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SELLING CROSS-BORDER IN ONLINE MARKETS: THE IMPACT OF THE BAN ON GEOBLOCKING STRATEGIES

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Selling Cross-Border in Online Markets: The Impact of the Ban on Geoblocking Strategies*

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Abstract

We develop a model of strategic geoblocking, where two competing multi-channel retailers, located in different countries, can decide to block access to their online store from foreign consumers. We characterize the equilibrium when firms decide unilaterally whether to introduce geoblocking restrictions. We show that geoblocking results in a "puppy dog" strategy (Fudenberg and Tirole, 1984) for firms, which allows them to soften competition, but that it comes at the cost of lower demand. In the short term, a ban on geoblocking leads to lower prices, both offline and online. However, in the longer term, when firms can invest in increasing the demand from online shoppers, the ban may have adverse effects on investment and social welfare. We extend our analysis to account for price discrimination and investigate the role of shipping costs.

KEYWORDS: Cross-border sales, Geoblocking, E-commerce, Investment.

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1 Introduction

With the advent of the internet, new online sellers entered the retail markets and started to compete with traditional brick-and-mortar retailers (Brynjolfsson et al., 2009). In a response to this new competition, traditional retailers have invested in online stores alongside their brick-and-mortar stores to extend their sales (Pozzi, 2013). Today, most retailers are *multi-channel*, selling both online and offline. However, for cost saving or strategic reasons, multi-channel retailers sometimes restrict online purchases from consumers in foreign countries, a practice known as *geoblocking*.[1]

The widespread adoption of geoblocking restrictions by retailers has been considered responsible for the low development of cross-border electronic commerce in the European Union (EU, 2016).[2] According to Eurostat, in 2019, where 63% of European consumers purchased goods online, less than one third shopped from an online merchant based in another European country.[3] In a response to this, in December 2018, the European Commission approved a new regulation, banning geoblocking restrictions.[4]

Duch-Brown and Martens (2016) and Duch-Brown et al. (2020) evaluated the ban's potential effect using data on consumer electronics products sold in EU countries from 2012 to 2015. Duch-Brown and Martens (2016) estimate that a ban on geoblocking can generate a 0.7% increase in consumer surplus, mainly due to lower retail prices. Duch-Brown et al. (2020) find more modest gains in consumer surplus and welfare. Those gains accrue mainly to the broader variety of products available to the consumers with more comprehensive market integration, while the effect of the ban on prices is negligible.

Duch-Brown and Martens (2016) and Duch-Brown et al. (2020) compare a situation where European markets are fully segmented (i.e., all retailers are assumed to have implemented geoblocking restrictions) to a situation where they are fully integrated after the ban on geoblocking. However, the European Commission's sector inquiry showed that geoblocking was a *unilateral* business decision of the retailers.[5] In this paper, we investigate whether

[1] A retailer can block customers at different stages of the purchase process. See Cardona (2016) for details.

[2] The sector inquiry on e-commerce conducted by the European Commission (EU, 2016) revealed that 36% of the retailers did not allow cross-border sales. It was also standard practice for some small- and medium-sized retailers: 17% of the retailers with less than a €100,000 turnover had implemented such restrictions.

[3] See `https://ec.europa.eu/eurostat/web/digital-economy-and-society/`.

[4] Regulation (EU) 2018/302 on addressing unjustified geo-blocking and other forms of discrimination based on customers' nationality, place of residence or place of establishment within the internal market.

[5] In a minority of cases, geoblocking restrictions were imposed by manufacturers in the form of vertical restraints, such as dual pricing. See Miklós-Thal and Shaffer (2019) for a theory of price discrimination across resale markets, with an application to dual pricing.

the industry-wide adoption of geoblocking restrictions is likely to arise without coordination between retailers.

Furthermore, these studies focus on the *short-term* impact of the ban. They suggest that a ban on geoblocking can stimulate competition and increase static efficiency. However, some parties raised concerns about the potential *long-term* distortions the ban may entail. For example, UEAPME, the association of crafts and SMEs in Europe, argued that the ban could impede the adoption of e-commerce by SMEs due to the increased competition in online markets.[6] In this paper, we consider the impact of the ban on retailers' efforts in enhancing online demand.

We develop a setting where two retailers, located in different countries, operate a traditional brick-and-mortar channel and an online channel. The retailers can decide to block access to their online store from foreign consumers. They then sell their products to offline and online shoppers, setting uniform prices across channels. We address three sets of questions. First, do geoblocking restrictions lead to higher prices? Second, when will firms adopt geoblocking restrictions? Third, what are the effects of a ban on geoblocking on consumer surplus?

We begin by showing that geoblocking restrictions lead to higher retail prices, both offline and online. When both retailers implement geoblocking restrictions, this is because each acts as a local monopolist in its home market. When one retailer introduces restrictions but not the other, the reason is subtler. The retailer that geoblocks access to its online store commits to be a soft competitor in the online retail market, thus rendering retail competition less intense and driving up prices.

Regarding our second question, we find that two distinct effects determine when a retailer wants to introduce geoblocking restrictions unilaterally: a *demand reduction* effect and a *competition softening* effect. Intuitively, by blocking access to its online store, a retailer loses demand from foreign consumers and therefore, profits. However, geoblocking also represents a "puppy dog" strategy in Fudenberg and Tirole (1984)'s taxonomy. Clearly, opening the online store to foreign consumers makes a retailer appear "tough" in the competition for online shoppers. Since retail prices are strategic complements, the retailer should "underinvest" by geoblocking access to its online store to soften competition. When retailers offer sufficiently differentiated products, the competition softening effect is small relative to the demand reduction effect, in which case retailers do not equally introduce geoblocking restrictions. Conversely, if retailers' products are strong substitutes, the competition softening

[6] See `https://smeunited.eu/`.

effect is the primary determinant of retailers' decisions, and all of them adopt geoblocking restrictions. However, we find that asymmetric equilibria are also possible, where one retailer implements geoblocking restrictions but not the other. We show that prisoner's dilemma cases can also arise where retailers do not introduce geoblocking restrictions, whereas it would be profitable to do so from the industry point of view.

For our third question, we find that a ban leads to (weakly) lower retail prices in the short term, both online and offline, thus increasing consumer surplus. However, the magnitude of the decrease in prices depends on whether all the firms, only some of them, or none of them, would adopt geoblocking restrictions in the absence of a ban. As we have shown, all three situations may arise as an equilibrium outcome. In the longer term, firms can make investments to increase their online demand, for example, through marketing campaigns. We find that when geoblocking is banned, retailers react by reducing their investment in enhancing online demand. Under-investment in the online channel is another "puppy-dog" strategy that retailers can adopt to soften competition in the online retail market. We show through an example that when the reduction of demand-enhancing investment is accounted for, consumer surplus in the long term can be lower with the ban on geoblocking practices.

In our baseline model, we consider that retailers charge uniform prices across their offline and online channels. This assumption is in line with the empirical evidence provided by Cavallo (2017), who shows that most multi-channel retailers charge the same price in their online and offline stores.[7]

We investigate the robustness of our analysis when firms can charge different prices in their offline and online stores. We find that our main results carry through. When firms sell differentiated products, the demand reduction effect is the main driving force for retailers, and they do not introduce geoblocking restrictions. Conversely, when products are strong substitutes, the magnitude of the competition softening effect is high, and retailers all block access to their online store from foreign shoppers.

As an extension, we also consider delivery costs for online purchases. We find that when firms can decide how much of these costs to pass through to their consumers in the shipping fee, they can implement a third-degree price discrimination scheme, charging different total

[7] Cavallo (2017) analyzes data from 56 large multi-channel retailers from 10 countries and finds that their online and offline prices are identical 72 percent of the time. When they are different, the difference tends to be very small: in his full dataset, the average online price difference is 1 percent in absolute terms. DellaVigna and Gentzkow (2019) document that uniform pricing is also a widespread practice of retail chains. They find that most US retail chains charge nearly uniform prices across stores, despite variations in consumer demographics or competition levels. They argue that those sub-optimal uniform prices might be the result of managerial inertia or brand-image concerns.

prices to online and offline customers. In particular, this occurs when firms' products are sufficiently differentiated. However, when products are strong substitutes, retailers offer free-shipping to online customers and implement non-discriminatory prices, as in the baseline model.

To sum up, we show that an industry-wide adoption of geoblocking restrictions may not always arise when retailers make unilateral decisions. Our results suggest that the evaluation of the impact of the ban on geoblocking should account for the degree of differentiation in the relevant markets, this practice being less likely to be adopted in markets with strong differentiation. Furthermore, our findings highlight a possible countervailing effect of the ban in the long term, with multi-channel retailers having the incentive to slow down their online development in response to the ban.

Related literature. Our paper contributes to the literature that explores the competition between online and offline retailers.[8] To the best of our knowledge, the literature has not investigated multi-channel retailers' incentives to block cross-border (online) sales, which represents our main contribution in this paper.

The existing literature has addressed a broad set of interesting questions, ranging from the strategic response of a traditional retailer facing the threat of entry of an online competitor (Liu et al. (2006), Dinlersoz and Pereira (2007)) to the competition between pure traditional brick-and-mortar retailers and purely online retailers (Loginova (2009), Guo and Lai (2017)). The closest paper to ours is Baye and Morgan (2001). The authors develop a model where traditional retailers are local monopolists in their home market and can decide to enter the online market via a marketplace (the 'gatekeeper'), charging uniform prices across channels. Baye and Morgan (2001) study the marketplace's pricing strategy vis-a-vis local firms and consumers, as well as retailers' pricing strategy. However, in our setting, multi-channel retailers operate an online store and do not need access to an intermediary to sell to online shoppers.

We also contribute to the literature that investigates why firms partition prices. The literature has rationalized partitioned pricing in models with rational consumers (e.g., Ellison (2005)) and with consumers suffering from behavioral biases (e.g., Gabaix and Laibson (2006)). In our setting, we address why firms partition prices while considering rational consumers who can anticipate their purchase's total price when retailers charge a base price for the product and a shipping fee for online delivery. It has been shown that with rational

[8]See Lieber and Syverson (2012) for a comprehensive review of the literature on online versus offline competition.

consumers, retailers may use shipping costs to discriminate between online customers (see, Li and Dinlersoz (2012)). In our setting, we find that shipping fees also allow retailers to price discriminate between online and offline shoppers. A more novel result is that when retailers' products are strong substitutes, competition for online shoppers is intense, which leads firms to offer free-shipping to online consumers. Thus, our model provides another explanation for free-shipping, which is discussed in the literature, but merely seen as a promotional strategy to stimulate sales (Lewis et al. (2006), Frischmann et al. (2012), and Chaoqun and Ngwe (2020)).

