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STRATEGIC ANONYMITY AND BEHAVIOR-BASED PRICING

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Strategic anonymity and behavior-based pricing[*]

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Abstract

In a model of behavior-based price discrimination (BBPD), we argue that sellers may have discretionary power to let buyers decide whether to be identified (e.g., creating an account) or remain anonymous (no account creation). The price equilibria generate a more fragmented market segmentation than under the standard BBPD. Firms might prefer a policy where they leave buyers the decision to remain or not be anonymous, breaking the standard BBPD result. Furthermore, firms can realize higher profits than under uniform pricing, contrary to the standard BBPD. Also, firms may adopt asymmetric policies concerning the account creation requirement.

JEL codes: D43, L13.

Keywords: strategic anonymity; behavior-based pricing; privacy.

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1. INTRODUCTION

The interaction between sellers and buyers over the Internet has recast many pre-Internet era characteristics. The search for products and sellers before purchase and the assistance after a sale—covering product usage guidance, repairs, maintenance, and the purchase of additional complementary goods or services—all go through within a web-based or web-augmented environment. Sellers play a significant role in shaping this digital space, although there are limitations on how users' communities can organize themselves.

In this respect, as buyers display much of the pre-Internet era heterogeneity, now they exhibit heterogeneity of preferences over websites in terms of the sites' organization, product information display, web tools, order placement methods, and payment systems. In fact, heterogeneity in the readiness to accept web-based self-service technologies, as related to different tastes and attitudes, is widely recognized in the retail management literature (Liljander et al. 2006, Ding et al. 2007). Therefore, buyers choose websites in a way that resembles the choice between differentiated products in the physical world.

In general, however, when buyers buy from a website, they leave a track record that purchasers in physical stores do not normally leave, inspiring the research on behavior-based price discrimination (BBPD), starting with Caminal and Matutes (1990) and Fudenberg and Tirole (2000). The literature has developed detailed analyses of the possibility to price discriminate between returning buyers and new customers (Chen 1997, Choe et al. 2018, Laussel and Resende 2022). The underlying assumption in BBPD is that firms can invariably identify purchasers when purchasing products or services, as with mobile phone service subscriptions.

Data protection laws and regulations, however, tend to limit data collection without the consent of the data owner when these are not necessary to the transaction. While exogenous (random) imperfect recognition is the object of some work in the BBPD area (Colombo 2016, Esteves 2014), the level of information accuracy is largely determined *endogenously* by consumers and/or firms' strategies. For instance, Amazon clients can purchase items only after creating a personal account (thus renouncing anonymity). On the opposite, eBay allows consumers to purchase after creating an account or even anonymously, and among eBay's clients, some choose the first option (account creation), whereas others choose the second one (anonymous purchase). Endogenous imperfect recognition has been so far neglected by the literature. Hence, the aim of the present paper is to explore endogenous imperfect recognition (generated by strategic anonymity by both buyers and sellers).

We posit that sellers possess discretionary power in deciding whether buyers can control the decision of being identified or remaining anonymous – we shall be a little more specific in the sequel. This discretionary power granted to the firms then translates into an added discretionary power to buyers when they behave strategically, and the resulting identification or anonymity of a buyer becomes entirely endogenous.

Our model, based on these considerations, simplifies the story by assuming that sellers can identify a buyer only if the purchase occurs after *creating an account* at the selling website. Sellers can, however, also allow purchases without creating an account. The decision by the seller in our model generates two distinct strategies: a compulsory account creation (implying identification of the buyer) or a menu choice for the consumers that might decide whether to purchase without an account ("anonymous" transactions) or with an account. These choices then shape the ensuing competition environment. Next, we also compare them with the case where firms allow only purchases without an account ("anonymous" transactions only), which amounts to a uniform pricing regime.

From the viewpoint of buyers, creating an account in a BBPD-like story implies the self-hurting consequence of being banned from future discounts that are practiced for new customers. Clearly, for a strategic consumer (as opposed to a "naïve" one), there must be a tradeoff in order to create an account. Account creation is the way for sellers to provide a set of opportunities in web search, post-sale services, ancillary services, advice about complementary products, user guides, and similar services. Those opportunities ameliorate the platform-related experience, reducing the transaction costs incurred by the buyer.[1,2] In brief, if an account is created, the buyer enters a group of identified customers, in sequel interactions, as "returning customers"; if an account is *not* created, the customer remains "anonymous."[3]

We model the following game. In the first stage, firms noncooperatively choose whether to (i) leave no choice to buyers and require every buyer to

[1] In the end, creating an account implies entering a relationship with the seller that provides some advantages while relinquishing anonymity. Strategic consumers will choose whether to create an account or remain anonymous based on balancing the value of the advantages against giving up access to future price discounts reserved for new customers.

[2] Casadesus-Masanell and Hervas-Drane (2015) assume there is a concave relationship between the amount of information that a consumer provides to a firm and the quality of the purchased item – and a negative relationship with the degree of disclosure to third parties. Similarly, Conti and Reverberi (2021) assume that opting-in for access to private information leads to higher quality of consumption. In a similar spirit, Conitzer et al. (2012) assume that hiding information from a monopolist is costly to consumers but prevents price discrimination.

[3] Fake accounts are possible in the real world, and a customer may create a false identity, even when account creation is mandatory for completing a transaction – with the aim to return as a new customer in the future, under a new and maybe again false identity. Consider, however, that a shipping address is needed for a large class of purchases, severely limiting the possibility of remaining unidentified. Furthermore, our analysis also reveals that some consumers strategically decide to be identified if they are given the choice (so that they will not create fake accounts even if they could). On the other side, sellers may circumvent the buyer's decision to remain anonymous by collecting data without the buyer's consent: we exclude this behavior by the sellers – possibly because of fear of intervention by regulatory agencies or of class actions.

create an account or (ii) allow buyers to buy with or without an account. Then, firms compete in prices over two periods. Incidentally, at the beginning of the second period, buyers can create an account at the seller they will buy from, had they not done so in the first period.

