clear whether competition is intensified or not following price discrimination and prices may increase or decrease for some or all consumers.**

As firms are increasingly able to segment consumers, i.e. as group sizes decrease towards 1 – perfect segmentation –, consumers become marginal consumers and will be charged the opportunity cost of shifting to a rival differentiated good, i.e. they will pay for their choosiness and switching costs. This will entail asymmetric outcomes to consumers, as some are more ambivalent towards the available goods and some are more loyal to either one of the differentiated groups. In other words, **some consumers will benefit from increased segmentation and others may be worse-off**¹².

Lastly, under best-response asymmetry, **if only one of the firms is able to price discriminate, the impact of price discrimination will be similar to the monopoly case**, no matter how different consumer group sizes may be. The firm that is able to price discriminate will take advantage of its ability to decrease prices for ambivalent consumers (in their weak group) without reducing them for loyal ones (in the strong group). In this scenario, poaching will be one-sided: the price discriminating firm will intensify competition for its weak group but the other firm is constrained in retaliating such that feedback effects are mitigated. Prices will, thus, increase for the price discriminating firm's strong group and decrease for its weak group.

¹² E.g., in a Hotelling framework, consumers at the extremes will be worse off regarding traditional third-degree price discrimination because of their unwillingness to consume the other good, i.e. they face a higher opportunity cost of shifting to the other good. On the other hand, those at the middle will benefit greatly, since their discriminatory price will tend to marginal cost.

The effects of personalised pricing under varying degrees of uncertainty about consumer types

Firms may not be able to accurately evaluate or estimate the WTP of a consumer or group of consumers (e.g., identifying low WTP consumers as high WTP – **false positives** – and identifying high WTP consumers as low WTP – **false negatives**).

Under a monopoly, from the point of view of the firm, these errors lead to losses of potential revenue:

- n. In false positives, firms fail to conclude a transaction by pricing out marginal consumers;
- o. In false negatives, they fail to extract part of the consumer surplus, as they obtain lower margins;
- p. Because of this, uncertainty in price discrimination decreases its attractiveness to firms.

False positives and false negatives yield opposite effects on consumers. False positives harm low WTP consumers, as they are excluded from the market. However, false negatives mean that high WTP consumers are able to keep a larger share of surplus.

As the number of groups identified for price discrimination increases, more and more consumers become marginal consumers within their own group. False positives – mistaking low WTP for high WTP – price out marginal consumers. Hence, as the number of marginal consumers increases, the probability that a given consumer is excluded from the market will also increase. For this reason, one should expect the number of false positives relative to false negatives to increase as one approaches first-degree price discrimination.

Firms will prefer risking lower margins rather than not selling their goods. False positives – mistaking low WTP for high WTP – are more costly than false negatives – mistaking high WTP for low WTP –, meaning that **firms will be biased towards false negatives**, i.e. towards setting a lower price than the estimated WTP to avoid pricing out marginal consumers. Therefore, even under first-degree price discrimination, uncertainty would ensure consumer surplus remains positive.

Acquiring more relevant data on consumers would reduce uncertainty on their WTP – i.e., decrease the false positives and false negatives. The net effect on consumers would depend on the relative number of false positives to false negatives. If false positives were more common, consumers would benefit as there would be more transactions. If, on the other hand, false negatives were

more common, consumers would be harmed, as firms would be able to extract more consumer surplus. Thus, **given the bias towards false negatives, it is likely that reducing uncertainty about the WTP harms consumers.**

In an oligopoly setting, if firms rank consumer groups equally (best-response symmetry), reducing uncertainty on consumers' WTP would lead to results similar to the monopoly case. However, if firms rank consumer groups differently (best-response asymmetry), firms would wrongly identify weak groups as strong, which would soften competition due to decreased poaching. Therefore, **reducing uncertainty would intensify competition. The net effect on consumer welfare is nonetheless ambiguous**, given the greater extent of appropriation from reducing the number of false negatives.

The need of algorithms for personalised pricing, and their impact on collusion

In digital contexts, personalised prices would likely be set by pricing algorithms used in conjunction with monitoring algorithms, which monitor rivals' prices. These algorithms may raise, in themselves, competition concerns and policy implications, namely regarding the risk of collusion, via increased transparency and frequency of interaction in the market.

Transparency may facilitate both tacit and explicit collusion, as it allows firms to detect deviations from collusive equilibria. It may be increased as a result of:

- q. The direct effect of monitoring algorithms, whose aim is to get more information on rivals' strategic variables;
- r. The simplicity of algorithms, which may make it easier for rivals to anticipate strategic reactions. Pricing algorithms would thus function as a commitment device for high prices and retaliation;
- s. Firms using similar algorithms, either due to the widespread use of open-source software or common developers (e.g., industry standards).

The frequency of interaction may facilitate both tacit and explicit collusion as well, since it allows firms to retaliate quickly following deviations from collusive equilibria. Given that pricing algorithms are mostly used in digital contexts and can be made to set prices in arbitrarily short time intervals, pricing algorithms will likely increase the frequency of interaction.

In addition to standard adaptive algorithms, firms may use self-learning algorithms which rely on artificial intelligence and large quantities of data to continuously improve their price setting. The nature of these algorithms is still unclear and there is no evidence of their widespread use. Nonetheless, there is a risk they

may be able to reach collusive Nash equilibria without ever being programmed with that intent.

4. Effects of personalised pricing in intermediate markets

The analysis on the effects of personalised prices in the previous section also applies to intermediate markets. Firms downstream may also value goods upstream differently (e.g., as a function of the extent of their market power downstream), such that upstream firms may rank their buyers.