The rest of the paper is organized as follows. We set up the model in Section 2. We then study the impact of geoblocking restrictions on prices in Section 3. In Section 4, we determine when geoblocking restrictions are adopted by retailers. In Section 5, we allow firms to invest in the demand for the online channel. In Section 6, we consider price discrimination between the offline and online channels and introduce delivery costs and shipping fees. In Section 7, we conclude.

2 The model

There are two countries, A and B, and two firms, a and b, based in markets A and B, respectively, selling differentiated products. We refer to market A as the home market for firm a, and to market B as its foreign market (and reciprocally for firm b).

Each firm has two sales channels: an offline sales channel, with brick-and-mortar shops, and an online sales channel through an online store. In line with empirical evidence (see, e.g., Cavallo (2017), and our discussion in the introduction), we assume that firms set uniform prices across their two channels.[9] Furthermore, we assume that marginal costs are the same in the two channels, and normalize them to zero. For the moment, we assume away any shipping costs for the online shops.[10]

In each market, there is a mass of offline shoppers who can only buy from the brick-and-mortar stores of the firm based in this market, and a mass of online shoppers who can only buy online from either of the online stores.[11] However, a firm can implement geoblocking restrictions for access to its online store, which means that the online shoppers from the

[9] In Section 6.1, we study the case where firms can price discriminate between their offline and online channels.

[10] We introduce shipping costs for online sales in Section 6.2, and study how much of the shipping costs firms wish to pass through to their customers.

[11] Duch-Brown et al. (2020) provide empirical evidence that consumers have a strong preference for one channel, online or offline, which is consistent with our assumption of two consumer groups.

other market cannot buy from its online store. We denote by ϕ_i and η_i the mass of offline and online shoppers, respectively, that firm $i = a, b$ can address in its home market, and by η_j, with $j \neq i$, the mass of online shoppers it can reach in the foreign market in the absence of geoblocking restrictions.

We assume that the monopoly and duopoly demands are the same in the two countries. We denote by $D^m(p_i)$ the downward-sloping monopoly demand for firm $i \in \{a, b\}$ for a given price p_i, where the superscript m stands for monopoly, and by $D_i^d(p_i, p_j)$ and $D_j^d(p_j, p_i)$ the duopoly demands for firms i and j, respectively, for given prices p_i and p_j, where the superscript d stands for duopoly. As usual, we assume that a firm's demand is decreasing in its own price and increasing in its rival's price: $\partial D_i^d / \partial p_i \leq 0$ and $\partial D_i^d / \partial p_j \geq 0$. We also assume that the duopoly demands are symmetric: $D_i^d(p_i, p_j) = D_j^d(p_i, p_j)$.

Finally, we assume that the monopoly and duopoly profit functions, $\pi_i^m(p_i) \equiv p_i D^m(p_i)$ and $\pi_i^d(p_i, p_j) \equiv p_i D_i^d(p_i, p_j)$, are concave in p_i, and that prices are strategic complements: $\partial^2 \pi_i^d / \partial p_i p_j > 0$.

Timing. We study the following two-stage game. In stage one, firms decide whether to implement geoblocking restrictions for access to their online store. Then, in stage two, they set uniform prices. We look for the subgame-perfect equilibrium of this game.

If there is a ban on geoblocking, firms cannot geoblock and stage two follows, where firms set their uniform prices. In Section 5, we will introduce an initial stage where firms can invest to increase the number of potential online shoppers in their home market.

3 Impact of geoblocking on prices

We start by studying firms' pricing decisions at stage two. Three possible subgames can arise, depending on the decisions of the firms at stage one: (i) both firms geoblock, (ii) none of them does, and finally, (iii) the mixed cases, where one firm geoblocks but not the other.

If both firms geoblock access to their online store, each firm is a monopolist in its home market. Firm i has a monopoly demand $\phi_i D^m(p_i)$ from offline shoppers and $\eta_i D^m(p_i)$ from online shoppers of its home market. Its profit is then given by $\Pi_i(p_i) = (\phi_i + \eta_i) p_i D^m(p_i)$, which is maximized at the monopoly price p^m. Therefore, in equilibrium each firm sets the monopoly price $p_i^{gg} = p^m$ for its offline and online sales channels, and makes the monopoly profit $\Pi_i^{gg} = (\phi_i + \eta_i) p^m D^m(p^m)$.

If neither firm geoblocks, online shoppers in each market can buy from the two firms.

Firm i has a monopoly demand $\phi_i D^m(p_i)$ from its offline shoppers, a duopoly demand $\eta_i D_i^d(p_i, p_j)$ from online shoppers in its home market, and a duopoly demand $\eta_j D_i^d(p_i, p_j)$ from online shoppers in the foreign market. Therefore, firm i's profit is given by

$$\Pi_i(p_i, p_j) = \phi_i p_i D^m(p_i) + (\eta_i + \eta_j) p_i D_i^d(p_i, p_j). \tag{1}$$

The first-order condition from the maximization of (1) is:

$$\phi_i \left(D^m(p_i) + p_i \frac{\partial D^m(p_i)}{\partial p_i} \right) + (\eta_i + \eta_j) \left(D_i^d(p_i, p_j) + p_i \frac{\partial D_i^d(p_i, p_j)}{\partial p_i} \right) = 0. \tag{2}$$

We assume that the duopoly pricing game, where each firm i maximizes the duopoly profit $p_i D_i^d(p_i, p_j)$, has a unique symmetric equilibrium; we denote by p^d the duopoly price.

Lemma 1. *If no firm geoblocks, in equilibrium each firm $i \in \{a, b\}$ sets the price p_i^{nn}, with $p^d < p_i^{nn} < p^m$. The equilibrium price p_i^{nn} is increasing in firm i's share of offline shoppers $\phi_i/(\phi_i + \eta_i + \eta_j)$, and decreasing in its share of online shoppers $(\eta_i + \eta_j)/(\phi_i + \eta_i + \eta_j)$.*

Proof. See Appendix A1. □

When they do not geoblock, firms have captive offline shoppers but compete for online shoppers in the two countries. Since they charge uniform prices, they trade off between setting a high price to exploit their captive offline customers and a low price to attract online shoppers. Therefore, competition is more intense than when the two firms geoblock, which leads to lower prices. A higher share of offline shoppers (resp., online shoppers) drives prices up (resp., down) because it makes the competition less (resp., more) intense.

Finally, there is the possibility of mixed regimes where one firm geoblocks, but not the other. Assume that firm i geoblocks access to its online store, but not firm $j \neq i$. This means that online shoppers in firm j's home country cannot buy from firm i's online store, whereas online shoppers in firm i's home country can buy from firm j's online store. Firm i's profit is then given by

$$\Pi_i(p_i, p_j) = \phi_i p_i D^m(p_i) + \eta_i p_i D_i^d(p_i, p_j), \tag{3}$$

whereas firm j's profit is

$$\Pi_j(p_j, p_i) = (\phi_j + \eta_j) p_j D^m(p_j) + \eta_i p_j D_j^d(p_j, p_i). \tag{4}$$

The first-order conditions that characterize firm i and firm j's equilibrium prices are

$$\frac{\partial \Pi_i(p_i,p_j)}{\partial p_i} = \phi_i \left(D^m(p_i) + p_i \frac{\partial D^m(p_i)}{\partial p_i} \right) + \eta_i \left(D_i^d(p_i,p_j) + p_i \frac{\partial D_i^d(p_i,p_j)}{\partial p_i} \right) = 0, \quad (5)$$

and

$$\frac{\partial \Pi_j(p_j,p_i)}{\partial p_j} = (\phi_j + \eta_j) \left(D^m(p_j) + p_j \frac{\partial D^m(p_j)}{\partial p_j} \right) + \eta_i \left(D_j^d(p_j,p_i) + p_j \frac{\partial D_j^d(p_j,p_i)}{\partial p_j} \right) = 0, \quad (6)$$

respectively. Comparing (5) and (6), one can see that the second term is the same, while the first term is different if $\phi_i \neq \phi_j + \eta_j$. Thus, firm i and firm j may have different pricing incentives, depending on their relative shares of captive customers.

Lemma 2. *If firm i geoblocks but not firm j, in equilibrium firms i and j set the prices p_i^{gn} and p_j^{gn}, respectively, with $p^d < p_l^{gn} < p^m$ for $l = i, j$. Firm i charges a lower price than firm j (i.e., $p_i^{gn} < p_j^{gn}$) if $\phi_i < \phi_j + \eta_j$.*

Proof. See Appendix A2. □

For example, assume that there is the same mass of offline shoppers in the two countries, i.e., $\phi_a = \phi_b$. Then, the lemma implies that the firm that does not geoblock is a softer competitor than the firm that geoblocks. This is because, the firm that does not geoblock has a monopoly over its offline and online shoppers, which makes it soft in the competition for online shoppers in the foreign market. This softening effect will play an important role when we study the incentives to geoblock in the next section.

Effect of geoblocking on prices

Comparing equilibrium prices across the different cases, we are now able to characterize the impact of geoblocking on prices.

Proposition 1. *Relative to the case where firms do not geoblock, geoblocking by one firm or both of them leads to higher equilibrium prices (i.e., $p_i^{gg} > p_i^{nn}$ and $p_i^{gn} > p_i^{nn}$, for $i = a, b$). Prices are higher if both firms geoblock than in the mixed case where one firm geoblocks but not the other (i.e., $p_i^{gg} > p_i^{gn}$, for $i = a, b$).*

Proof. See Appendix A3. □

Geoblocking leads to higher prices. When all firms geoblock, this is because each firm acts as a monopoly over its offline and online consumers. In the mixed regime, the effect of geoblocking is more subtle: geoblocking by one firm makes the rival firm, which does not geoblock, less aggressive in the competition for online shoppers, which drives prices up due to the strategic complementarity of prices.

The short-run impact on prices of a ban on geoblocking is then as follows:

Corollary 1 (Short-run impact of the ban on geoblocking)**.** *When the potential demand for offline and online sales channels is given, a ban on geoblocking leads to lower prices, both offline and online.*

Two remarks are in order. First, a ban on geoblocking leads to lower prices online, but offline consumers also benefit from lower prices, because firms set uniform prices across channels. Second, the magnitude of the price decrease depends on the nature of the equilibrium in the counterfactual situation without the ban. In particular, the reduction in prices will be smaller if the counterfactual involves a mixed regime where only one firm geoblocks, compared to a regime where all of them geoblock.

Therefore, to fully assess the impact of the ban on prices, we have to study firms' incentives to adopt geoblocking restrictions and characterize the equilibrium of the geoblocking game.

4 Adoption of geoblocking restrictions

We now proceed with the analysis of the first stage of the game where each firm can decide to geoblock access to its online store.