We then obtain the following results. If both consumers and firms are perfectly foresighted, we might observe either a symmetric equilibrium where both firms offer a menu choice regarding account creation or a symmetric equilibrium where both firms adopt a no-choice policy that forces buyers to create an account. Multiple symmetric equilibria are also possible. Notably, when offering a menu choice is the unique equilibrium, it is not a prisoner dilemma for the firms. When comparing this last equilibrium with a compulsory anonymity regime (or standard uniform pricing regime), we show that allowing consumers to choose whether or not to be anonymous might dominate the compulsory anonymity regime in terms of profits. In other words, behavior-based price discrimination when consumers are free to hide or not their identity might outperform uniform pricing, in contrast with the typical result when standard BBPD and uniform pricing are compared (see Fudenberg and Tirole 2000, Villas-Boas, 1999 and 2004). Lastly, when allowing for not perfectly foresighted consumers and firms, we obtain that asymmetric account policy equilibria are possible, where one firm offers the menu choice regarding account creation to buyers, whereas the other does not. In particular, the outcome happens when the discount factor is not large. This helps explain the existence of competing firms adopting different privacy policies.

While BBPD has been investigated from several perspectives (see Esteves 2009 and Acquisti et al. 2016 for extended reviews of this literature), there are very few papers trying to incorporate some sort of information endogeneity in the model. Conitzer et al. (2012) focus on a monopolistic environment where consumers decide whether to leave track of their previous purchases to the firm or not, and the monopolistic firm adopts BBPD. Hence, this paper does not consider competition between firms. Ali et al. (2023) and Anderson et al. (2023) extend to oligopoly, but they consider personalized pricing rather than third-degree price discrimination.[4] Closer to our work, Heiny et al. (2022) consider two competing firms. Each consumer can reveal her identity (like our "account creation" decision) so that a firm can kept track of their past purchases. However, there is no heterogeneity among consumers regarding the cost/benefit of anonymity; hence, unlike our paper, the co-existence of buyers that choose to reveal their identity and buyers that prefer remaining anonymous is never observed in equilibrium. Moreover, we depart from Heiny et al. (2022) by investigating strategic anonymity from the firms' perspective. Namely, as stressed above, sellers might strategically decide whether or not to allow consumers to purchase without revealing their identity. This aspect is out of scope in Heiny et al. (2022).

The rest of the paper runs as follows. In Section 2, we introduce the model. In Section 3, we characterize the equilibrium outcomes for the different account policies of the firms, and the main results are derived. In Section 4 welfare implications are discussed. Section 5 extends the main model to the case of different discount factors between sellers and buyers. Section 6 concludes. The proofs of the propositions are in the Appendix.

2. THE MODEL

There are two selling websites (or firms), say A and B, located at the endpoints of a Hotelling (1929) segment of length 1 ranging from 0 to 1, that

[4] Cong and Matsushima (2023) also consider consumer data management in a two-market model where firms collect data in a market and apply them in another market. In their paper, data management policy is exogenous.

differ in the way described in the Introduction. Firm A is located at 0, whereas Firm B is located at 1.

Buyers display different satisfaction/abilities when surfing a website. [5] Because the characteristics of the websites are different, consumers view those websites as horizontally differentiated. For example, buyers with high curiosity or education appreciate websites that provide detailed information about their products, while less knowledgeable buyers will rather rely on reviews by other customers (as in Tripadvisor). When a web seller has built its product/website configuration, any buyer is defined by a "degree of mismatch" with the seller. Consumers are uniformly distributed along the Hotelling segment, with $x \in [0,1]$ indicating the "location" of the consumer on the segment. Along the segment, proximity to a website is related to low mismatch (transportation) costs. The usual unit transportation cost in the Hotelling model is normalized to 1. Hence, the mismatch costs of a consumer at x with firms A and B are respectively $1 \times x = x$ and $1 \times (1 - x) = 1 - x$. As explained below, consumers can reduce the unit transportation costs.

Creating an account reduces the transaction cost by reducing the per-length costs from 1 to τ<1 because it allows the consumer to obtain desirable ancillary services that are not accessible otherwise. When creating the account, a consumer sustains (once and forever) a cost equal to $c > 0$. For instance, a consumer at x buying from firm A has transaction costs x or $\tau x + c$, according to whether she buys anonymously or creates an account first. Therefore, if a buyer is very close to a web seller (if she has a very low mismatch level, to begin with), the advantage of further reducing the mismatch is likely overridden by the cost of account creation. Not so for more distant buyers, for which the additional benefit of account creation is larger.

[5] See, for instance, Gadalla et al. (2013).

There are two periods, 1 and 2. Buyers purchase in both periods. In period 1, before purchasing, each consumer visits the websites and decides whether or not to create an account. Even if the consumer does not create the account in period 1, she can create it in period 2. If a buyer creates an account in the first period and purchases from the *same* firm in both periods, she is recognized by that firm and cannot buy at a discount as a newcomer in period 2. In all the other cases, she will be treated as a newcomer in period 2 – in particular, a buyer who is a newcomer to a firm in period 2 and creates an account only in the second period buys at a price reserved for newcomers, so that we can group those buyers with the "anonymous" ones for that firm. The discount factor for both consumers and firms is $\delta \in (0,1]$. In a separate extension, we consider the case of distinct discount factors for firms and consumers.

Since in period 1, no firm is able to identify any buyer, each firm sets a uniform price, q_j (j=A,B). In period 2, Firm j recognizes those consumers ("identified consumers") that have purchased from j in period 1 if and only if they have an account for website j (in both periods); it, therefore, charges them with a price that is different from a price offered to all the other consumers ("unidentified consumers"), thus engaging in BBPD. We denote by p_j the price to its own identified consumers and by $\tilde{p}_j$ the price to the unidentified consumers.

3. ACCOUNT POLICIES

3.1 Both firms provide two options: creating an account and no creation

Suppose that each firm offers the option to buy in the first and second periods with or without an account (strategy F, as "free choice"). We refer to this situation as case FF. We tentatively assume that the market configuration is with buyers near the firms' location choosing not to set up an account. Then, we check if it is sustainable as an equilibrium outcome. Indeed, consistent with second-period utilities, the consumers located close to the firms, namely close to the endpoints, are less interested in revealing their identity since they have low mismatch costs to start with and low benefits from the account. The conjectured market structure is represented in Figure 1.

