UNIVERSITAT ROVIRA I VIRGILI

PLATFORM ECONOMICS IN VERTICALLY-RELATED STRUCTURES

Giuseppe D'Amico

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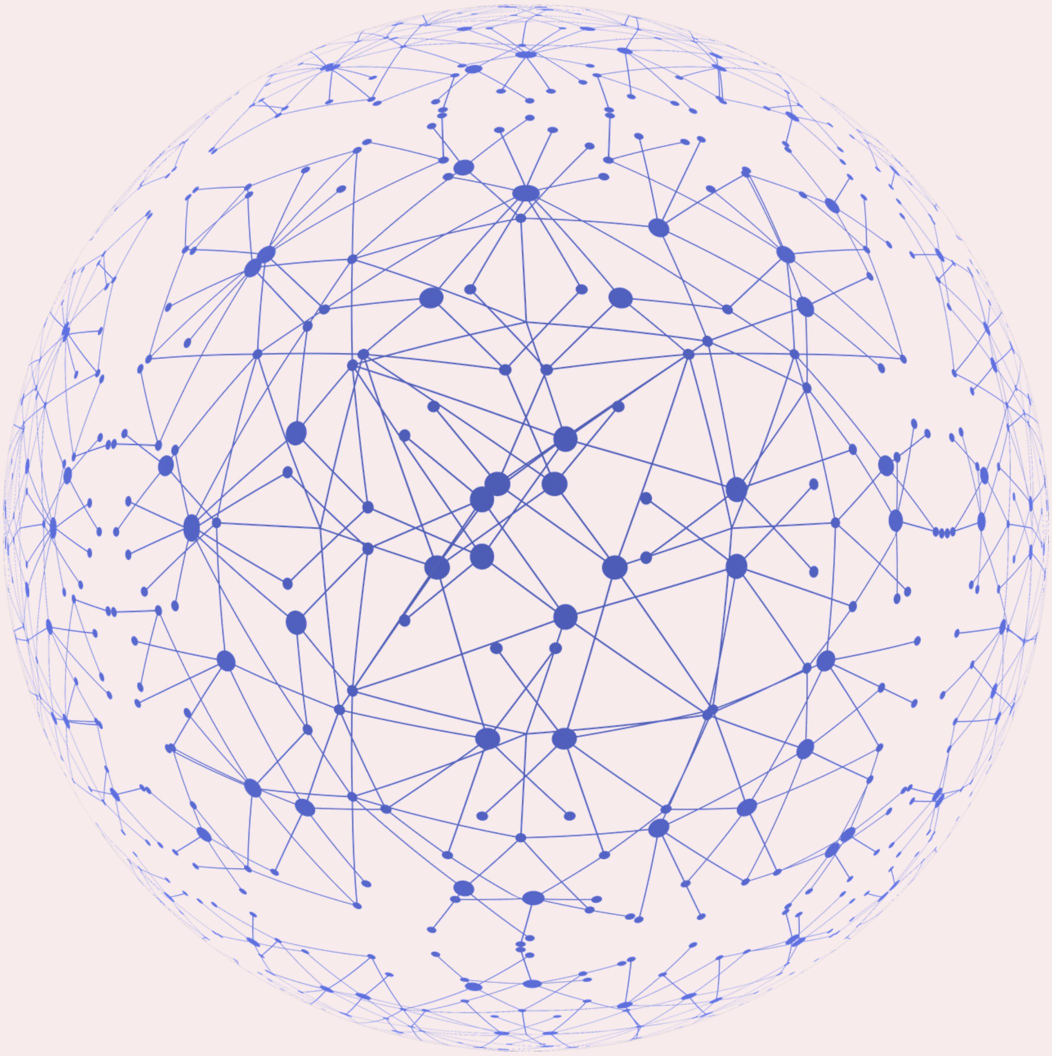

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Platform economics in vertically-related structures

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FAIG CONSTAR que aquest treball, titulat "Platform economics in vertically-related structures", que presenta Giuseppe D'Amico per a l'obtenció del títol de Doctor, ha estat realitzat sota la meva direcció al Departament d'Economia d'aquesta universitat.