To characterize the possible equilibria, we begin by studying the conditions under which in equilibrium either no firm or both of them adopt geoblocking restrictions. For this to be true, it must be that no firm wants to deviate unilaterally to the mixed regime where only one firm geoblocks.

Consider first the case where no firm geoblocks. This is an equilibrium if none of the firms wants to deviate by adopting geoblocking restrictions unilaterally. In other words, for the deviating firm, say firm i, it must be that $\Pi_i^{gn} \leq \Pi_i^{nn}$, that is:

$$\left(\phi_i p_i^{gn} D^m(p_i^{gn}) + \eta_i p_i^{gn} D_i^d(\mathbf{p}^{gn})\right) - \left(\phi_i p_i^{nn} D^m(p_i^{nn}) + \eta_i p_i^{nn} D_i^d(\mathbf{p}^{nn})\right) - \eta_j p_i^{nn} D_i^d(\mathbf{p}^{nn}) \leq 0, \quad (7)$$

where $\mathbf{p}^{nn} = (p_i^{nn}, p_j^{nn})$ and $\mathbf{p}^{gn} = (p_i^{gn}, p_j^{gn})$ denote the vector of equilibrium prices in the no-geoblocking and mixed regimes, respectively.

The difference between the first two terms in (7) is always positive[12] and represents a (strategic) competition softening effect. Through geoblocking, firm i commits not to compete for firm j's online shoppers, which leads to higher prices ($p_i^{gn} > p_i^{nn}$ and $p_j^{gn} > p_j^{nn}$), and then, higher profits. Geoblocking corresponds here to a "puppy dog" strategy (Fudenberg and Tirole, 1984). Opening its online channel to foreign shoppers makes firm i "tough". Since prices are strategic complements, firm i should, therefore, underinvest by geoblocking its online channel to avoid an agressive price reaction of its rival. The last term on the left-hand side of the inequality (7) represents a (direct) demand reduction effect. By geoblocking, firm i loses demand, and hence profits, from online shoppers in the foreign market. Therefore, the case where no firm geoblocks is an equilibrium if and only if the demand reduction effect dominates the competition softening effect.

While firm i faces a trade-off, firm j always benefits when firm i deviates and implements geoblocking restrictions, as

$$\begin{aligned}\Pi_j^{gn} - \Pi_j^{nn} = & \left[(\phi_j + \eta_j)\, p_j^{gn} D^m(p_j^{gn}) + \eta_i p_j^{gn} D_j^d(\mathbf{p}^{gn}) - \left((\phi_j + \eta_j) p_j^{nn} D^m(p_j^{nn}) + \eta_i p_j^{nn} D_j^d(\mathbf{p}^{nn})\right)\right] \\ & + \eta_j p_j^{gn} \left[D^m(p_j^{gn}) - D_j^d(p_j^{gn}, p_i^{gn})\right] \geq 0,\end{aligned}$$

where the inequality follows from the fact that the two terms into brackets are positive.[13] Firm j benefits in two ways from firm i's deviation: (i) it leads to higher prices; (ii) firm j moves from a duopoly to a monopoly situation over online shoppers in its home market (hence, its demand from these consumers increases).

Consider now the case where both firms geoblock. This is an equilibrium if none of the firms wants to deviate by removing geoblocking restrictions unilaterally. Firm j has no incentive to deviate if $\Pi_j^{gn} \leq \Pi_j^{gg}$, that is,

$$(\phi_j + \eta_j)\left(p_j^{gn} D^m(p_j^{gn}) - p^m D^m(p^m)\right) + \eta_i p_j^{gn} D_j^d(\mathbf{p}^{gn}) \leq 0. \tag{8}$$

In a similar way as above, firm j faces a trade-off between a competition strengthening effect and a demand expansion effect. The first term represents the (strategic) competition strengthening effect: by removing geoblocking restrictions, firm j commits to compete for its rival's online shoppers, which leads to lower prices ($p_j^{gn} < p_i^{gg}$), and thus, lower profits

[12] See Appendix B for details.
[13] See Appendix B.

from captive shoppers in the home country. The second term represents a (direct) demand expansion effect: by removing geoblocking restrictions, firm j attracts demand from online shoppers in the foreign market. Thus, the case where both firms geoblock is an equilibrium if and only if the competition strengthening effect dominates the demand expansion effect.

Note that firm i is always hurt when firm j deviates by removing geoblocking restrictions, since

$$\Pi_i^{gn} - \Pi_i^{gg} = \phi_i \left(p_i^{gn} D^m(p_i^{gn}) - p^m D^m(p^m)\right) + \eta_i \left(p_i^{gn} D_i^d(\mathbf{p}^{gn}) - p^m D^m(p^m)\right) \leq 0.$$

This is because, firm i is harmed by the competition strengthening effect but does not benefit from the demand expansion effect. Given this asymmetry between the two firms in the gains from deviations, there is the possibility of a prisoners' dilemma, which we will explore below.

We can now characterize the possible equilibria of the game:

Proposition 2. *The equilibrium outcome is as follows:*

(i) if the demand reduction effect dominates the competition softening effect, i.e., (7) *holds, there is an equilibrium where no firm geoblocks;*

(ii) if the competition strengthening effect dominates the demand expansion effect, i.e., (8) *holds, there is an equilibrium where both firms geoblock;*

(iii) if neither of these conditions hold, there are only asymmetric equilibria where one firm geoblocks but not the other.

An illustrative example

An important determinant of the equilibrium outcome is the degree of differentiation between firms. Suppose that the duopoly demand is given by[14]

$$D_i^d(p_i, p_j) = \frac{1}{2}\left(1 - (1+\gamma)p_i + \frac{\gamma}{2}(p_i + p_j)\right), \tag{9}$$

where $\gamma \geq 0$ represents the degree of substitutability between goods. A higher γ implies more substitution, with $\gamma = 0$ implying demand independence, and $\gamma \to \infty$ perfect substitutes. This demand function is particularly suited for our purpose, as the aggregate demand

[14]This demand function is derived from the maximization of a representative consumer's utility with the quasi-linear preferences: $U = q_0 + q_i + q_j - \frac{1}{1+\gamma}\left(q_i^2 + q_j^2 + \frac{\gamma}{2}(q_i + q_j)^2\right)$, where q_0 represents the consumption of the numeraire and q_k is the consumption of good $k \in \{a, b\}$. See Shubik and Levitan (1999).

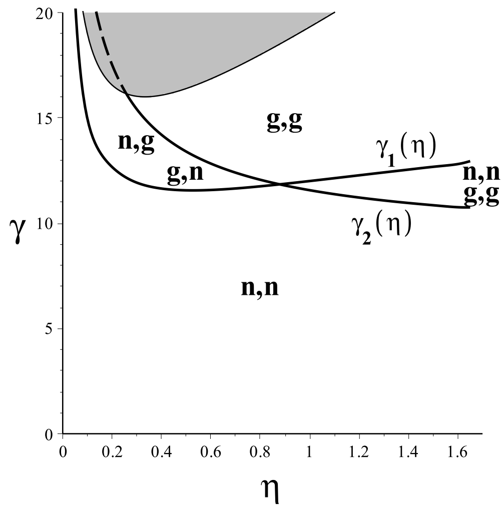

Figure 1: Equilibrium of the game.

depends neither on the degree of substitution, nor on the number of active firms. Therefore, the size of the market is not affected by firms' geoblocking decisions. The monopoly demand function is $D^m(p_i) = 1 - p_i$. For the sake of simplicity, we assume that the mass of offline and online customers are the same in the two countries, and we denote them by ϕ and η, respectively. We normalize $\phi = 1$.

Figure 1 represents the Nash equilibria in the (η, γ) space, with (g, g), (n, n) and (g, n)-(n, g) designating the equilibria where both firms geoblock, none geoblocks, and only one firm geoblocks, respectively.[15] If $\gamma < \min\{\gamma_1(\eta), \gamma_2(\eta)\}$, no firm adopts geoblocking restrictions (part (i) of Proposition 2). By contrast, if $\gamma > \max\{\gamma_1(\eta), \gamma_2(\eta)\}$, both firms adopt geoblocking (part (ii) of Proposition 2). Finally, for intermediate values of γ, there are multiple equilibria. If η is low and $\gamma \in (\gamma_1(\eta), \gamma_2(\eta))$, there are two asymmetric equilibria where only one firm geoblocks (part (iii) of Proposition 2). If η is high and $\gamma \in (\gamma_2(\eta), \gamma_1(\eta))$, there are two symmetric equilibria, where either no firm geoblocks or both of them do.

This example highlights the impact of differentiation between firms on market outcomes. When the firms' products are strongly differentiated (i.e., γ is small), the competition softening effect is small relative to the demand reduction effect. Therefore, no firm geoblocks, regardless of the mass of online shoppers η. On the contrary, when products are strong substitutes (i.e., γ is large), online competition is intense. In this case, firms have a strong incentive to introduce geoblocking restrictions to soften competition. No firm has an in-

[15]The formal details of the illustrative model are provided in Appendix C1. The grey area in the top-left part of Figure 1 indicates the values of η and γ for which the equilibrium is not robust to large price deviations and, therefore, that we exclude from the analysis.

centive to deviate from the equilibrium where both of them geoblock, as the competition strengthening effect is substantial and it dominates the demand expansion effect.

Finally, it is interesting to notice that $\Pi_i^{nn} < \Pi_i^{gg}$, for any η and γ. Therefore, when the equilibrium is (n, n), the game is a prisoners' dilemma: firms do not geoblock in equilibrium despite the fact that they would be both better off if they all adopted geoblocking restrictions.

5 Development of online channel

So far, we have assumed that the mass of offline and online consumers was exogenous. However, firms may invest in expanding the sales from their online channel, for example, by running marketing campaigns to stimulate online demand. In this section, we consider such demand-enhancing investment.[16]

We first focus on the symmetric configurations where either both firms geoblock or none of them does. We take these configurations as given and study the following game. In stage one, each firm $i = a, b$ decides on a level of investment to increase the mass of online consumers in its home market. Then, in stage two, firms set uniform prices. To simplify the exposition, we assume that there is the same mass of offline shoppers, ϕ, in both markets. We assume furthermore that it costs $C(\eta_i)$ to firm i to attract a mass η_i of online shoppers in its home market, with $C' > 0$ and $C'' > 0$. Below, we use our illustrative model to study the full game where firms first decide whether to implement geoblocking restrictions before playing the investment-pricing game.