In Figure 1, the consumers at w_A, who buy from Firm A, are indifferent between creating an account and buying anonymously; the buyers to the left of w_A never create an account, thus never sustaining the cost c and always paying a unit transportation cost equal to 1. The consumers between w_A and k_A do not create any account in period 1, but they create the account for Firm A in period 2, sustaining the cost c, so that they can purchase at price $\tilde{p}_A$ even if buying from Firm A in both periods (as hinted above, they are not recognized because they have not created an account in the first period; hence, they are treated as new customers). The consumers between k_A and x_A in period 1 create the account with Firm A, sustaining the cost c and purchasing from Firm A; in period 2, they purchase again from Firm A at price p_A, because Firm A identifies them as returning buyers. The consumers between x_A and k in period 1 create the account with Firm A sustaining the cost c and purchase from Firm A; in period 2, however, they create the account for Firm B sustaining the cost c again and can purchase as new buyers from B at price $\tilde{p}_B$ (Firm B treats them as "unidentified"). A similar market structure holds for consumers from k to 1. [6]

[6] It is worth mentioning that *ex-ante* asymmetric locations of the indifferent consumers are allowed; Figure 1 is symmetric for convenience since the equilibrium is expected to be symmetric. The same holds for Figure 2 (see later).

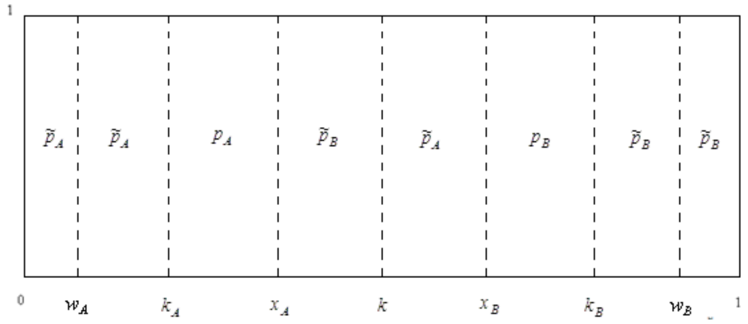

Figure 1: market structure in case FF

The set of consumers who created accounts in period 1 is the interval $[k_A, k_B]$; hence, in period 2, the extreme points of this interval are taken as given. The dividing points w_A and w_B depend upon the choices to create or not accounts in the second period but are independent of the prices, as to be seen below since they only depend upon c and τ.

The indifferent second-period consumers x_A and x_B are respectively given by $v - p_A - \tau x_A = v - c - \tilde{p}_B - \tau(1 - x_A)$ and $v - p_B - \tau(1 - x_B) = v - c - \tilde{p}_A - \tau x_B)$. Hence:

$$x_A = \frac{\tilde{p}_B - p_A + c + \tau}{2\tau};\ x_B = \frac{p_B - \tilde{p}_A - c + \tau}{2\tau}. \tag{1}$$

The indifferent second-period consumers w_A and w_B are respectively given by[7] $v - \tilde{p}_A - w_A = v - c - \tilde{p}_A - \tau w_A$ and $v - \tilde{p}_B - (1 - w_B) = v - c - \tilde{p}_B - \tau(1 - w_B)$. Hence:

$$w_A = \frac{c}{1-\tau};\ w_B = 1 - \frac{c}{1-\tau}. \tag{2}$$

The second-period profits functions are:

$$\pi_{A,2} = p_A(x_A - k_A) + \tilde{p}_A(x_B - k + k_A), \tag{3}$$

$$\pi_{B,2} = p_B(k_B - x_B) + \tilde{p}_A(k - x_A + 1 - k_B). \tag{4}$$

By maximizing, we get the second-period equilibrium prices, that is:

[7] Note that w_A and w_B do not enter the profit functions because they do not depend on prices. However, they contribute to characterizing the admissible parameter set.

$$p_A = \frac{[(3+2k-4k_A-2k_B)\tau+c]}{3};\ \tilde{p}_A = \frac{(1-4k+4k_A+2k_B)\tau-c}{3};$$

$$p_B = \frac{(-1-2k+2k_A+4k_B)\tau+c}{3};\ \tilde{p}_B = \frac{(3+4k-2k_A-4k_B)\tau-c}{3}. \quad (5)$$

When moving to period 1, the first-period indifferent consumer k is given by the condition: $v - c - q_A - \tau k + \delta[v - c - \tilde{p}_B - \tau(1-k)] = v - c - q_B - \tau(1-k) + \delta[v - c - \tilde{p}_A - \tau k]$, that is:

$$k = \frac{3(q_B - q_A) + [3-(5-6k_A-6k_B)\delta]\tau}{2(3+\delta)\tau}. \quad (6)$$

This is similar to the market boundary defined in standard BBPD models, as it does not depend on c. The overall profits functions are:

$$\pi_A = q_A k + \delta\pi_{A,2}, \quad (7)$$

$$\pi_B = q_B(1-k) + \delta\pi_{B,2}. \quad (8)$$

By maximizing, we get the first-period equilibrium prices:

$$q_A = \frac{(3+\delta+4\delta k_A)\tau - 2\delta c}{3} - \frac{2(1-k_A-k_B)(27-\delta)\delta}{3(27-11\delta)}\tau, \quad (9)$$

$$q_B = \frac{(3+5\delta-4\delta k_B)\tau - 2\delta c}{3} + \frac{2(1-k_A-k_B)(27-\delta)\delta}{3(27-11\delta)}\tau. \quad (10)$$

Now, we find the indifferent consumers k_A and k_B. They are obtained by solving simultaneously the following equations: $v - c - q_A - \tau k_A + \delta(v - p_A - \tau k_A) = v - q_A - k_A + \delta(v - c - \tilde{p}_A - \tau k_A)$ and $v - c - q_B - \tau(1-k_B) + \delta[v - p_B - \tau(1-k_B)] = v - q_B - (1-k_B) + \delta[v - c - \tilde{p}_B - \tau(1-k_B)]$, yielding:

$$k_A^{FF*} = \frac{\delta\tau + c(3-\delta)}{3(1-\tau)+4\delta\tau};\ \ k_B^{FF*} = 1 - \frac{\delta\tau + c(3-\delta)}{3(1-\tau)+4\delta\tau}. \quad (11)$$

The equilibrium profits, indicated by π^{FF}, are reported in the Appendix. The conjectured market structure – that is $1 > w_B > k_B > x_B > k > x_A > k_A > w_A > 0$ – is verified in equilibrium when $c \leq \frac{\tau(1-\tau)}{1+3\tau}$. Concretely, those three variables are: $k^{FF*} = \frac{1}{2}, x_A^{FF*} = \frac{1}{3} + \frac{4\delta\tau^2+3(1+3\tau)c}{6\tau(3-3\tau+4\delta\tau)}$ and $x_B^{FF*} = \frac{2}{3} - \frac{4\delta\tau^2+3(1+3\tau)c}{6\tau(3-3\tau+4\delta\tau)}$. Note that $x_A^{FF*} > \frac{1}{3}$ (and, symmetrically, $x_B^{FF*} < \frac{2}{3}$), so that the "poaching" areas are lower than 1/6, which is the case in the traditional BBPD model because the existence of unidentified consumers closer to each firm reduces the incentives of firms to offer low poaching prices.