HAGO CONSTAR que el presente trabajo, titulado "Platform economics in vertically-related structures", que presenta Giuseppe D'Amico para la obtención del título de Doctor, ha sido realizado bajo mi dirección en el Departamento de Economía de esta universidad.

I STATE that the present study, entitled "Platform economics in vertically-related structures", presented by Giuseppe D'Amico for the award of the degree of Doctor, has been carried out under my supervision at the Department of Economics of this university.

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Contents

Introduction

In the last decade, the rise and expansion of the platform economy have represented the new economic revolution. Helped by the digitization, this new form of organizing the economy has changed the overall Industry Architecture by renovating the whole value-creation process, which has passed from vertical-chain structures to more horizontal ecosystems. Companies such as Amazon, Facebook, Google and Microsoft are clear examples of this disruptive change.

Rochet & Tirole (2003) in their seminal work state that *"many if not most markets with network externalities are two-sided"*. Indeed, the benefits that every single user derives when joining a network crucially depend on the number and the quality of the possible interactions with other users. As a consequence, multi-sided platforms have the crucial role of managing, facilitating and, to some extent, regulating such interactions.

Since Rochet & Tirole (2003), an extensive body of literature emerged trying to disentangle the huge number of issues arising around the role of multi-sided platforms. An endlessly debated issue, to provide an example, deals with the social and private effects of competition between platforms (Rochet & Tirole, 2003; Armstrong, 2006a; Armstrong & Wright, 2007; Jullien & Sand-Zantman, 2021). Platform competition has ambiguous effects on welfare. On the one hand, the competitive forces exert downward pressure on prices and prevent platforms from engaging in opportunistic behaviors. On the other hand, an excessive platforms fragmentation, indeed, might lead to weaker cross-group network externalities (Sokol & Van Alstyne, 2021) resulting in sub-optimal outcomes.

Nevertheless, although most of the theories recognize the benefits of a monopoly platform, it is extremely important to recognize the social and economic risks of leaving a platform in a dominant position. Concerning this argument, many economists advocate the need to call for a stricter regulation safeguarding consumers (L. M. Khan, 2016; L. Khan, 2018; Ciriani & Lebourges, 2018).

Another relevant topic in the two-sided markets literature concerns the role of the expectations. When making their joining decision, users may lack of relevant information. To provide some examples, they are rarely informed about the levels of participation and the type of the other users, or they might systematically overestimate (or underestimate) the true extent of the cross-group network externalities. As a consequence, expectations assume a critical role as they directly affect the users' responsiveness to platform strategies. (Caillaud & Jullien, 2001, 2003; Hagiu, 2009; Halaburda & Yehezkel, 2013; Hagiu & Hałaburda, 2014; Hałaburda & Yehezkel, 2016).

Finally, another stream of literature has focused on the key role of the ecosystems in platform-based industries, analyzing their structures and organizational forms Rietveld et al., 2019; Cusumano et al., 2019; Cennamo & Santalo, 2013.

The core of this thesis builds on the vertical relations among platforms and their ecosystems. Differently from most of the papers in the two-sided markets literature, which assign a pretty passive role to its ecosystem, the present research focuses on a more active behavior of platform users. In particular, this is the case of B2C platforms, which facilitate interactions among buyers and sellers. In Duch-Brown (2017), the author remarks that the vertical relations a platform has with its users are significantly affected by the organizational structure of the seller downstream markets. Interestingly, we find a similar result in Chapter 1.

Despite its relevance, the body of literature exploring the nature of the vertical structures in platform-based markets is rather scarce and has received attention only recently.

Relevant contributions are provided by Hagiu (2009), who offers a detailed microfoundation of the buyer-seller interaction and Galeotti & Moraga-González (2009) who suggest that platforms are not always willing to increase the product variety in their marketplace. The reason behind such results is that an increase in product variety exerts a downward pressure on seller prices which in turn decrease the extra-profits a platform could extract. In this case, as well, this result is qualitatively recovered in Chapter 1.