Consider first the case where both firms geoblock. At stage two, firms set the monopoly price p^m for their offline and online sales channels, as shown in Section 3. Moving backward, at stage one, each firm i decides on a level of investment η_i to maximize its profit,

$$\Pi_i^{gg}(\eta_i) = (\phi + \eta_i)p^m D^m(p^m) - C(\eta_i).$$

The equilibrium level of investment is given by the first-order condition,

$$p^m D^m(p^m) - C'(\eta_i) = 0. \tag{10}$$

Since the equilibrium price is independent of the mass of offline and online consumers,

[16] This investment may have the effect of stimulating online demand at the expense of offline demand. However, empirical evidence suggests that the market expansion effect of e-commerce dominates the cannibalization effect (see, e.g., Pozzi (2013) and Duch-Brown et al. (2017)). We adopt a reduced-form approach with only a (net) market-expansion effect.

firm i decides on an investment that equates the marginal revenue from increasing the mass of online shoppers (the per-capita monopoly profit, $p^m D^m(p^m)$) and the marginal investment cost. Therefore, firms' incentives to expand online demand in their home market are only driven by a demand expansion effect.

Consider now the other case, where no firm geoblocks. At stage two, firms set symmetric prices, $p^{nn}(\eta_i + \eta_j)$ (see Section 3). Moving backward, at stage one each firm i decides on a level of investment η_i to maximize its profit,

$$\Pi_i^{nn}(\eta_i, \eta_j) = \phi p^{nn} D^m(p^{nn}) + (\eta_i + \eta_j) p^{nn} D_i^d(p^{nn}, p^{nn}) - C(\eta_i).$$

Through its investment η_i, firm i stimulates its demand from online shoppers in its home market, but also the online demand of the rival firm j in the same market. Reciprocally, firm i benefits from firm j's demand-enhancing investment η_j in the foreign market.

Using the envelope theorem, the equilibrium level of investment for firm i is given by the first-order condition,

$$\frac{\partial \Pi_i^{nn}(\eta_i, \eta_j)}{\partial \eta_i} = \frac{\partial \Pi_i}{\partial \eta_i} + \frac{\partial \Pi_i}{\partial p_j}\frac{\partial p^{nn}}{\partial \eta_i} - C'(\eta_i),$$

which can be rewritten as

$$\underbrace{p^{nn} D_i^d(p^{nn}, p^{nn})}_{\text{direct effect (+)}} + \underbrace{(\eta_i + \eta_j) p^{nn} D_i^d(p^{nn}, p^{nn}) \frac{\partial p^{nn}}{\partial \eta_i}}_{\text{strategic effect (-)}} - C'(\eta_i) = 0. \tag{11}$$

The first term corresponds to the demand expansion effect discussed above, and it is positive. The second term represents a strategic effect, which is negative, as $\partial p^{nn}/\partial \eta_i \leq 0$.[17] By stimulating online demand in its home market, firm i makes itself "tougher," which triggers an aggressive reaction of its rival at the pricing stage. Therefore, firm i has an incentive to reduce its demand-enhancing investment to soften competition (another "puppy dog" strategy).

Effect of geoblocking on investment in online channel

Comparing the first-order conditions (10) and (11) with and without geoblocking restrictions, we obtain the following result on the impact of geoblocking on investment in enhancing online

[17]From the implicit function theorem, $\partial p^{nn}/\partial \eta_i$ has the sign of the derivative of the first-order condition that characterizes firm i's price with respect to η_i, and hence, it has the sign of the duopoly marginal revenue at the optimal price, which is negative.

demand.

Proposition 3. *When firms can invest to increase the potential online demand in their home market, investment is higher when both firms have adopted geoblocking restrictions than when none of them has.*

Proof. The direct effect of investment is higher with geoblocking, because firms can set higher prices and earn higher profits from online sales. In addition, when firms do not geoblock, there is a negative strategic effect, due to the strengthening of competition, which is absent under the geoblocking regime. Thus, investment is unambiguously higher under geoblocking. □

We can now characterize the long-run impact of the ban on geoblocking on investment.

Corollary 2 (Long-run impact of the ban on geoblocking)**.** *When firms can invest to increase the potential online demand in their home market, a ban on geoblocking leads to lower investment.*

As we have seen, geoblocking represents a "puppy dog" strategy for firms to soften competition in online markets. When a ban on geoblocking is enforced, firms may react by employing another "puppy dog" strategy: they can under-invest in enhancing online demand, as a way to make their rival a softer competitor.

Therefore, from a policy perspective, a ban on geoblocking may involve a trade-off between the short-run benefits accruing from lower prices and the long-term harm due to the lower development of online demand. We analyze this trade-off with our illustrative model.

Illustrative example

We extend our illustrative model of Section 4 to incorporate demand-enhancing investment in the online channel. We assume that the investment cost is quadratic, $C(\eta_i) = \eta_i^2/h$, where $h > 0$ represents the productivity of the investment. We normalize the mass of offline shoppers in each market, ϕ, to 1.

We study the following three-stage game. First, firms decide whether to adopt geoblocking restrictions. Second, they decide on their level of investment. Third, and finally, they set uniform prices. In Appendix C2, we solve for the subgame-perfect equilibrium of this game.

Figure 2 shows the equilibrium outcome as a function of the productivity of investment h and the degree of substitutability γ. The two solid lines separate the three possible equilibrium regions. When γ is sufficiently small ($\gamma < \gamma_1(h)$), firms do not geoblock. When

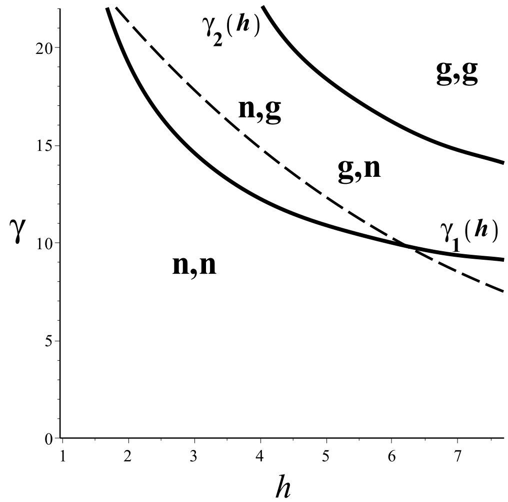

Figure 2: Equilibrium when firms invest in enhancing online demand.

$\gamma > \gamma_2(h)$, both firms geoblock. Finally, when γ takes intermediate values, the mixed regime emerges in equilibrium, with one firm geoblocking and not the other. Figure 2 also shows that the more productive the investment made by the firms is (i.e., the higher h), the more likely they are to geoblock. When the investment cost is low (h is high), firms invest heavily in developing online demand in their home market, which intensifies price competition and, consequently, increases firms' incentives to implement geoblocking restrictions.

To evaluate the long-run welfare effect of a ban on geoblocking, we focus on the case where both firms would geoblock access to their online stores in the absence of a ban, which corresponds the top-right region in Figure 2. We compare the consumer surplus in the two countries when both firms adopt geoblocking restrictions and when none of them does.

When both firms geoblock, each firm is a monopolist over the online and offline customers of its home country. In this case, the consumer surplus in country $i \in \{A, B\}$ is

$$CS_i^{gg} = (1 + \eta_i)\,\frac{(1 - p_i)^2}{2}. \tag{12}$$

When no firm geoblocks, the consumer surplus in country i is given by[18]

$$CS_i^{nn} = \frac{(1 - p_i)^2}{2} + \frac{\eta_i}{2}\left(1 + \frac{\gamma + 2}{4}\,\left(p_i^2 + p_j^2\right) - \frac{\gamma}{2}\,p_i\,p_j - p_i - p_j\right). \tag{13}$$

[18]The second term in (13) is the total surplus enjoyed by online consumers in country i. This surplus amounts to $\eta_i\,(U(q_i, q_j) - p_i q_i - p_j q_j)$, where the utility function $U(q_i, q_j)$ is defined in footnote 14 above.

Plugging in the equilibrium prices and investments in the (g,g) and (n,n) subgames, we obtain the consumer surplus in the two scenarios. The dashed line in Figure 2 represents the locus of the points in the (h,γ) plane for which $CS^{gg} = CS^{nn}$. Above the dashed line, we have $CS^{gg} > CS^{nn}$, and below the dashed line, $CS^{gg} < CS^{nn}$. As the dashed line lies below $\gamma_2(h)$, we obtain the result that whenever (g,g) is the equilibrium, a ban on geoblocking reduces consumer surplus.

6 Price discrimination and shipping costs

Empirical evidence shows that uniform pricing across offline and online channels is the rule. However, one could argue that there are indirect ways for firms to price discriminate, for example, through coupons or discounts. When they charge shipping costs for purchases made on their online store, firms may also have some pricing flexibility.

We first discuss the impact of third-degree price discrimination between the offline and online channels on firms' incentives to adopt geoblocking restrictions. Then, we introduce delivery costs into our baseline model and study firms' pass-through of these costs to the consumers.

6.1 Price discrimination between offline and online channels

Assume that firms can implement third-degree price discrimination and set different prices to offline and online shoppers (but cannot price discriminate based on the consumers' country of origin). As in the baseline model, in stage one, firms decide whether to adopt geoblocking restrictions. Then, in stage two, they set prices for their offline and online channels.

We start by determining the equilibrium prices at stage two in the different possible subgames. If both firms geoblock, the analysis is the same as in the baseline model with uniform pricing. Each firm charges the monopoly price p^m for its offline and online shoppers. Firm i's profit is then $\Pi_i^{gg} = (\phi_i + \eta_i)p^m D^m(p^m)$.

If no firm geoblocks, firm i's profit is given by $\Pi_i = \phi_i p_i^\phi D^m(p_i^\phi) + (\eta_i + \eta_j) p_i^\eta D_i^d(p_i^\eta, p_j^\eta)$, where p_i^ϕ and p_i^η are the prices charged by firm i for its offline and online channels, respectively, and p_j^η is the price charged by firm j for its online channel. In equilibrium, firms charge the monopoly price $p_i^\phi = p_j^\phi = p^m$ to offline shoppers and the duopoly price $p_i^\eta = p_j^\eta = p^d$ to online shoppers. Firm i's equilibrium profit is $\Pi_i^{nn} = \phi_i p^m D^m(p^m) + (\eta_i + \eta_j) p^d D_i^d(p^d, p^d)$.

Finally, consider the mixed case where firm i geoblocks, but not firm j. Firm i's profit is given by $\Pi_i = \phi_i p_i^\phi D^m(p_i^\phi) + \eta_i p_i^\eta D_i^d(p_i^\eta, p_j^\eta)$, whereas firm j's profit is given by

$\Pi_j = \phi_j p_j^\phi D^m(p_j^\phi) + \eta_j p_j^\eta D^m(p_j^\eta) + \eta_i p_j^\eta D_j^d(p_j^\eta, p_i^\eta)$. In each market, the equilibrium price for offline shoppers is the monopoly price, i.e., $p_i^\phi = p_j^\phi = p^m$. By contrast, firms compete for the online shoppers in firm i's home market, while firm j has a monopoly over the online shoppers of its home market.