The topic of personalised pricing mainly relates to business-to-consumer relationships, as these markets will more likely have the scale to deliver network effects from consumer data and the conditions for personalised pricing to emerge as an optimal pricing strategy. The implications of personalised pricing in business-to-business relationships remains relatively unexplored in the literature, seemingly because it is likely more prevalent or relevant in final consumers markets.

In intermediate markets, it may be harder to acquire rich datasets in comparison to final consumer markets, to the higher concentration on the buyer side and the way the buyer-seller relationship is conducted. Having fewer possible buyers will prevent upstream firms from enjoying network effects in the data they may acquire. Moreover, since transactions in intermediate markets typically have higher value, the weight of transaction costs on the final value of the product is lower, such that it pays off for firms in intermediate markets to interact through bilateral negotiations to decide on product characteristics and prices. This makes it harder to build datasets on these interactions.

Personalised pricing in intermediate markets may be less data-driven than in the case for consumers and more based on bilateral negotiations where buyers and sellers meet half way of their respective willingness to pay and willingness to accept.

In competitive assessments, emphasis is placed on consumer welfare. Thus, both the ability of upstream firms to extract surplus from downstream firms and structural changes in how firms compete are relevant to the extent they affect markets for final consumers, downstream:

- t. Higher prices in intermediate markets resulting from personalised prices may raise costs downstream – pass-through effect –, which may negatively impact final consumers – leading to decreased output, higher consumer prices and consumer welfare losses.
- u. Personalised prices in the intermediate market affect the degree of competition downstream, as it may create or strengthen differences in

firms' ability to compete downstream for final consumers. Under personalised pricing, prices may increase for high value buyers and decrease for low value buyers, and this may affect the degree of competition amongst them in supplying the downstream consumers market.

- v. If there is perfect segmentation, firms will be charged for input specificity and switching costs, which may also lead to discriminatory conditions that hamper firms' ability to compete downstream and harm consumer welfare.

In addition to these partial implications from personalised prices, the final impact on the degree of competition in downstream markets will also depend on how these effects interplay with the relative bargaining power of firms that are suppliers in the downstream consumer market.

5. Implications for competition policy

Personalised pricing has an ambiguous effect on consumer welfare depending on the specifics of the market and the interactions between market players. As a result, **a *per se* negative position towards personalised pricing is not adequate**, as it would entail potential losses in terms of consumer welfare – **a rule of reason approach should thus be preferred**.

Personalised pricing may increase the ability of firms to extract surplus from consumers – extent of appropriation. It may also structurally change the way firms compete in a market relative to uniform pricing and more traditional practices of price discrimination – extent of competition.

Price discrimination may only benefit both consumers and producers if it leads to greater output expansion. Otherwise, it transfers surplus from consumers to producers (e.g. appropriation effect) or from producers to consumers (e.g. poaching effect). If a firm, under personalised pricing, targets only consumers with very high WTP, output expansion will be minimal and there will be a large transfer of consumer surplus to producers.

In terms of competition law enforcement, concerns that follow from personalised pricing imposed by a firm in a dominant position could theoretically fall within the scope of an abuse of **dominant position, due to excessive prices, predatory behaviour or price discrimination in an intermediate goods market**.

Under Law 19/2012 of 8 May (hereinafter the Portuguese Competition Act), a situation in which personalised pricing is harmful to competition and consumers could theoretically be regarded as a potential abuse of dominance if undertaken

by a firm in a dominant position that exploits consumers by imposing excessive prices¹³.

The Portuguese Competition Act also prohibits firms in a dominant position from engaging in predatory pricing¹⁴, i.e., an abuse of dominance with the intent of excluding firms from the market.

Price discrimination, in general, makes it easier for firms to engage in predatory behaviour, by lowering foregone profits. Under personalised pricing, foregone profits could be minimised, as the incumbent may target solely the entrant's strong customer groups while keeping its own groups captive, thus minimising losses.

The application of **personalised prices in intermediate markets may disrupt competition in downstream markets**, as it may render some firms less competitive or even exclude them from the market. In Portugal, the application of discriminatory prices by a firm in a dominant position to commercial partners in otherwise identical conditions could also be seen as an abuse of dominant position under the Portuguese Competition Act, to the extent it affects competition in relevant markets¹⁵.

In terms of merger control, a merger that will entail the combination of two or more datasets may give rise to competition concerns by allowing **the merged firm to move along the sliding scale of price discrimination** and, at the same time, better estimate the buyers' WTP. In this case, the merged entity may fully appropriate merger efficiencies or even reduce consumer surplus.

The degree of uncertainty when identifying consumers' types may have an impact on the effects of personalised pricing on consumer welfare. Greater certainty in the estimation of WTP is likely to harm consumers, as firms will be less likely to bias personalised pricing (or third-degree price discrimination) towards false negatives – mistaking high WTP for low WTP. This entails that, as firms accumulate richer datasets (e.g., via merger activity), uncertainty is mitigated and personalised pricing could, under certain circumstances, make consumers worse off. This thus brings one further element to the competitive assessment in merger control.

When it comes to consumer protection, fairness and trust, in terms of institutional design, the AdC powers only relate to the enforcement of competition law, and

¹³ Article 11(2)(a) of the Portuguese Competition Act).

¹⁴ Article 11(2) of the Portuguese Competition Act.

¹⁵ Article 11(2)(c) of the Portuguese Competition Act.

the AdC does not have enforcement powers in pure consumer protection matters other than those that follow from protecting competition in the market.

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