3.2 Both firms require consumers to create accounts

Suppose that each firm allows only to purchase with an account (strategy N, as "no choice"): this situation is indicated as case NN. Then, only buyers who switch providers will pay the price to new buyers. This assumption is the usual BBPD market configuration. Figure 2 shows how the firms segment the market in case NN.

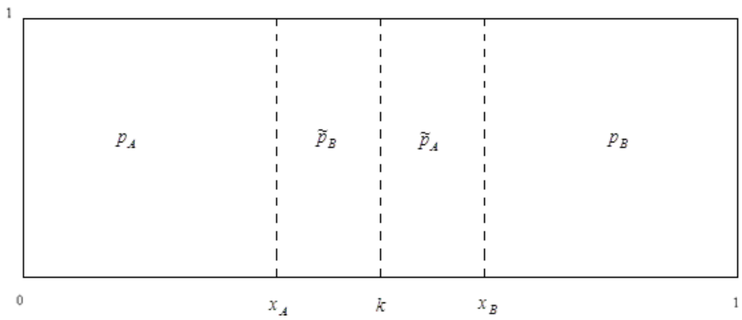

Figure 2: market structure in case NN

The indifferent second-period consumer x_A and x_B are given by (1). The second-period profits functions are:

$$\pi_{A,2} = p_A x_A + \tilde{p}_A(x_B - k), \tag{12}$$

$$\pi_{B,2} = p_B(1 - x_B) + \tilde{p}_A(k - x_A). \tag{13}$$

By maximizing, we get the second-period equilibrium prices, that is:

$$p_A = \frac{(1+2k)\tau+c}{3}; \tilde{p}_A = \frac{(3-4k)\tau-c}{3},$$

$$p_B = \frac{(3-2k)\tau+c}{3}; \tilde{p}_B = \frac{(-1+4k)\tau-c}{3}. \tag{14}$$

When moving to period 1, the first-period indifferent consumer k is given by the condition: $v - c - q_A - \tau k + \delta[v - c - \tilde{p}_B - \tau(1-k)] = v - c - q_B - \tau(1-k) + \delta[v - c - \tilde{p}_A - \tau k]$, that is:

$$k = \frac{3(q_B - q_A) + (3+\delta)\tau}{2(3+\delta)\tau} \tag{15}$$

The overall profits functions are as (7) and (8). By maximizing, we get the first-period equilibrium prices:

$$q_A^{NN*} = q_B^{NN*} = \frac{\tau(3+\delta) - 2\delta c}{3} \tag{16}$$

The equilibrium profits, indicated by π^{NN}, are reported in the Appendix. The conjectured market structure – that is, $1 > x_B > k > x_A > 0$ – is verified in equilibrium when $c \leq \tau$. Concretely, those three variables are $k^{NN*} = \frac{1}{2}$, $x_A^{NN*} = \frac{1}{3} + \frac{c}{6\tau}$, and $x_B^{NN*} = \frac{2}{3} - \frac{c}{6\tau}$. Note that when $c = 0$, we are back to the equilibrium market configuration in Fudenberg and Tirole (2000) because consumers do not need to incur cost c to switch from one firm to the other.

3.3 Asymmetric account creation policies

Suppose that only Firm A allows its buyers to create an account or not (strategy F). Consumers of Firm B instead must create an account if they purchase from Firm B (strategy N). This is denoted as case FN. Clearly, case NF, where only Firm B's consumers are free whether to create the account or not, can be treated symmetrically. Figure 3 shows how the firms segment the market in case FN.

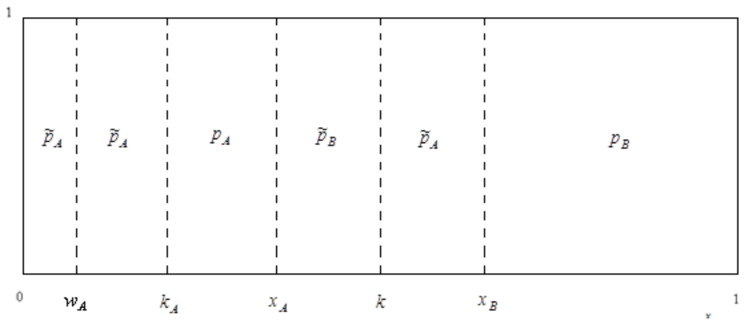

Figure 3: market structure in case FN

Here, poaching by Firm B is akin to that under standard BBPD (the segment $[x_A, k]$), while Firm A retains a richer market segmentation, with consumers near its location choosing not to open accounts in the first period. The indifferent second-period consumer x_A and x_B are given by (1), whereas the indifferent second-period consumer w_A is given by (2). The second-period profits function of Firm A is:

$$\pi_{A,2} = p_A(x_A - k_A) + \tilde{p}_A(x_B - k + k_A), \tag{17}$$

whereas that of Firm B is as (13). By maximizing, we get the second-period equilibrium prices, that is:

$$p_A = \frac{(1+2k-4k_A)\tau + c}{3}; \tilde{p}_A = \frac{(3-4k+4k_A)\tau - c}{3},$$

$$p_B = \frac{(3-2k+2k_A)\tau + c}{3}; \tilde{p}_B = \frac{(-1+4k-2k_A)\tau - c}{3}. \tag{18}$$

Let us consider the difference between the poaching prices when k is close to $1/2$. It can be observed that $(\tilde{p}_A - \tilde{p}_B)|_{k=1/2} > 0$. Indeed, Firm A is less aggressive with its poaching price since it also applies this price to its own unidentified consumers.