Firm i's best response to a price p_j^η set by firm j for its online store is the duopoly best-response, $p_i^\eta = r_i(p_j^\eta)$, whereas firm j's best response is $p_j^\eta = \arg\max_{p_j} \eta_j p_j D^m(p_j) + \eta_i p_j D_j^d(p_j, p_i^\eta)$. The same arguments than the ones used for Lemma 1 ensure the existence and uniqueness of an equilibrium. In equilibrium, firms i and j charge prices $p_i^{\eta *}$ and $p_j^{\eta *}$, respectively, with $p_l^{\eta *} \in (p^d, p^m)$ for $l = i, j$. Firm i's profit is $\Pi_i^{gn} = \phi_i p^m D^m(p^m) + \eta_i p_i^{\eta *} D_i^d(p_i^{\eta *}, p_j^{\eta *})$, while firm j's profit is $\Pi_j^{gn} = \phi_j p^m D^m(p^m) + \eta_j p_j^{\eta *} D^m(p_j^{\eta *}) + \eta_i p_j^{\eta *} D_j^d(p_j^{\eta *}, p_i^{\eta *})$.

Moving backward, we now turn to stage one of the game where firms decide whether to geoblock access to their online stores. Consider first the case where no firm geoblocks as a candidate equilibrium. It is an equilibrium if each firm i has no incentive to deviate by implementing geoblocking restrictions unilaterally, that is, if:

$$\Pi_i^{gn} - \Pi_i^{nn} = \eta_i \left[p_i^{\eta *} D_i^d(p_i^{\eta *}, p_j^{\eta *}) - p^d D_i^d(p^d, p^d) \right] - \eta_j p^d D_i^d(p^d, p^d) \leq 0. \tag{14}$$

The first term represents the competition softening effect, which is positive since $p_i^{\eta *} \in (p^d, p^m)$, whereas the second term represents the demand reduction effect. Thus, the case where no firm geoblocks is an equilibrium if and only if the demand reduction effect dominates the competition softening effect.

Consider now the case where both firms geoblock. This is an equilibrium if none of the firms wants to deviate by removing geoblocking restrictions unilaterally. Therefore, for, let's say, firm j, the gain from this deviation must be negative:

$$\Pi_j^{gn} - \Pi_j^{gg} = \eta_j \left[p_j^{\eta *} D^m(p_j^{\eta *}) - p^m D^m(p^m) \right] + \eta_i p_j^{\eta *} D_j^d(p_j^{\eta *}, p_i^{\eta *}) \leq 0. \tag{15}$$

The first term represents the competition strengthening effect: by removing geoblocking restrictions, firm j commits to compete for its rival's online shoppers, which leads to lower prices ($p_j^{\eta *} < p^m$). The second term represents the demand expansion effect: by removing geoblocking, firm j attracts demand from online shoppers in the foreign market. Thus, the case where both firms geoblock is an equilibrium if and only if the competition strengthening effect dominates the demand expansion effect. If neither (14) nor (15) holds, there are only asymmetric equilibria where one firm geoblocks, but not the other.

In sum, when firms can price discriminate between their offline and online stores, the

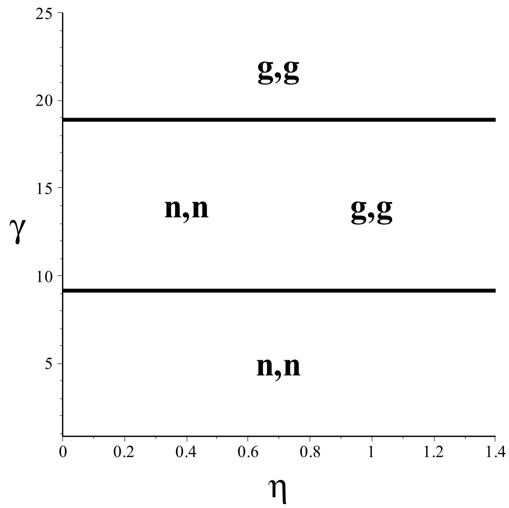

Figure 3: Equilibrium with price discrimination

characterization of equilibria is similar as in the baseline model, and depends on the same economic mechanisms.

We can fully characterize the equilibrium for the illustrative linear demand model. We assume that there is the same mass of offline and online customers in the two countries, $\phi = 1$ and η, respectively. Figure 3 shows the equilibrium regions as a function of η and γ (see Appendix C3 for details). When the degree of substitution is low ($\gamma < 9.1$), no firm geoblocks in equilibrium. When it is sufficiently high ($\gamma > 18.9$), both firms geoblock. Finally, for intermediate values of the degree of substitution ($\gamma \in (9.1, 18.9)$), there are two equilibria where either no firm geoblocks, or both of them do. Therefore, as in the baseline model, when firms price discriminate, geoblocking arises as an equilibrium outcome when the firms' products are strong substitutes.

Finally, it is interesting to compare firms' profits with and without price discrimination. The comparison reveals that when firms do not geoblock, they derive larger profits with price discrimination than with uniform pricing only if their products are sufficiently differentiated.[19] When firms set uniform prices, they charge a price between the monopoly and duopoly prices (see Lemma 1). With price discrimination, firms set the monopoly price offline and the duopoly price online. Therefore, with price discrimination, firms obtain larger profits offline but smaller profits online, as they compete more aggressively for online customers. When online competition is strong enough (γ is sufficiently large), the reduction in

[19]Formally, firms' profits when neither of them geoblocks are larger when they price discriminate if $\gamma < 4\sqrt{\eta(1+\eta)}/\eta$.

online profits more than outweighs the larger profits from the offline segment.

6.2 Shipping costs

So far, we have assumed away shipping costs for online purchases. Now, we extend our model by assuming that online purchases entail a delivery cost, t. For simplicity, we assume that this cost is the same whether the purchase takes place on the domestic market or cross border. We consider that each firm i can decide to bear a share $\alpha_i \in [0,1]$ of the delivery cost, charging its online consumers for the remaining part, $(1-\alpha_i)t$, which represents the shipping cost for the consumers. For a given geoblocking configuration, we then study the game where firms set simultaneously their uniform price p_i and the share α_i of the delivery cost that they bear.[20] We focus on the symmetric configurations where either both firms geoblock or none of them does.

First, assume that both firms geoblock access to their online store. Each firm i is then a monopolist over its offline and online shoppers. Firm i's profit is given by:

$$\Pi_i(p_i,\alpha_i) = \phi_i p_i D^m(p_i) + \eta_i \left(p_i - \alpha_i t\right) D^m\left(p_i + (1-\alpha_i)t\right). \tag{16}$$

Let $\hat{p}_i \equiv p_i + (1-\alpha_i)t$ designate the total price paid by online customers. The two first-order conditions of maximization of (16) with respect to p_i and α_i can then be written as:

$$\phi_i \left(D^m(p_i) + p_i \frac{\partial D^m(p_i)}{\partial p_i}\right) + \eta_i \left(D^m(\hat{p}_i) + (\hat{p}_i - t)\frac{\partial D^m(\hat{p}_i)}{\partial p_i}\right) = 0, \tag{17}$$

and

$$D^m(\hat{p}_i) + (\hat{p}_i - t)\frac{\partial D^m(\hat{p}_i)}{\partial p_i} = 0, \tag{18}$$

respectively. If we ignore the boundaries of α_i, everything is as if the firms were able to price discriminate between offline and online customers through the prices p_i and $\hat{p}_i$.

Let $p^m(c) = \arg\max_p (p-c)D^m(p)$ denote the monopoly price for a constant marginal cost of c. If we ignore the boundary constraints of α_i, the first-order conditions (17) and (18) imply that in equilibrium firm i charges the monopoly price $p^m(0)$ to its offline and online shoppers, and a shipping cost equal to $p^m(t) - p^m(0)$ to its online shoppers such that they

[20] We assume that consumers act rationally and only consider the total price of the product and not its division between the actual price and the cost of shipping. Thus, it is irrelevant whether the firm shows the total price to the consumer or the price of the product and the shipping cost separately. A recent body of literature has investigated how consumers can react differently to the so-called partitioned prices by not fully considering the add-on fees, such as shipping costs. See DellaVigna (2009).

pay the total price $p^m(t)$.

Now, assume that no firm geoblocks. Firm i's profit is then given by:

$$\Pi_i(p_i, \alpha_i) = \phi_i p_i D^m(p_i) + (\eta_i + \eta_j)(p_i - \alpha_i t) D_i^d(p_i + (1-\alpha_i)t, p_j + (1-\alpha_j)t). \tag{19}$$

In a similar way as above, the two first-order conditions of maximization of (19) with respect to p_i and α_i can be written as:

$$\phi_i \left(D^m(p_i) + p_i \frac{\partial D^m(p_i)}{\partial p_i} \right) + (\eta_i + \eta_j) \left(D_i^d(\hat{p}_i, \hat{p}_j) + (\hat{p}_i - t) \frac{\partial D_i^d(\hat{p}_i, \hat{p}_j)}{\partial p_i} \right) = 0, \tag{20}$$

and

$$D_i^d(\hat{p}_i, \hat{p}_j) + (\hat{p}_i - t) \frac{\partial D_i^d(\hat{p}_i, \hat{p}_j)}{\partial p_i} = 0. \tag{21}$$

If we ignore boundary constraints on α_i, the first-order conditions (20) and (21) imply that in equilibrium, firm i charges the monopoly price $p^m(0)$ to its offline and online shoppers, and a shipping cost equal to $p^d(t) - p^m(0)$ to its online shoppers such that they pay the total price $p^d(t)$.

Thus, in this setting with shipping costs, the ban on geoblocking does not affect final prices. It only affects the shipping costs charged to online shoppers. With or without geoblocking, consumers pay the monopoly price for the offline channel, both offline and online. Offline customers are charged a shipping cost on top of this price. When the ban is enforced, online shoppers are charged lower shipping costs, resulting in a lower total price.

Illustrative model

Our illustrative model allows us to check the boundary conditions on the share of the delivery cost borne by the firms.

If we ignore those boundary constraints for the moment, we find that the firms set $\alpha_i = 1/2$ when they both geoblock and $\alpha_i = (4t + \gamma)/2t(4 + \gamma)$ when none of them does.[21] In the mixed regime, where firm i geoblocks but not firm j, firm i sets the share $\alpha_i = (4t(5\gamma + 12) + 3\gamma(\gamma + 4))/(2t(3\gamma^2 + 32\gamma + 48))$ for the delivery cost, and firm j the share

[21] The fact that when both firms geoblock they cover half of the delivery cost is consistent with the well-known result in the literature on pass-through that a monopolist facing a linear demand passes through half of the marginal cost (see, e.g., Bulow and Pfleiderer, 1983). When no firm geoblocks, firms are willing to cover a larger share of the delivery cost: $d\hat{p}/dt = (\gamma + 2)/(\gamma + 4) \geq 1/2$. This is consistent with, for example, Zimmerman and Carlson (2010), who show that compared to monopoly, in a Bertrand oligopoly with differentiated products, firms pass through a larger share of their marginal cost to consumers.