The purpose of this thesis is to contribute to this stream of literature on two-sided platforms.

The present document is composed of three independent essays, each one addressing a different topic of the platform literature.[1] The remainder of the thesis is as follows:

Chapter 1 studies the effect of competition and consumer foresight on platform profits.[2] Building on Flores-Fillol et al. (2018), this chapter focuses on the role of airports as platforms which connect airlines, retailers and passengers. By determining the number of active retailers through the award of concessions, the airport has partial control over the degree of competition in the retail market. Interestingly, I find that the optimal strategy of a monopoly airport ultimately depends on the degree of consumer foresight and it is insensitive to changes in the competitive environment. Nevertheless, the correlation between airport profits and consumer myopia is positive when considering a monopoly airport and weakly negative when considering airport competition.

Moreover, the study allows us to derive two managerial implications. The first one states that, under certain conditions, airport competition leads to higher landing fees. The second one shows that competing airports would be better off by not informing consumers about their retail facilities. However, such a result never arises in equilibrium.

Chapter 2 analyzes the e-book industry by comparing two business models: self- and delegated distribution, by taking into consideration the specific case of Amazon.[3]

Our results suggest that: *i*) self-publishing results in higher e-book prices for consumers under certain circumstances; *ii*) Amazon would benefit from driving publishing companies out of the e-book market in the segment of non-specialized books or novels written by emerging authors; *iii*) Amazon's dominance over traditional publishing companies should

[1]Given their independent nature, each chapter has an introduction, a conclusion and a more detailed literature review.

[2]This Chapter is derived from the article: "Platform Competition and Consumer Foresight: The Case of Airports". Published in Economics of Transportation, Volume 29, March 2022, 100248.

[3]This Chapter is derived from the article: "Self versus delegated distribution in digital platforms: The case of Amazon". Joint with Ricardo Flores Fillol and Bernd Theilen

not cause damage to final consumers and, consequently, does not call for regulatory action.

Chapter 3 addresses the topic of the sale of consumer information. In the literature of economics of privacy, the leading theory states that the interest of sellers for purchasing customer information relies on the possibility to set personalized prices. The main implication of this theory is that, in horizontally differentiated markets, a symmetric information provision exacerbates price competition and leads to lower industry prices in equilibrium, with positive consequences on consumer welfare. Motivated by a lack of evidence of personalized pricing, I propose an alternative theory with respect to the type of information a seller could infer when purchasing data.

More specifically, this chapter analyzes the case of two horizontally differentiated sellers who are uncertain about the true degree of product differentiation and a data owner, which can operate under two modes: the selling mode and the competing mode. In the selling mode, the data owner acts as a pure data broker by selling information to the sellers. In the competing mode, he exploits his exclusive information to directly compete in the market.

I find that, a data owner does not have a dominant strategy and his decision ultimately depends on to what extent the sellers underestimate or overestimate the true value of product differentiation.

Chapter 1

Platform Competition and Consumer Foresight: The Case of Airports

Abstract

This paper studies the effect of competition and consumer foresight on platform profits. The focus is on airports, which provide passengers with aeronautical and commercial services through airlines and retailers. Our results can be summarized as follows. First, we unravel the relationship between consumer foresight and the optimal pricing of the two services. When passengers are myopic, they undervalue the surplus they derive from the retail services, so that the airport charges low landing fees and makes profits from the retail business. When passengers are foresighted, they better anticipate the surplus from the retail services, so that the airport changes its strategy by charging higher landing fees and boosting competition in the retail sector. Second, we find that the relationship between profits and consumer foresight strictly depends on the considered market structure. When the airport has no competitors, airport profits are non-decreasing in the degree of consumer foresight. By contrast, under duopoly competition, a weakly-negative correlation between airport profits and consumer foresight is observed. These results allow to derive two main managerial implications. First, airport competition can lead to higher landing fees. Second, under competition, an airport is not necessarily interested in informing passengers about its retail facilities. However, an extension where airports decide whether to set an advertising campaign to inform passengers about their retail facilities reveals that they end up locked in a Prisoner's Dilemma.