When moving to period 1, the first-period indifferent consumer k is given by the condition: $v - c - q_A - \tau k + \delta[v - c - \tilde{p}_B - \tau(1-k)] = v - c - q_B - \tau(1-k) + \delta[v - c - \tilde{p}_A - \tau k]$, that is:

$$k = \frac{3(q_B - q_A) + [3 + (1 + 6k_A)\delta]\tau}{2(3+\delta)\tau}. \tag{19}$$

If $q_B = q_A$, k is higher than 1/2 unless $k_A = 0$. Thus, Firm A has an advantage over Firm B in period 1 because $\tilde{p}_A$ is more likely to be higher than $\tilde{p}_B$, inducing the first-period indifferent consumers, who will switch in period 2, to prefer Firm A more. [8]

The overall profits functions are as (7) and (8). By maximizing, we get the first-period equilibrium prices:

$$q_A = \frac{(3+\delta)\tau - 2\delta c}{3} + \frac{2(81-23\delta)\delta k_A \tau}{3(27-11\delta)}, \tag{20}$$

$$q_B = \frac{(3+\delta)\tau - 2c}{3} - \frac{2(27-\delta)\delta k_A \tau}{3(27-11\delta)}. \tag{21}$$

Now, we find the indifferent consumer k_A. It is obtained by solving $v - c - q_A - \tau k_A + \delta(v - p_A - \tau k_A) = v - q_A - k_A + \delta(v - c - \tilde{p}_A - \tau k_A)$, that yields:

$$k_A^{FN*} = \frac{[(3-\delta)c + \delta\tau](27-11\delta)}{3(27-11\delta) - (81 - 249\delta + 34\delta^2)\tau}. \tag{22}$$

The equilibrium profits, indicated by π_A^{FN} and π_B^{FN}, are reported in the Appendix. The conjectured market structure – that is $1 > x_B > k > x_A > k_A > w_A > 0$ – is verified in equilibrium when $c \leq \hat{c}(\tau, \delta) \equiv \frac{\tau(1-\tau)(27-11\delta)}{27-11\delta+189\tau-23\tau\delta}$. Concretely, those variables except for k_A^* are: $k^{FN*} = \frac{1}{2} - \frac{9\delta((3-\delta)c+\delta\tau)}{3(27-11\delta)-(81-249\delta+34\delta^2)\tau}$, $x_A^{FN*} = \frac{1}{3} + \frac{c}{6\tau} + \frac{(27-20\delta)k_A^{FN*}}{3(27-11\delta)}$, and $x_B^{FN*} = \frac{2}{3} - \frac{c}{6\tau} - \frac{(27-2\delta)k_A^{FN*}}{3(27-11\delta)}$.

Furthermore, note that $q_A^{FN*} - q_B^{FN*} = \frac{8\delta\tau(9-2\delta)[(3-\delta)c+\delta\tau]}{\delta(33-249\tau)-81(1-\tau)+34\delta^2\tau} > 0$. Indeed, Firm B has a stronger incentive to expand the first-period demand in order to enlarge its own no-poaching area in the second period. This logic does not

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[8] However, as shown later, the first-period price of Firm A is greater than that of Firm B in equilibrium.

apply to Firm *A* because Firm *A* needs to use the "poaching" price also to its own unidentified consumers.

3.4 Equilibrium policies

In the first stage, each firm chooses F or N. Their binary decisions can be represented as a 2x2 normal form game based on the ensuing equilibrium intertemporal profits. The resulting matrix is represented for convenience.

	F	N
F	π^{FF}, π^{FF}	π^{FN}, π^{NF}
N	π^{NF}, π^{FN}	π^{NN}, π^{NN}

Table 1: the payoff matrix

First, since $\hat{c} \leq \frac{\tau(1-\tau)}{1+3\tau}$ and $\hat{c} \leq \tau$, the relevant parameter constraint is $c \leq \hat{c}$. Given the payoff structure, therefore, in order to characterize the equilibrium policy, we have to compare π^{NF} with π^{FF}, and π^{NN} with π^{FN}, under $c \leq \hat{c}$. First, we consider the case of perfectly foresighted consumers and firms ($\delta = 1$). It is possible to characterize two critical thresholds for variable c, say $c_1(\tau) = \frac{\tau(48+3375\tau+14034\tau^2+7399\tau^3)}{3072+15534\tau+13580\tau^2-3274\tau^3}$ and $c_2(\tau) = \frac{\tau(48+2749\tau)}{3072+3346\tau}$ with $c_1(\tau) > c_2(\tau)$, such that the following holds:

- If $c \in [c_1(\tau), \hat{c}(\tau)]$, NN is the unique equilibrium;
- If $c \in [c_2(\tau), c_1(\tau)]$, both NN and FF are equilibria;
- If $c \in [0, c_2(\tau)]$, FF is the unique equilibrium.

It is then possible to state the following result:

PROPOSITION 1. *For a symmetric discount factor $\delta = 1$ common to firms and buyers, (a) If the reduction in transaction costs due to an account creation is below a threshold, FF is the unique Nash equilibrium; (b) if the cost of account creation is large, NN is more likely to emerge in equilibrium; (c) in an intermediate region the two* *equilibria FF and NN coexist; (d) when FF is the unique equilibrium, it is not a prisoner dilemma.*

Figure 4 illustrates Proposition 1:

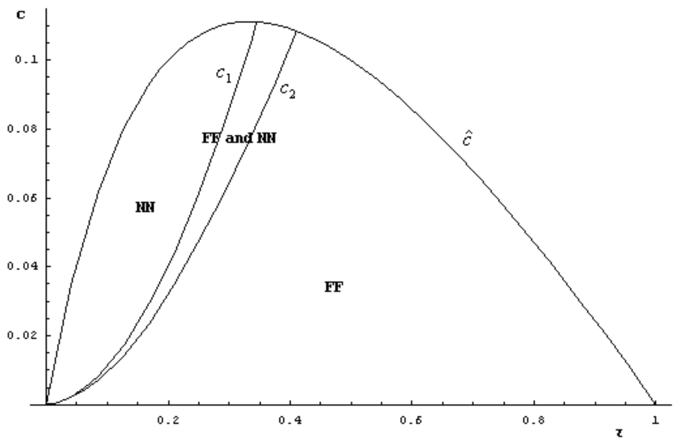

Figure 4: equilibrium policies when $\delta = 1$

Proposition 1 shows that for a preponderant configuration of parameters, firms give the option to buy with or without an account (equilibrium FF). Therefore, it is by no means clear that firms will always try to identify their customers by obliging them to leave their credentials at the firm. It is also interesting to note that even if $c = 0$, not all consumers choose to reveal their identity at the first period– as it is apparent that neither k_A nor $1 - k_B$ vanishes in equations (11) above if $c = 0$.

Considering the impact of τ and c, we can obtain the following observations. When τ increases, the *horizontal* differentiation between the firms increases as well. Suppose that Firm A chooses F. When τ is small (large), Firm A is more (less) likely to apply its poaching price $\tilde{p}_A$ to the rival's consumers because poaching is easier (more difficult). The pricing implies that Firm A is more (less) likely to abandon high profits from the highly profitable consumers located close by Firm A. The low (high) profits from those consumers are less (more) likely to induce Firm A to choose F. Therefore, all else being equal, FF is more likely when τ is large (Figure 1).