$\alpha_j = (\gamma\,(3\,\gamma+4)+4t\,(7\gamma+12))/(2t\,(3\gamma^2+32\gamma+48))$.

Note that, as the firms implement a third-degree price discrimination scheme using the endogenous shipping cost, the equilibrium outcome in terms of geoblocking decisions is the same as with price discrimination (see Figure 3).

We find that when no firm geoblocks or only one does, the share of the delivery cost borne by the firms is interior in equilibrium (i.e., $\alpha_i \leq 1$) if products are not too strong substitutes.[22] If products are substitutes enough (i.e., γ is high enough), firms charge online and offline customers the same price and offer free-shipping to online consumers (i.e., $\alpha_i = 1$).

When firms offer free-shipping, the model with delivery costs is qualitatively similar to our baseline model with uniform pricing. Figure 4 shows how the delivery cost affects the equilibrium, assuming that $t = 0.1$. In this figure, the parameters ensure that in the subgames where only one firm geoblocks or none of them does, firms offer free shipping ($\alpha_i = 1$).[23] The red dashed lines represent the thresholds for the equilibrium regions in the benchmark case, when $t = 0$. The black solid lines represent the same thresholds when $t = 0.1$.

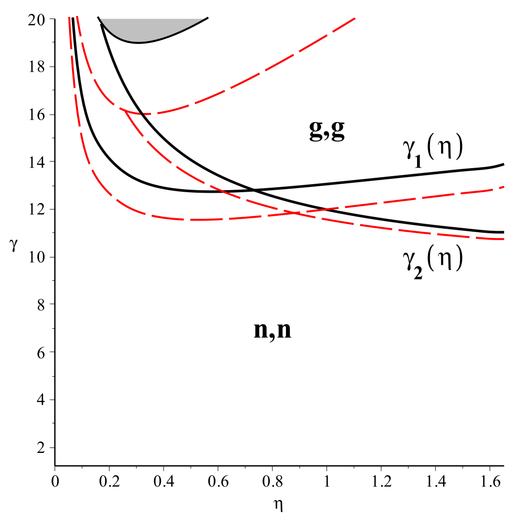

Figure 4: Equilibrium with delivery costs fully covered by the firms.

Figure 4 shows that when delivery costs are fully covered by the firms, the thresholds $\gamma_i(\eta)$ move upwards. As a consequence, the region where no firm geoblocks in equilibrium becomes larger. This analysis shows that delivery costs for online purchases tend to favor

[22] Formally, when no firm geoblocks, we have $\alpha_i \leq 1$ if $\gamma \leq 4t/(1-2t)$. In the mixed regime, we have $\max\{\alpha_i, \alpha_j\} < 1$ for $\gamma < 2(9t-1+\sqrt{9t(t+2)+1})/(2t-1)$.

[23] Free shipping occurs for $\gamma > \max\{4t/(1-2t), 2(9t-1+\sqrt{9t(t+2)+1})/(2t-1)\}$. If $t = 0.1$, this happens for $\gamma > 1.3$.

the emergence of the no-geoblocking equilibrium. Therefore, the impact of the ban is likely to be smaller for products with high delivery costs.

7 Conclusion

In December 2018, a new regulation prohibiting companies from adopting geoblocking restrictions came into force in Europe. In this paper, we analyzed the short-term and long-term impact of this ban. To do so, we developed a model of strategic geoblocking, where two multi-channel retailers located in different countries and distributing substitute products can decide to block access to their online store from foreign consumers. Our focus is on multi-channel retailers that operate brick-and-mortar shops in their home market and start selling online to expand their sales, but do not have an active presence abroad. In our setting, a ban on geoblocking leads to lower prices, both offline and online. The ban leads to fiercer competition in the online market, thus spilling over to the offline market due to the firms setting uniform prices across their retail channels.

We then characterized the equilibrium when firms decide unilaterally whether to introduce geoblocking restrictions. Geoblocking involves a trade-off for firms between a demand reduction effect and a competition softening effect. By blocking access to their online store from foreign customers, firms give up the online demand from the foreign market. However, geoblocking also acts as a commitment to be a soft competitor, leading to higher prices and profits. Thus, geoblocking corresponds to a “puppy dog” strategy in Fudenberg and Tirole (1984)’s taxonomy. Depending on the magnitude of these two opposite effects, different equilibria can arise. When firms sell sufficiently differentiated products, the demand reduction effect dominates, and in equilibrium, firms allow for cross-border sales. In contrast, when products are strong substitutes, online competition is intense, and firms have a strong incentive to introduce geoblocking restrictions to soften price competition.

While the ban on geoblocking has a positive effect in the short-run for consumers due to lower prices, we show that it may have adverse effects in the long-run. More specifically, we show that the ban reduces firms’ incentives to increase the demand from online shoppers, which is detrimental to social welfare.

We conclude the analysis by introducing delivery costs for online purchases. We show that when firms can decide how much of these costs to pass through to their consumers via a shipping fee, they are able to implement a third-degree price discrimination scheme, charging different total prices to online and offline customers. In our illustrative model, this occurs when firms' products are sufficiently differentiated. However, when products are strong substitutes, firms offer free-shipping to online customers, thus returning to implementing non-discriminatory prices, as in the baseline model.

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Appendix

A. Equilibria of pricing subgames

A1. Proof of Lemma 1

The first-order condition for the maximization of (1) can be written as:

$$(1-\rho_i)\left(D^m(p_i)+p_i\frac{\partial D^m(p_i)}{\partial p_i}\right)+\rho_i\left(D_i^d(p_i,p_j)+p_i\frac{\partial D_i^d(p_i,p_j)}{\partial p_i}\right)=0, \tag{22}$$

where $\rho_i \equiv (\eta_i+\eta_j)/(\phi_i+\eta_i+\eta_j)$ represents the share of online consumers of firm i, and hence, $(1-\rho_i)$ is the share of offline consumers for this firm.

Note that the first term in parenthesis, which corresponds to the marginal revenue in monopoly, is always greater than the second term in parenthesis, which represents the marginal revenue in duopoly. To see that, we can write the monopoly demand as $D^m(p_i) = D_i^d(p_i, \bar{p}_j(p_i))$, where $\bar{p}_j(p_i)$ is the price where firm j's demand falls to zero. Since prices are strategic complements, the marginal revenue under duopoly is increasing in p_j, and thus, highest at $\bar{p}_j(p_i)$.

At $p_i = p^m$, the first term of (22) is equal to 0, and therefore, the second term is negative. Conversely, at $p_i = p^d$, the second term is equal to 0, and the first one is positive. Therefore, given that an equilibrium exists and is unique, equilibrium prices satisfy the inequality $p_i^d < p_i^{nn} < p_i^m$.

The existence of the equilibrium follows from our assumption of concavity of profit functions (which implies quasi-concavity) and the compactness of strategy space. We also assume that $D_i^d(p^m,0) > 0$. If this condition does not hold, that is, if $D_i^d(p^m,0) = 0$, the profit function is discontinuous and an equilibrium in pure-strategy may fail to exist (see Gautier and Wauthy, 2010). Uniqueness of the equilibrium is ensured if own effects dominate cross effects. A sufficient condition is that $\partial D_i/\partial p_i + \partial D_i/\partial p_j < 0$ and $\partial^2 D_i/\partial p_i^2 + |\partial^2 D_i/\partial p_i p_j| < 0$, where $D_i(p_i,p_j) \equiv \phi_i D^m(p_i) + (\eta_i+\eta_j)D_i^d(p_i,p_j)$ (see Vives, 1999).

To prove the last point of the proposition, let $\hat{r}_i(p_j;\rho_i) \equiv \arg\max_{p_i}(1-\rho_i)p_i D^m(p_i) + \rho_i p_i D_i^d(p_i,p_j)$. Notice that $\hat{r}_i(p_j;\rho_i)$ in increasing in p_j (due to the strategic complementarity assumption) and decreasing in ρ_i. Therefore, when ρ_i increases (i.e., firm i has a higher share of online shoppers), firm i reacts by decreasing its price, and by strategic complementarity, firm j also decreases its price, leading to lower equilibrium prices. Conversely, if ρ_i decreases (i.e., firm i has a higher share of offline shoppers), firm i reacts by increasing its price, and by strategic complementarity, firm j does the same, which leads to higher prices.

A2. Proof of Lemma 2

The first-order condition (3) for the maximization of firm i's profit can be written as

$$(1-\rho_i)\left(D^m(p_i)+p_i\frac{\partial D^m(p_i)}{\partial p_i}\right)+\rho_i\left(D_i^d(p_i,p_j)+p_i\frac{\partial D_i^d(p_i,p_j)}{\partial p_i}\right)=0,$$

with $\rho_i = \eta_i/(\phi_i+\eta_i)$, while the first-order condition (4) for the maximization of firm j's profit can be written as:

$$(1-\rho_j)\left(D^m(p_j)+p_j\frac{\partial D^m(p_j)}{\partial p_j}\right)+\rho_j\left(D_j^d(p_j,p_i)+p_j\frac{\partial D_j^d(p_j,p_i)}{\partial p_j}\right)=0,$$

with $\rho_j = \eta_i/(\phi_j+\eta_i+\eta_j)$.

Let $\hat{r}_i(p_j;\rho_i) \equiv \arg\max_{p_i}(1-\rho_i)p_iD^m(p_i)+\rho_ip_iD_i^d(p_i,p_j)$. Firm i's best-response is then given by $p_i = \hat{r}_i(p_j;\rho_i)$, with $\rho_i = \eta_i/(\phi_i+\eta_i)$, while firm j's best-response is $p_j = \hat{r}_j(p_i;\rho_j)$, with $\rho_j = \eta_i/(\phi_j+\eta_i+\eta_j)$. The same arguments that we used in Appendix A1 for the proof of Lemma 1 ensure the existence and uniqueness of the price equilibrium and prove that $p_l^{gn} \in (p^d, p^m)$ for $l = i, j$. Likewise, using similar arguments as in Appendix A1, we can show that equilibrium prices are decreasing with ρ_i.

To prove the last point of the lemma, assume that firms i and j set the same price p, and that this price is set such that the first-order condition (3) for firm i holds. Using the two first-order conditions (3) and (4), from the concavity of the profit functions and the symmetry of demand functions, we have $\partial\Pi_j(p_j,p)/\partial p_j|_{p_j=p} \geq 0$ if and only if $\phi_i \leq \phi_j+\eta_j$. If this condition holds, firm j sets a higher price than firm i.