1.1 Introduction

Platforms are typically multi-services. Along with their core product, they offer a wide variety of complementary services to enrich customer experience. Nowadays, many industries are characterized by this kind of structure. Among others, examples include: *i)* the video-game industry, where game publishers sell video-games (core business) and allow users to make in-game micropurchases of items that strengthen player performance (secondary services); *ii)* the hotel industry, where revenues from in-room services (secondary services) complement those from room rental (primary business); *iii)* the banking sector, where customers having savings account (primary business) are offered a wide variety of commercial and financial products (secondary services); *iv)* the grocery industry where, despite the lack of a specific core service, products are characterized by multiple network externalities.

Airports constitute a paradigmatic example where only air-travelers (primary business) get access to the restricted shopping area once at the terminal (secondary services).

Although it is common knowledge that such side-services are usually over-charged to exploit the consumers' myopic behavior, they do not always represent a direct source of profit. Bertini et al. (2008) point out that add-on features can change the perceived value of the base good. Thus, side-services may turn out to be a relevant instrument to attract those consumers who attach a low value to the core-product. Over the last years, non-aeronautical operations played a strategic role for airports. Indeed, according to many surveys carried out by the Airports Council International (ACI), non-aeronautical operations constitute the main source of revenue for many airports. Total airport industry revenues in 2016 amounted to \$161.3 billion, of which \$89.3 billion (55.4%) was aeronautical revenue and \$72 billion (44.6%) non-aeronautical.

However, the importance of non-aeronautical operations does not merely rely on the revenues they directly generate. They can also be a useful tool to attract passengers to their terminals.[1]

Currently, the airport retail sector is undergoing a period of deep renovation. With the digital revolution, both stores and passengers have access to a huge amount of information. Nowadays, passengers can easily compare prices and product features as well as learn about all the available services at the terminal. From the retailers' perspective,

[1]The rationale behind the rise of the airport cities, so called "Aerotropolis" (Kasarda, 2019), builds on a similar concept.

facing more informed customers has ambiguous implications. Airport retailers have the advantage of dealing with a larger potential demand as competition has extended to city-center retailers (Czerny & Zhang, 2020; D'Alfonso et al., 2017). Nevertheless, the new marketing methods associated with the digital innovation have given rise to an internal, harsher competition among airport retailers by offering high-quality services and by developing personalized customer experiences.[2] Airports, on their side, are making huge investments to extend the commercial area, thus enhancing passenger satisfaction at the terminal and the overall travel experience.[3]

In our framework, airports choose landing fees and organize the non-aeronautical sector by deciding the number of concessions to award. We analyze two market structures: monopoly and duopoly competition. Under monopoly, passengers are just offered the options of traveling from a single airport. Whereas, under duopoly competition, they have the alternative of traveling from another airport.[4] In making their travel decision, passengers attach a personal value to flying and anticipate a surplus they expect to derive from the consumption of retail services (henceforth *retail surplus*). It follows from the above discussion that those passengers who assign a low value to the flight (core business) need to anticipate retail surplus to travel. However, consumers may underestimate the true value of the retail surplus as they are, generally, myopic when accounting for side-

[2]More detailed information about how to develop a customer experience at https://www.adlittle.com/sites/default/files/viewpoints/ADL_Customer_Experience.pdf and https://home.kpmg/xx/en/home/media/press-releases/2019/10/customer-obsessed-brands-drive-greater-share-of-wallet.html

[3]There are uncountable examples. In 2015, Aeroporti Di Roma approved a multi-year plan to pursuing a progressive passenger experience strategy. The value of the investment is (approximately) \$12 billion http://www.airport-business.com/2015/04/rome-fiumicinos-e12bn-transformation-enhancing-end-end-travel-experience/. Recently, the Changi Airport Group (CAG) has inaugurated the new Terminal 4. The group has awarded all concession contracts for retail, food & beverage and service outlets at its new terminal. Overall, Terminal 4 will have more than 80 outlets over 16,000 squared meters of space. The total value of the investment is of \$985 million.