The impact of greater c is to enlarge the area of anonymous consumers, from which the firm cannot extract so much surplus. Therefore, the incentive to choose F is weaker when c is large. Also, when c goes up, the incentive to choose N increases because protecting the turf becomes easier (indeed, under strategy N, c is a proxy of vertical differentiation between the firms).[9, 10] Therefore, all else being equal, NN is more likely when c is larger (Figure 1).

Finally, the identification of own customers allows poaching from the rival, which is a "best reply" – when τ is large and/or c is small – against the rival who does not poach; however, as is also well known in the BBPD literature, this ends up being a reciprocal dumping strategy, that goes to the advantage of buyers, and it is detrimental to firms. Hence, leaving the consumers the possibility of remaining anonymous does not generate a prisoner dilemma (Proposition 1, point (d)).

PROPOSITION 2. *For a symmetric discount factor $\delta < 1$, asymmetric account policy equilibria can emerge in addition to the cases in Proposition 1, provided δ is not large enough. As the value for δ is lowered, the parameter area of such equilibria widens; the parameter area of multiple symmetric equilibria shrinks, and then it disappears when δ reaches a threshold value.*

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[9] Indeed, consider the indifferent consumers x_A and x_B. A consumer willing to repeat the purchase from the same firm does not sustain the cost c in the second period; instead, if she wants to shift to the other firm, she opens the account and sustains the cost c. Therefore, the poaching firm is a sort of "low-quality" firm from the consumer's perspective, and c measures the degree of vertical differentiation.

[10] A reinforcing argument is that when c increases, the number of buyers willing to create an account dwindles, and choosing the N strategy is a way to force them to do so, enlarging the "recognized turf" to be protected.

The message of Proposition 2 is that, when consumers and firms partially discount second-period gains, we can observe more diverse identification policies, with firms also choosing asymmetric strategies in equilibrium. So that our model does not necessarily predict a uniform type of selling policy.

We explain the benefit/cost of choosing F (N) to understand the mechanism behind Proposition 2. The benefit (cost) of choosing F (N) is that the firm can (cannot) commit not to poach the rival's customers aggressively inducing a strategic effect on the rival's first-period price because its price for new customers is available not only to those rival's customers but also to its previous customers who remained "anonymous". On the other hand, the cost (benefit) of choosing F (N) is that the firm cannot (can) extract surpluses from unidentified consumers who strongly prefer it to the rival because it cannot offer a price for old customers to those unidentified consumers. The net gain from choosing F emerges in period 1 and that from choosing N does in period 2. Therefore, the net gain from choosing F outperforms that from choosing N if δ is not large. Given that the net gain from choosing F is relatively important if δ is not large, the parameter area of NN is substituted by the area of asymmetric equilibria NF and FN or that of FF if δ is not large.

In what follows, we consider the implications of strategic anonymity compared with a standard uniform pricing framework. It is well known that BBPD reduces firms' profits with respect to the standard Hotelling Nash equilibrium, increasing competition on contended consumers (i.e., those that are poached in equilibrium). Therefore, we have also made a comparison to the standard Hotelling game where no buyer is ever identified: this corresponds to a situation in which both firms voluntarily at the first stage disallow all account creation (or firms allow anonymous transactions only). For simplicity, we consider perfectly foresighted consumers and firms ($\delta = 1$). In this case, the equilibrium profits are simply $\pi^{UU} = 1$. First, we observe that $\pi^{UU} > \pi^{NN}$: this is in line with the standard result in the BBPD literature, where it is shown that behavior-based pricing (with no anonymity), tends to decrease profits with respect to uniform pricing. However, and quite surprisingly, we observe that allowing buyers to choose whether to be identified or not strategically may result in higher profits than under no BBPD, that is $\pi^{FF} > (<)\ \pi^{UU}$ if τ is high (low) and c is low (high). This result is summarized in the next proposition:

PROPOSITION 3. *The standard no-poaching equilibrium profits (uniform pricing) can be dominated by the FF equilibrium, where firms allow consumers the choice to remain anonymous or create an account.*

As mentioned previously, when τ is high, letting consumers choose whether or not to create the account implies that the firm can extract more surplus from the closer consumer by means of the "poaching" price (which, however, in this case, is used not to poach rival's consumers, but rather to extract surplus from closer and anonymous consumers). On the other hand, when c is high, the profits under *FF* are lower. Indeed, in order to exploit the second-period lock-in effect, the firms compete fiercely in the first period, which is detrimental to profits.[11] Therefore, the *FF* equilibrium profits are more likely to outweigh the standard no poaching uniform pricing equilibrium profits when τ is high and c is low. In other words, behavior-based pricing might generate larger profits than uniform pricing when buyers are free to choose whether to remain anonymous or not.[12]

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[11] It can be easily observed that $\frac{\partial \pi^{FF}}{\partial \tau} > 0$ and $\frac{\partial \pi^{FF}}{\partial c} < 0$.

[12] We have not considered the possibility for buyers to delete their account in period 2 after creating it in period 1. Indeed, it is easy to show that this strategy is always dominated by the strategy we considered in the analysis: not creating the account in period 1 and then creating the account in period 2. Consider a consumer buying from Firm A. Under both strategies, she pays $\tilde{p}_A$ in the second period. Under the deleting strategy, the cost of the buyer (net of the price)

4. WELFARE

In this section, we consider welfare implications. Since the market is covered and each consumer purchases one unit of good, prices are irrelevant for welfare (they only redistribute surplus from consumers to firms). Therefore, welfare is given by [13]

$$W^{FF} = 2\{v(1+\delta) - \int_0^{w_A^{FF*}} (x+\delta x)dx - \int_{w_A^{FF*}}^{k_A^{FF*}} \big(x + \delta(c+\tau x)\big)dx \\ - \int_{k_A^{FF*}}^{x_A^{FF*}} (c+\tau x+\delta\tau x)dx - \int_{x_A^{FF*}}^{1/2} \Big(c+\tau x+\delta\big(c+\tau(1-x)\big)\Big)\, dx\} \tag{23}$$

in the case of free choice (FF) and by

$$W^{NN} = 2\{v(1+\delta) - \int_0^{x_A^{NN*}} (c+\tau x+\delta\tau x)dx \\ - \int_{x_A^{NN*}}^{1/2} (c+\tau x+\delta(c+\tau(1-x)))dx\} \tag{24}$$

in the case of no choice (NN). By comparing (23) with (24), we can state the following proposition:

PROPOSITION 4. *Welfare is greater when consumers can decide whether to create an account or not (FF) than when consumers are forced to create an account (NN).*

The explanation of proposition 4 is the following. Welfare depends on three factors:

i) total account creation costs;

ii) unit transportation costs;

iii) number of consumers that switch in the second period.