A3. Proof of Proposition 1

Lemma 1 shows that prices are lower when no firm geoblocks compared to the case where both of them do, and Lemma 2 shows that they are also lower in the mixed regime compared to the case where both firms geoblock.

It remains to show that prices are higher in the mixed regime than in the no-geoblocking regime. This comes from the fact that firms' best responses shift outwards in the mixed regime compared to the no-geoblocking regime. Indeed, consider that in the mixed regime, firm i geoblocks, but not firm j. Using the analysis in Appendix A1 and A2, firm i's best-response is then given by $\hat{r}_i(p_j;(\eta_i+\eta_j)/(\phi_i+\eta_i+\eta_j))$ under no-geoblocking and by $\hat{r}_i(p_j;\eta_i/(\phi_i+\eta_i))$ in the mixed regime, with $(\eta_i+\eta_j)/(\phi_i+\eta_i+\eta_j) > \eta_i/(\phi_i+\eta_i)$. Similarly, firm j's best-response is given by $\hat{r}_j(p_i;(\eta_i+\eta_j)/(\phi_j+\eta_i+\eta_j))$ in the no-geoblocking case and by $\hat{r}_j(p_i;\eta_i/(\phi_j+\eta_i+\eta_j))$ in the mixed regime, with $(\eta_i+\eta_j)/(\phi_j+\eta_i+\eta_j) > \eta_i/(\phi_j+\eta_i+\eta_j)$. Since both best responses shift outwards, the equilibrium prices are higher in the mixed regime than in the no-geoblocking regime.

B. Unilateral incentive to introduce geoblocking restrictions

When no firm geoblocks, firm i's unilateral incentive to deviate and implement geoblocking restrictions is given by

$$\left(\phi_i p_i^{gn} D^m(p_i^{gn}) + \eta_i p_i^{gn} D_i^d(\mathbf{p}^{gn})\right) - \left(\phi_i p_i^{nn} D^m(p_i^{nn}) + \eta_i p_i^{nn} D_i^d(\mathbf{p}^{nn})\right) - \eta_j p_i^{nn} D_i^d(\mathbf{p}^{nn}).$$

We show that the difference between the first two terms in parenthesis (that we interpret as the competition softening effect) is always positive. Indeed, it can be rewritten as

$$\begin{aligned}\left(\phi_i p_i^{gn} D^m(p_i^{gn}) + \eta_i p_i^{gn} D_i^d(p_i^{gn}, p_j^{gn})\right) - \left(\phi_i p_i^{nn} D^m(p_i^{nn}) + \eta_i p_i^{nn} D_i^d(p_i^{nn}, p_j^{gn})\right)\\ +\eta_i p_i^{nn}\left(D_i^d(p_i^{nn}, p_j^{gn}) - D_i^d(p_i^{nn}, p_j^{nn})\right).\end{aligned}$$

The difference of terms on the first line is positive, as $p_i^{gn} = \arg\max_p \phi_i p D^m(p) + \eta_i p D_i^d(p, p_j^{gn})$. The term on the second line is also positive as $p_j^{gn} > p_j^{nn}$ and $\partial D_i^d/\partial p_j > 0$. Therefore, the competition softening effect is always positive.

Finally, firm j always benefits when firm i deviates to geoblocking as

$$\begin{aligned}\Pi_j^{gn} - \Pi_j^{nn} = &\left[(\phi_j+\eta_j)\, p_j^{gn} D^m(p_j^{gn}) + \eta_i p_j^{gn} D_j^d(\mathbf{p}^{gn}) - \left((\phi_j+\eta_j) p_j^{nn} D^m(p_j^{nn}) + \eta_i p_j^{nn} D_j^d(\mathbf{p}^{nn})\right)\right]\\ &+ \eta_j p_j^{gn}\left[D^m(p_j^{gn}) - D_j^d(p_j^{gn}, p_i^{gn})\right] \geq 0.\end{aligned}$$

Indeed, let $\Pi_j(p_j, p_i) \equiv (\phi_j+\eta_j)\, p_j D^m(p_j) + \eta_i p_j D_j^d(p_j, p_i)$. The first term into brackets is equal to $\Pi_j(p_j^{gn}, p_i^{gn}) - \Pi_j(p_j^{nn}, p_i^{nn})$, which can also be written as

$$\left(\Pi_j(p_j^{gn}, p_i^{gn}) - \Pi_j(p_j^{nn}, p_i^{gn})\right) + \left(\Pi_j(p_j^{nn}, p_i^{gn}) - \Pi_j(p_j^{nn}, p_i^{nn})\right).$$

The first term in parenthesis is positive as $p_j^{gn} = \arg\max_p \Pi_j(p, p_i^{gn})$. The second term simplifies to $\eta_i p_j^{nn}\left[D_j^d(p_j^{nn}, p_i^{gn}) - D_j^d(p_j^{nn}, p_i^{nn})\right]$, which is positive too as $p_i^{gn} > p_i^{nn}$.

C. Illustrative model

C1. Equilibrium prices and geoblocking strategies

Equilibrium prices. Using the linear demands $D^m(p_i)$ and $D_i^d(p_i, p_j)$, it is easy to define firms' profit functions in the various scenarios. When both firms geoblock, firm i's profit is:

$$\Pi_i(p_i) = (1+\eta)(1-p_i)p_i. \tag{23}$$

When no firm geoblocks, firm i's profit is:

$$\Pi_i(p_i, p_j) = p_i(1-p_i) + \eta\left(1-(1+\gamma)p_i + \frac{\gamma}{2}(p_i+p_j)\right)p_i. \tag{24}$$

Finally, in the mixed regime where firm i geoblocks, but not firm j, firm i's profit is

$$\Pi_i(p_i, p_j) = (1-p_i)p_i + \frac{\eta}{2}\left(1-(1+\gamma)p_i + \frac{\gamma}{2}(p_i+p_j)\right)p_i, \tag{25}$$

while firm j profit is:

$$\Pi_j(p_j, p_i) = (1+\eta)(1-p_j)p_j + \frac{\eta}{2}\left(1-(1+\gamma)p_j + \frac{\gamma}{2}(p_i+p_j)\right)p_j. \tag{26}$$

When both firms geoblock, each firm charges the monopoly price $p_i^{gg} = 1/2$ and obtains the monopoly profit $\Pi_i^{gg} = (1+\eta)/4$. When no firm geoblocks, using (24) and solving for the system of first-order conditions[24] leads to the equilibrium prices

$$p_i^{nn} = \frac{2(1+\eta)}{4+\eta(\gamma+4)},$$

and profits:

$$\Pi_i^{nn} = \frac{2(2+\eta(\gamma+2))(1+\eta)^2}{(4+\eta(\gamma+4))^2}.$$

Finally, using (25) and (26), when firm i does not geoblock while firm j does, solving for the system of first-order conditions yields the following prices and profits:

$$p_i^{gn} = 2\,\frac{\eta\,\gamma\,(5\,\eta+6)+4\,(\eta+2)\,(3\,\eta+2)}{\eta\,\gamma\,(3\,\eta\,\gamma+32\,(1+\eta))+16\,(\eta+2)\,(3\,\eta+2)},$$

[24] Second order conditions are satisfied.

$$p_j^{gn} = 2\frac{\eta\,\gamma\,(7\,\eta+6)+4\,(\eta+2)\,(3\,\eta+2)}{\eta\,\gamma\,(3\,\eta\,\gamma+32\,(1+\eta))+16\,(\eta+2)\,(3\,\eta+2)},$$

and

$$\Pi_i^{gn} = \frac{(\eta\,\gamma\,(5\,\eta+6)+4\,(\eta+2)\,(3\,\eta+2))^2\,(4+\eta(\gamma+2)}{(\eta\,\gamma\,(3\,\eta\,\gamma+32\,(1+\eta))+16\,(\eta+2)\,(3\,\eta+2))^2},$$

$$\Pi_j^{gn} = \frac{(\eta\,\gamma\,(7\,\eta+6)+4\,(\eta+2)\,(3\,\eta+2))^2\,(4+\eta(\gamma+6))}{(\eta\,\gamma\,(3\,\eta\,\gamma+32\,(1+\eta))+16\,(\eta+2)\,(3\,\eta+2))^2}.$$

Equilibrium of the geoblocking game. No firm geoblocks, (n,n), is a Nash equilibrium if and only if (7) holds, that is, $\Pi_i^{gn} - \Pi_i^{nn} \leq 0$. Firm i's incentive to deviate can be decomposed into the competition softening effect and the demand reduction effect as follows:

$$\begin{aligned}\Pi_i^{gn} - \Pi_i^{nn} =& \frac{\gamma^2\eta^2}{(\gamma\eta\,(3\,\gamma\eta+32\eta+32)+16\,(\eta+2)\,(3\eta+2))^2\,(4+(\gamma+4)\,\eta)^2}\Big(16\,(\gamma+6)\,(\gamma+2)^2\,\eta^5+\\ &+\big((33\gamma^2+524\gamma+2096)\,\gamma+2368\big)\,\eta^4+((2\gamma\,(9\gamma+287)+3632)\,\gamma+5728)\,\eta^3+\\ &+(12\,\gamma\,(17\gamma+224)+6720)\,\eta^2+(704\gamma+3712)\,\eta+768\Big)\\ &-\frac{\eta\,(\eta+1)\,(\gamma\eta+2\eta+2)}{(4+(\gamma+4)\,\eta)^2},\end{aligned}$$

where the first three lines represent the competition softening effect, which is positive, while the term on the last line is the demand reduction effect, which is negative.[25] We find that $\Pi_i^{gn} - \Pi_i^{nn} = 0$ for $\gamma = \gamma_1(\eta)$, where the function $\gamma_1(\eta)$ is plotted in Figure 1. For $\gamma < \gamma_1(\eta)$, $\Pi_i^{nn} > \Pi_i^{gn}$ and (n,n) is a Nash equilibrium.

Similarly, (g,g) (i.e., both firms geoblock) is a Nash equilibrium if and only if (8) holds, that is, $\Pi_j^{gn} - \Pi_j^{gg} \leq 0$. Firm j's profit gain from deviation can be decomposed as the sum of the competition strengthening effect and the demand expansion effect:

$$\begin{aligned}\Pi_j^{gn} - \Pi_j^{gg} =& \frac{-(\eta+1)\,\gamma^2\eta^2\,((3\,\gamma+4)\,\eta+8)^2}{4\,(\gamma\eta\,(3\,\gamma\eta+32\,(\eta+1))+16\,(\eta+2)\,(3\,\eta+2))^2}+\\ &+\frac{\eta\,(\gamma\eta\,(7\,\eta+6)+4\,(\eta+2)\,(3\,\eta+2))\,\big(\gamma^2\eta^2+2\,\eta\,(9\,\eta+10)\,\gamma+8\,(\eta+2)\,(3\,\eta+2)\big)}{(\gamma\eta\,(3\,\gamma\eta+32\,\eta+32)+16\,(\mu+2)\,(3\,\mu+2))\,,^2}\end{aligned}$$

where the first term represents the competition strengthening effect and the second term the demand expansion effect. We find that $\Pi_j^{gg} = \Pi_j^{ng}$ for $\gamma = \gamma_2(\eta)$, where $\gamma_2(\eta)$ is plotted in Figure 1. For $\gamma > \gamma_2(\eta)$, we have $\Pi_j^{gg} > \Pi_j^{gn}$ and (g,g) is a Nash equilibrium.