[4]Different from the standard definition of *monopoly airport* adopted in the transport literature (where the term "monopoly" indicates that the airport is dominated by a single carrier), here we refer to a geographical monopoly, where the airport has a sort of exclusivity over a certain catchment area.

services or products' secondary attributes (Ellison, 2005). It turns out that the extent to which travelers anticipate the retail surplus, i.e., their degree of consumer foresight, is crucial in determining their travel decision.

The main purpose of this paper is analyzing the pricing mechanism of a multi-product airport when changes in the competitive environment occur. It constitutes a first attempt to study the effect of competition and consumer foresight on platform profitability. Our results can be summarized as follows. First, we unravel the relationship between consumer foresight and optimal pricing for the two services. On the one hand, when consumers are myopic, they undervalue the true retail surplus, thus airports optimally set low landing fees and allow for a concentrated retail market. On the other hand, when consumers are foresighted, they have a more correct perception and are more sensitive to changes in the retail surplus, thus airports set high landing fees and boost competition in the retail market. These results are insensitive to changes in the market structure as they hold under monopoly and duopoly. The rationale behind these strategies relies on the extent of consumer foresight. When consumers are myopic, they underestimate the true retail price and the average mismatching cost, which depend on the number of retailers in the market. As a consequence, airports use the aeronautical sector to attract passengers to the terminals and make profits through the retail business by inducing the highest possible retail price. For a sufficiently high level of consumer foresight, passengers are more sensitive to changes in the retail surplus than to changes in the airfare. As a consequence, airports award the maximum possible number of concessions to boost the retail surplus and attract passengers, while making profits through the aeronautical business by setting high landing fees.

Second, our results emphasize the importance of market structure when considering the impact of consumer foresight on platform profitability. Under monopoly, airport profits are increasing in consumer foresight (a result obtained in Flores-Fillol et al., 2018), whereas they decrease under duopoly competition when the product differentiation in the retail sector is high. Such a difference comes from the loss in the airport's geographical market power. These results yield two main implications. First, airport competition can lead to higher landing fees. Second, under competition, an airport is not necessarily interested in informing passengers about its retail facilities. However, an extension of the study where airports decide whether to set an advertising campaign to inform passengers about their retail facilities reveals that they end up locked in a Prisoner's Dilemma.

Our paper is related to three streams of economic literature: *i) non-aeronautical revenues, ii) add-ons and consumer foresight* and *iii) airport competition and two-sided markets.*

Non-aeronautical revenues. The liberalization of air transportation has emphasized the role of non-aeronautical revenues for airport profitability. The existing complementarity between aeronautical and non-aeronautical business turns non-aeronautical operations into a strategic tool to raise airport profits. On the one hand, they have a direct impact on airport profits through commercial sales. On the other hand, they can foster the demand for aeronautical services (Bracaglia et al., 2014; Starkie, 2002, 2008; Zhang & Zhang, 2003, 2010; Adler et al., 2014; Oum et al., 2004; Yang & Zhang, 2011). Flores-Fillol et al. (2018) suggest that: *i)* when consumers are myopic, airports decrease aeronautical charges to attract more passengers and increase commercial sales, and *ii)* when consumers are foresighted, non-aeronautical operations are used as a tool to attract passengers at the terminal so that the airport can increase its aeronautical revenues. Consistently, our results align with these findings and show that this airport strategy is independent of the air-travel market structure.

Add-ons and consumer foresight. Typically, add-ons are used to exploit consumers' myopic behaviour and represent a significant source of profit (Verboven, 1999; Gabaix & Laibson, 2006; Ellison, 2005). Retail services can be considered as an add-on that complements the consumption of aeronautical services. As a consequence, passengers do not consider add-ons as a mere cost. When the airport faces myopic travelers, our findings align with the current literature. By contrast, when passengers are foresighted and account for retail prices, airports implement a *loss-leader pricing strategy* and retail services are priced at the marginal cost to induce a higher demand for aeronautical services.