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is $c + \tau x$ in period 1, and $s + x$ in period 2, where $s > 0$ is the cost of account deletion. In the alternative strategy, the cost of the buyer is x in period 1 and $c + \tau x$ in period 2. Therefore, the latter strategy always outperforms the deletion strategy.

[13] The equilibrium welfare equations are reported in the Appendix.

Regarding total account creation costs (*i*), it is obvious that when some consumers decide not to create the account (case FF), the total account creation costs are lower. On the other hand, forcing all consumers to create the account (case NN) reduces the unit transportation costs – which is τ rather than 1 – for all consumers (*ii*): this benefits welfare. Finally, in case FF, poaching is less effective than in case NN (see the discussion in Section 3). Therefore, in case FF, fewer consumers switch in the second period to patronize the most distant firm (indeed, $x_A^{FF*} > x_A^{NN*}$): this benefits welfare. In sum, as *i*) and *iii*) outweigh *ii*), welfare is greater when consumers are free to choose whether to create an account or not.

5. EXTENSION

In this section, we assume that consumers and firms have different discount factors, δ_c and δ_f, respectively. We replace the discount factor δ in (19) with δ_c and use the profits' functions $\pi_A = q_A k + \delta_f \pi_{A,2}$ and $\pi_B = q_B(1-k) + \delta_f \pi_{B,2}$. Due to the analytical complexity, we adopt numerical simulations,[14] which yield the following result:[15]

PROPOSITION 5. *Suppose $\delta_c = 1$ and $\delta_f < 1$. There is a unique equilibrium where both firms offer a menu choice in terms of account creation (FF) if τ is larger than a threshold value. Suppose $\delta_f = 1$ and $\delta_c < 1$. There is an equilibrium where both firms adopt a no-choice policy that forces buyers to create an account (NN) if $0.1 \leq \delta_c \leq 0.8$, if c is lower than a threshold value c_T for $\delta_c < 0.1$, or if c is higher than the threshold value c_T for $\delta_c > 0.8$; in addition to NN, FF is also sustainable as an equilibrium if τ is larger than a threshold value for each δ_c and c.*

[14] The details of the numerical simulations are available on request.

[15] The threshold value of c, c_T, in Proposition 5 is

$$c_T \equiv \frac{\tau\{3(7+9\delta_c)(-44+18\delta_c+27\delta_c^2)+(924-4718\delta_c+1791\delta_c^2+4023\delta_c^3+729\delta_c^4)\tau\}}{12(7+9\delta_c)^2-(5652-2716\delta_c-6120\delta_c^2+81\delta_c^3-243\delta_c^4)\tau}.$$

Proposition 5 shows that when consumers are perfectly patient ($\delta_c = 1$) and firms are not perfectly patient ($\delta_f < 1$), equilibrium FF becomes more likely (it is the unique equilibrium when δ_f is low). Indeed, as argued in Section 3, the gain from choosing F is prevalent in period 1 and that from choosing N in period 2; hence, when δ_f is low, F is the dominant strategy. At the same time, Proposition 5 shows that when consumers are not perfectly patient ($\delta_c < 1$) and firms are perfectly patient ($\delta_f = 1$), FF ceases to be a unique equilibrium (it might emerge only together with the NN equilibrium). In other words, when the rival chooses N, the best reply always consists in choosing N too. Indeed, when consumers are myopic, the first-period demand elasticity is greater, thus lowering the first-period price. [16] Hence, the second-period profits become more important, boosting the incentive of firms to choose N.

6. CONCLUSIONS

The question addressed in this paper is whether two competing firms will always want to identify their buyers in order to go into behavior-based price discrimination in the second period. As we are in an increasingly sophisticated marketing environment where buyers and sellers behave strategically and are aware of the consequences of the information they release during the transactions, exploring *strategic anonymity* by buyers and sellers is worthwhile. While previous works have considered the possibility of imperfect consumer recognition due to technology imperfections (*exogenous* imperfect consumer recognition), in this paper, we allow firms to give buyers the option to remain anonymous if they so decide or to be recognized, thus endogenizing the degree of consumer recognition imperfectness.

[16] It is well-known (Fudenberg and Tirole, 2000) that the higher the discount factor of consumers, the lower the demand elasticity in the first period because consumers anticipate the poaching strategy of the firms.

Our results indicate that sellers, for a wide range of parameters, will provide buyers with the option to remain anonymous or to buy with an account. When the discount factor is not so large, we also observe multiple asymmetric equilibria, where one firm gives free choice to consumers, whereas the other imposes account creation on its own buyers. The interpretation of this result is twofold. First, it shows that firms can improve upon a rigid account policy that only allows buying with being recognized. Second, it rationalizes the observation that different sellers may use different policies for account creation (as in the Amazon/eBay example discussed in the Introduction). Indirectly, it also shows that (some) buyers, if allowed to conceal their identity, will instead reveal it - provided this allows them to access ancillary services connected with the account opening. We also show that, when allowing consumers to maintain their anonymity, behavior-based pricing might outperform uniform pricing: this contrasts with several findings in the BBPD literature (see Fudenberg and Tirole 2000, and Villas-Boas 1999 and 2004, among the others).