Wrapping everything up, Figure 1 shows in the (η,γ) plane the regions where each possible

[25]It is possible to see that the competition softening effect increases both with γ and η, while the demand reduction effect decreases with γ and increases with η.

equilibrium outcome emerges. Note that an asymmetric equilibrium where only one firm geoblocks occurs when $\gamma_1(\eta) < \gamma < \gamma_2(\eta)$.

To complete the analysis, we need to check that our candidate Nash equilibria are robust to large price deviations. Indeed, firms may be willing to charge the monopoly price and concentrate on their offline customers rather than competing with the rival firm in online markets. Let us start with the (n, n) equilibrium. If it sells online, firm i's price in the candidate equilibrium is $p^{nn} < p^m$. Alternatively, firm i may deviate and charge the monopoly price $p^m = 1/2$, focusing only on offline customers. If, at this price, the firm still faces a positive demand from online customers, this price cannot be an optimal deviation as when the firm sells online, its best response is to set the price p^{nn}. On the contrary, if at the monopoly price 1/2, the firm has no online buyers, its payoff is 1/4. It is immediate to see that the profits from deviation are lower than Π^{nn} if and only if $\gamma < 4\left(\eta + \sqrt{\eta(1+\eta)}\right)(\eta+1)/\eta$.

Consider now the asymmetric equilibrium (g, n). Both firms i and j may deviate by charging the monopoly price. If, at this price, they still face some demand from local online customers, the deviation is not profitable, since the monopoly price is not their best response in this case. On the contrary, if at this price they have only offline customers, they obtain monopoly profits from their offline customers, i.e., a profit of 1/4. Comparing Π_i^{gn} (resp., Π_j^{gn}) with 1/4, it is possible to see that $\gamma < 4\left(\eta + \sqrt{\eta(1+\eta)}\right)(\eta+1)/\eta$ is a sufficient condition for both firms not to deviate.

Finally, when the equilibrium is (g, g), the two firms are monopolies and there is no profitable upward deviation in prices. The grey area in the top-left part of Figure 1 indicates the values of γ for which the equilibria are not robust to large price deviations. We exclude those values from the analysis.

C2. Development of online channel

Using our illustrative model, we study the three-stage game where: first, firms decide whether to adopt geoblocking restrictions; second, they decide on their level of investment; third, they set uniform prices. We look for the subgame-perfect equilibrium of this game.

Let us start with the subgame where no firm geoblocks at stage one. Given the investment levels η_i and η_j set at stage two, in the last stage, each firm i decides on a uniform price p_i to maximize its profit:

$$p_i(1-p_i) + \frac{\eta_i + \eta_j}{2}\left(1 - (1+\gamma)p_i + \frac{\gamma}{2}(p_i + p_j)\right)p_i - \frac{\eta_i^2}{h}.$$

Solving for the equilibrium, we find firms' prices as a function of investment levels. Plugging back those prices into the profit functions, firm i's profit at stage two can be expressed as:

$$\Pi_i^{nn}(\eta_i, \eta_j) = \frac{((\eta_i + \eta_j)(\gamma + 2) + 4)(\eta_i + \eta_j + 2)^2}{((\eta_i + \eta_j)(\gamma + 4) + 8)^2} - \frac{\eta_i^2}{h}. \tag{27}$$

Firm i chooses its investment level η_i to maximize its profit (27). We find numerically the symmetric equilibrium levels of investment as a function of the parameters γ and h.

In the mixed regime where firm i geoblocks but not firm j, firms' profits at stage three, given investment levels, are

$$(1 - p_i) p_i + \frac{\eta_i}{2}\left(1 - p_i (1 + \gamma) + \frac{\gamma}{2}(p_1 + p_j)\right) p_1 - \frac{{\eta_i}^2}{h},$$

for firm i, and

$$(1 + \eta_j)(1 - p_j) p_j + \frac{\eta_i}{2}\left(1 - p_j (1 + \gamma) + \frac{\gamma}{2}(p_i + p_j)\right) p_j - \frac{\eta_j^2}{h}.$$

for firm j. Solving for the system of first-order conditions, we find firms' prices given investment levels. Replacing for those prices into the profit functions, firms' profits at stage two can be written as:

$$\Pi_i^{gn}(\eta_i, \eta_j) = \frac{(\gamma\eta_i(3\eta_i + 2\eta_j) + 6\eta_i\gamma + 4\eta_i(\eta_i + 2\eta_j) + 16(1 + \eta_i + \eta_j))^2 (\eta_i(\gamma + 2) + 4)}{({\eta_i}^2(\gamma + 4)(3\gamma + 4) + 16(\eta_j + 2)(\gamma + 2)\eta_i + 64(1 + \eta_j))^2} - \frac{{\eta_i}^2}{h},$$

and

$$\Pi_j^{gn}(\eta_i, \eta_j) = \frac{(\gamma\eta_i(3\eta_i + 4\eta_j + 6) + 4\eta_i(\eta_i + 2\eta_j) + 16(1 + \eta_i + \eta_j))^2 (\eta_i(\gamma + 2) + 4(1 + \eta_j))}{({\eta_i}^2(\gamma + 4)(3\gamma + 4) + 16(\eta_j + 2)(\gamma + 2)\eta_i + 64(1 + \eta_j))^2} - \frac{{\eta_j}^2}{h}.$$

As above, solving for the solution of the system of first order conditions, we find numerically the equilibrium levels of investment as a function of the parameters γ and h.

Finally, consider the case where both firms geoblock. At the pricing stage, each firm charges the monopoly price 1/2. Hence, firm i's second-stage profits are given by

$$\Pi_i^{gg}(\eta_i) = \frac{1 + \eta_i}{4} - \frac{\eta_i^2}{h}. \tag{28}$$

Solving for the first-order condition, firms' equilibrium level of investment is $h/8$ and the associated profit is $(1 + 16h)/4$.

At stage one, firms decide simultaneously whether to implement geoblocking restrictions. Through numerical simulations, we find that for $\gamma < \gamma_1(h)$, the equilibrium is (n,n); for $\gamma > \gamma_2(h)$, the equilibrium is (g,g); finally, for $\gamma_1(h) < \gamma < \gamma_2(h)$, there are two possible equilibria, (g,n) and (n,g). The thresholds $\gamma_1(h)$ and $\gamma_2(h)$ are represented in Figure 2.

Impact of the ban. As we have seen, when both firms geoblock, they invest $\eta_i = \eta_j = h/8$. The consumer surplus is easily computed, and equal to $CS^{gg} = (8+h)/64$.

When no firm geoblocks, we plug firms' third-stage equilibrium prices into (13) to derive the consumer surplus in country i, given investment levels:

$$\frac{1}{2}\frac{(\eta_i+1)\left((2+\gamma)(\eta_i+\eta_j)+4\right)^2}{\left((4+\gamma)(\eta_i+\eta_j)+8\right)^2}.$$

Using the profit maximizing values of η_i and η_j in the no-geoblocking case determined above, we obtain the consumer surplus in this case. In Figure 2, the dashed line indicates the points in the (h,γ) plane where $CS^{gg} = CS^{nn}$. Above this line, we have $CS^{gg} > CS^{nn}$, while below the line, we have $CS^{gg} < CS^{nn}$.

C3. Price discrimination

We know from the theoretical analysis that regardless the geoblocking subgame, firms always charge the monopoly price p^m to their captive (offline) customers. Besides, we know that when both firms geoblock they also charge p^m to their online customers, while when no firm geoblocks, each of them charges the duopoly price , p^d to online customers. With the linear demand (9), we find that $p^d = 2/(4+\gamma)$.

In the mixed regime where firm i geoblocks and firm j does not, it is possible to show that online customers are charged

$$p_i^{\eta*} = \frac{2(5\gamma+12)}{3\gamma^2+32\gamma+48}, \quad \text{and} \quad p_j^{\eta*} = \frac{2(7\gamma+12)}{3\gamma^2+32\gamma+48},$$

by firm i and firm j, respectively, with $p_l^{\eta*} \in (p^d, p^m)$ for $l = i, j$.

Replacing for those prices into the profit functions, we obtain firms' profits in the various subgames. When both firms geoblock and no of them does, firms' profits are

$$\Pi_i^{gg} = \frac{1+\eta}{4} \quad \text{and} \quad \Pi_i^{nn} = \frac{\gamma^2 + 8(\eta+1)(\gamma+2)}{4(\gamma+4)^2},$$

respectively, while in the mixed regime profits are

$$\Pi_i^{gn} = \frac{9\gamma^4 + (100\eta + 192)\,\gamma^3 + (680\eta + 1312)\,\gamma^2 + (1536\eta + 3072)\,\gamma + 1152\eta + 2304}{4\left(3\gamma^2 + 32\gamma + 48\right)^2},$$

and

$$\Pi_j^{gn} = \frac{9\gamma^4 + (196\eta + 192)\,\gamma^3 + (1848\eta + 1312)\,\gamma^2 + (4608\eta + 3072)\,\gamma + 3456\eta + 2304}{4\left(3\gamma^2 + 32\gamma + 48\right)^2}.$$

No firm geoblocks is an equilibrium if $\Pi_i^{nn} - \Pi_i^{gn} \geq 0$, that is, if:

$$-\frac{\eta\,(\gamma+2)\left(7\,\gamma^4 - 64\,\gamma^3 - 1120\,\gamma^2 - 3072\,\gamma - 2304\right)}{\left(\gamma+4\right)^2\left(3\,\gamma^2 + 32\,\gamma + 48\right)^2} \geq 0,$$

which holds for $\gamma < 18.9$. Both firms geoblock is an equilibrium if $\Pi_i^{gg} - \Pi_j^{gn} \geq 0$, that is, if:

$$\frac{\eta\,\left(9\,\gamma^4 - 4\,\gamma^3 - 536\,\gamma^2 - 1536\,\gamma - 1152\right)}{\left(3\,\gamma^2 + 32\,\gamma + 48\right)^2} \geq 0,$$

which holds for $\gamma > 9.1$.