Airport competition and two-sided markets. The literature on air transport has not really focused on the role of airports and airlines as platforms. Nevertheless, it seems that airports are a unique type of platform that connects several groups of agents. Bettini & Oliveira (2016) study the recent privatization of Brazilian airports and observe that profit-oriented airports develop strong network effects between aeronautical and non-aeronautical business similar to a multi-sided platform. Ivaldi et al. (2012) claim the multi-sided nature of airports because of their connecting role between airlines and passengers and in their article provide an empirical methodology to test it. Differently, Malavolti & Marty (2017) and Flores-Fillol et al. (2018) assert that the airport two-sided structure is based on the duality of its source of revenue (aeronautical and commercial). In our paper, airports compete and need to take into account the cross-demand elasticity between aeronautical and non-aeronautical business to design a profitable strategy. To our knowledge, this is the first article making a two-sided market analysis on airport competition. More general insights about platform competition can be found in Rochet & Tirole (2003) and Armstrong (2006a).

Our paper presents some differences with respect to the literature on two-sided markets and platform competition. First, the network externalities between airlines and retailers do not depend on a direct interaction between them. Indeed, what links aeronautical and non-aeronautical sector is their relative importance for the passengers who are the real end-users of the airports. In our paper, although potential passengers differ in their distance from the airport (or, more generally, willingness to pay), airports cannot price-discriminate on the basis of passengers' location as they can only charge uniform prices for aeronautical and non-aeronautical activities. Second, although the airport extracts all the profits from the non-aeronautical sector, it does not have full control over retail prices as it only decides the number of competing retailers. Finally, different from standard platform models, airlines are not atomistic and there is a double-marginalization problem that prevents airports from directly charging passengers.

In a similar framework, Flores-Fillol et al. (2018) analyze the case of a monopoly airport and find that airport profits increase as consumers become more foresighted. However, their analysis considers just one airport and their findings hold for specific values of consumer foresight. Our set-up has the advantage of being more tractable and general, so that we can qualitatively recover the monopoly results in Flores-Fillol et al. (2018)

for any degree of consumer foresight. Interestingly, airport competition crucially determines the effect of consumer foresight on airport profits. In the same way, airports' profit composition is also affected by airport market structure.

Hagiu & Hałaburda (2014) study the impact of consumer information on platform profits under monopoly and duopoly market structures. They show that, under monopoly, platforms are more profitable when facing informed users. Instead, this result is reverted under duopoly competition. Despite the substantial differences in terms of modeling, the rationale for this similarity stems from the common effect that *consumer information* and *consumer foresight* have on the aggregate demand. In Hagiu & Hałaburda (2014), buyers can exhibit either responsive or passive rational expectations over developers' participation. The way buyers are informed affects their responsiveness to changes in developers' prices. In the same way, consumer foresight affects the passengers' responsiveness to retail prices, thus affecting airport strategy.

The paper is structured as follows. Section 2 proposes an airport-specific model with the purpose of deriving clear results and derive managerial implications. Section 3 characterizes the airports' optimal choices under monopoly and duopoly. Section 4 analyzes the effect of airport competition on profits. Managerial implications are provided in Section 5. Finally, Section 6 concludes. Proofs are provided in the Appendix.

1.2 An airport model

Airports, in the upstream market, provide essential inputs to the downstream markets that serve the demand with a base good (aeronautical services) and a complementary add-on (retail services). In detail, we assume that: *i)* airports are dominated by a single carrier that pays a per-passenger landing fee for the use of its infrastructure (ℓ), *ii)* airports decide the number of concessions to award in the retail market (n).[5]

Passengers. Passengers derive utility from flying and making purchases at the ter-

[5] Although the monopoly airline assumption might appear strong, actually, several airports are dominated by a single carrier. However, assuming airline competition does not provide any additional information and, qualitatively, does not alter the sense of the paper.