APPENDIX

Equilibrium profits

$$\pi^{FF} = \frac{6c^2\delta[1-(3-2\delta)\tau]^2 - 12c\tau\delta[1-4\tau(1-\delta)+(3-8\delta+4\delta^2)\tau^2] + \tau^2[27(1-\tau)^2+24\delta^2\tau(3-\tau)+56\delta^3\tau^2+24\delta(1+\tau-2\tau^2)]}{6\tau[3-(3-4\delta)\tau]^2}$$

$$\pi^{NN} = \frac{2c\delta(c-2\tau)+(9+8\delta)\tau}{18\tau}$$

$$\pi^{FN} = \frac{\begin{gathered}\tau^2[19683(1-\tau)^2 + 24\tau\delta^4(297-2371\tau) + 5336\tau^2\delta^5 + 1458\delta(1+70\tau-71\tau^2) - 27\delta^2(407-2182\tau-3409\tau^2) + 24\delta^3(121+ \\ -2324\tau+6199\tau^2)] - 12c\tau\delta[2\tau\delta^3(253-3027\tau) + 572\tau^2\delta^4 + 729\delta(1-3\tau+2\tau^2) - 54\delta(11-135\tau+232\tau^2)+ \\ +\delta^2(121-3849\tau+18308\tau^2)] + 6c^2\delta[729(1-5\tau)^2 + 2\delta^3\tau(286-4049\tau) + 640\tau^2\delta^4 - 54\delta(11-218\tau+788\tau^2)+ \\ +\delta^2(121-4990\tau-32293\tau^2)]\end{gathered}}{6\tau[81(1-\tau)-\delta(33-249\tau)-34\tau\delta^2]^2}$$

$$\pi^{NF} = \frac{\begin{array}{c}\tau^2[19683(1-\tau)^2 + 48\tau\delta^4(121-879\tau) + 3008\tau^2\delta^5 + 1458\delta(1+70\tau-71\tau^2) - 27\delta^2(407-2182\tau-3409\tau^2) + 24\delta^3(121+ \\ -2189\tau + 5821\tau^2)] - 12c\tau\delta[2\tau\delta^3(77-585\tau) + 48\tau^2\delta^4 + 729\delta(1-3\tau+2\tau^2) - 54\delta(11-93\tau+136\tau^2) + \\ +\delta^2(121-2061\tau+7124\tau^2)] + 6c^2\delta[729(1-\tau)^2 - 2\delta^3\tau 44 + 17\tau - 20\tau^2\delta^4 - 54\delta(11-32\tau-70\tau^2) + \\ +\delta^2(121-1162\tau+337\tau^2)]\end{array}}{6\tau[81(1-\tau) - \delta(33-249\tau) - 34\tau\delta^2]^2}$$

Proof of Proposition 1 and 2

The conditions for (FF) to be an equilibrium are:

$\pi^{FF} \leq (\geq)\, \pi^{NF}$ if $c \geq (\leq) c_1(\tau,\delta)$

$\pi^{FN} \leq (\geq)\, \pi^{NN}$ if $c \geq (\leq) c_2(\tau,\delta)$

where

$c_1(\tau,\delta) \equiv \frac{\tau\left[2187(1-\tau)^3 - 81(1-\tau)^2(37-253\tau)\delta + \left(858-19665\tau+83412\tau^2-64605\tau^3\right)\delta^2\right]}{H} + \frac{\tau\left[18\tau\left(173-1798\tau+3965\tau^2\right)\delta^3 + 48\tau^2(76-397\tau)\delta^4 + 1384\tau^3\delta^5\right]}{H}$, with

$$\begin{aligned} H \equiv 8748(1-\tau)^3 &- 81(88-939\tau+1758\tau^2-907\tau^3)\delta \\ &+ 3(484-13197\tau+63102\tau^2-58165\tau^3)\delta^2 \\ &+ 2\tau(2655-32954\tau+68963\tau^2)\delta^3 + 8\tau^2(792-4237\tau)\delta^4 \\ &+ 2472\tau^3\delta^5, \end{aligned}$$

$c_2(\tau,\delta) \equiv \frac{\tau[2187(1-\tau) - 81(37-181\tau)\delta + 3(286-3805\tau)\delta^2 + 1690\tau\delta^3]}{8748(1-3\tau) - 81(88-597\tau)\delta + 3(484-7023\tau)\delta^2 + 2302\tau\delta^3}$. [17]

Therefore,

- If $c \in [\max[c_1(\tau,\delta), c_2(\tau,\delta)], \hat{c}(\tau,\delta)]$, NN is the unique equilibrium
- If $c \in [0, \min[c_1(\tau,\delta), c_2(\tau,\delta)]]$, FF is the unique equilibrium
- If $c \in [\max[0, c_1(\tau,\delta)], \min[c_2(\tau,\delta), \hat{c}(\tau,\delta)]$, both FN and NF are equilibria
- If $c \in [\max[0, c_2(\tau,\delta)], \min[c_1(\tau,\delta), \hat{c}(\tau,\delta)]$, both NN and FF are equilibria

Then we observe the following:

[17] Note that when $\delta = 1$, we have $\frac{\partial c_1}{\partial \tau} > 0$ and $\frac{\partial c_2}{\partial \tau} > 0$.

- When δ is high (say greater than 0.95), we have these possibilities: only NN; both NN and FF; only FF. In other words, multiple asymmetric equilibria never arise.
- When δ is intermediate (say about 0.9), we have these possibilities: only NN; both NN and FF; both FN and NF; only FF. In other words, all cases are possible, depending on c and τ.
- When δ is low (say lower than 0.85), we have these possibilities: only NN; both FN and NF; only FF. In other words, multiple symmetric equilibria never arise.

Proof of Proposition 3

By comparing π^{UU} with π^{NN}, π^{UU} with π^{FF}, we observe the following: $\pi^{UU} > \pi^{NN}$ and $\pi^{UU} < (>)\, \pi^{FF}$ if $c < (>)\, c_3(\tau)$ where $c_3(\tau) = \frac{\tau(1+\tau)}{1-\tau} - (1-\tau)(3+\tau)\sqrt{\frac{\tau(6-5\tau)}{6}}$, or if $\tau \geq (\leq)\, \tau_3(c)$, where $\tau_3(c) = c_3(\tau)^{-1}$, and $\pi^{UU} = \pi^{FF}$ if $c = c_3(\tau)$.

Welfare

$$W^{FF} = v(1+\delta) - \frac{4c\tau(1-\tau)[9(1-\tau)^2 + 8\tau\delta^2(1+\tau\delta^2) + 2\delta(1+8\tau-9\tau^2)] - 2c^2\begin{bmatrix}18(1-\tau)^2 + 16\tau^2\delta^3(1+\tau) + 2\tau\delta^2(9-10\tau+\tau^2) + \\ \delta(5-17\tau+51\tau^2-39\tau^3)\end{bmatrix} - \tau[9(1-\tau)^2 + 16\tau^2\delta^3 + 4\tau\delta^2(7-3\tau) + \delta(11+2\tau-13\tau^2)]}{4(1-\tau)[3-(3-4\delta)\tau]^2}$$

$$W^{NN} = v(1+\delta) - \frac{4c\tau(9+2\delta) - 10c^2\delta + \tau^2(9+11\delta)}{72\tau}$$

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