minal. We consider a continuum of passengers with a linear utility function of the form $Z_i(p_A, \boldsymbol{p}_R; \theta) = z - s\theta_i + \delta\mathbb{E}[CS\,(\boldsymbol{p}_R)] - p_A$, where p_A is the airfare and $\boldsymbol{p}_R$ is the final retail price set by the n retailers; z is the gross benefit that passengers derive from traveling; $s > 0$ is the per unit cost born by travelers to reach the airport and $\theta \in [0,1]$ identifies traveler location; $\delta \in [0,1]$ is the *degree of consumer foresight*, with $\delta = 1$ identifying perfect foresight and $\delta = 0$ full myopia; and $\mathbb{E}CS\,(\boldsymbol{p}_R)$ is the *expected surplus* each passenger derives from the consumption of the retail product.[6] Consequently, if consumers are not fully myopic ($\delta > 0$), flight decisions are not independent from retail purchases. Passengers can purchase at most one flight ticket and have a zero outside option. Let $\widetilde{\theta}$ be the location parameter characterizing the indifferent consumer between flying or not. Thus, the demand for flights is defined as

$$Q(p_A, \boldsymbol{p}_R) = \int_0^{\widetilde{\theta}(p_A, p_R)} dF(\theta) = \frac{z - p_A + \delta\mathbb{E}[CS\,(p_R)]}{s}, \tag{1.1}$$

whenever this is positive.[7]

Retail market structure. Our retail structure recovers the one in Flores-Fillol et al. (2018). The n retailers sell a differentiated good and pays to the airport a fee f to stay in the terminal. Retailers are symmetrically distributed around a Salop circle of unit length, with $n \geq 2$. As already discussed, the retail product is available only to that segment of demand making use of aeronautical services. The mass of potential consumers is $Q(p_A, \boldsymbol{p}_R)$. Each consumer has a unit demand and a taste parameter x for the retail good, which is uniformly distributed over the support $[0,1]$ and identifies her position around the circle. When buying from the nearby retail firm located in x_j, a consumer located at x_i derives a utility of the form: $V_i(p_{R_j}; x_i) = v - p_{R_j} - t|x_i - x_j|$, where p_{R_j} is the price set by retailer j, $\forall j \in 1, ..., n$, $t > 0$ is the standard Salop *transportation cost* capturing product differentiation and v denotes the gross utility from retail. To ensure passengers will always anticipate a positive $\mathbb{E}[CS(p_R)]$, v is assumed to be sufficiently

[6]The sum $z - s\theta$ is the *passenger willingness to fly* that uniquely identifies travelers.

[7]By assuming that $\theta \sim U[0,1]$, we are implicitly allowing for a linear demand function.

high.[8] As it will become clear at a later stage, this implies

$$v > \frac{5}{8}t. \tag{1.2}$$

Demand and profits are derived in the standard way. By assuming symmetrically located retailers around the circle, the marginal consumer between firm j and one of its nearest rivals, say firm k, is $\widetilde{x}_{j,k} = (2n)^{-1} + (p_{R_k} - p_{R_j})/2t$. In a symmetric equilibrium, the demand for j becomes $Q_R(p_{R_j}, \boldsymbol{p_{-j}})Q(p_A, \boldsymbol{p_R}) = 2\widetilde{x}_{k,j}\left(p_{R_j}, p_{R_k}\right)Q(p_A, \boldsymbol{p}_R)$. After normalizing costs to 0, retailer i's profits are

$$\pi_j\left(p_A, p_{R_j}, \boldsymbol{p}_k, p_R\right) = p_{R_j}Q_R(p_{R_j}, p_{R_k})Q(p_A, \boldsymbol{p}_R) = \tag{1.3}$$
$$p_{R_j}\left(\frac{1}{n} + \frac{p_{R_k} - p_{R_j}}{t}\right)\frac{z - p_A + \delta\mathbb{E}[CS\left(\boldsymbol{p}_R\right)]}{s} - f. \tag{1.4}$$

When making their flight decision, travelers do not exhibit clear preferences over the retail product (they do not know their location x on the Salop circle), yet. Therefore, they are just able to form an expectation over the surplus they will enjoy from consuming retail services. Such expectation takes the form: $\mathbb{E}[CS(p_R)] = v - t/4n - p_R$, where v is the gross utility passengers derive from the consumption of retail services; p_R is the retail price; and $t/4n$ is the average mismatch disutility suffered by passengers when there is an imperfect alignment between their preferences and the services offered by the retailer.[9]

Lastly, it is important to underline that: *i)* retailers do no coordinate on a unique retail price, p_R; and *ii)* we assume that, unilaterally, a single retailer does not contribute to the airport demand formation, thus the yielded market price p_R only depends on the competition among retailers. In other terms, we might say that they hold passive expectation over the airport demand. Therefore, when setting their retail price p_i, they do not try to affect the general demand $Q(p_A, p_R)$.

[8]To avoid irregularities, another important assumption is $v < \frac{24}{5}z$.

[9]Without any loss of generalities, by recovering Salop (1979), we assume that passengers anticipate the Salop average consumer welfare minus an average price, p_R, $W(n, p_R) = 2n\int_0^{1/2n} v - tx - p_R\,dx = v - t/4n - p_R$. It is worthy to notice that such expectations are formed before passengers observe prices. Therefore, when setting their profit-maximizing prices, retailers will take the $\mathbb{E}[CS(p_R)]$ as part of an expectation they cannot change. In other words, at the time of setting their prices, they assume they cannot affect the overall demand.

The timing of the game is the following:

- First stage: Upstream choice. The airport sets the landing fee (ℓ) and the number of concessions to be awarded in the retail market (n);
- Second stage: Downstream choice. Retailers compete á la Salop and a unique price (p_R) is formed in the retail market; at the same time, the monopoly airline sets the airfare (p_A);
- Third stage: Consumer choice. Passengers observe (p_A, p_R) and make their travel decision.

1.3 Equilibrium analysis

In this section, we present two scenarios. In the first one, we analyze the case of a single airport providing services within a certain catchment area. In the second one, we turn to the case of two competing airports.

1.3.1 Monopoly

Consider a monopoly airport serving a certain catchment area. The airport is uncongested and dominated by a single carrier.[10]

The advantage of using such an approach is to have analytical solutions for the whole range of δ and a setting that can be easily compared with the duopoly case. We first analyze the second-stage equilibrium in which retailers and the single airline choose their prices and, then, we consider the first-stage equilibrium in which the airport sets the landing fee and the number of retail concessions to be awarded.

[10] As already stated in the introduction, such assumptions do not alter qualitatively the results of the paper as the way the downstream market is designed does not affect airport choices at the first stage, more precisely, a more fragmented airline market decreases the demand for the single airline, thus, scaling down profits.

Second stage. Retailers and the monopoly airline simultaneously choose prices. Retailers hold fixed expectations on $Q(p_A, p_R)$. As a consequence, their price decisions do not affect these expectations, i.e., $\partial \mathbb{E}CS(p_R)/\partial p_{R_j} = 0$.

Each retailer is involved in a symmetric price game with the other retailers and maximizes its profits, i.e., $\max_{p_{R_j}} \pi_j \left(p_A, p_{R_j}, \boldsymbol{p}_j, p_R\right) = p_{R_j} Q_R(p_{R_j}, \boldsymbol{p}_j) Q(p_A, \boldsymbol{p}_R) - f$. Similarly, the monopoly airline chooses optimally its airfare by solving $\max_{p_A} \pi_A \left(p_A, p_R\right) = \left(p_A - \ell\right) Q(p_A, \boldsymbol{p}_R)$. In line with the literature, aeronautical services are sold to airlines at a uniform per-passenger landing fee $\ell \geq 0$. [11]

Lemma 1 *The second stage equilibrium yields the following retail and airline prices:*

$$p_R(\ell, n) = \frac{t}{n}, \qquad p_A(\ell, n) = \frac{z+\ell}{2} + \frac{\delta}{2}\left(v - p_R\left(\ell, n\right) - \frac{t}{4n}\right). \tag{1.5}$$

In equilibrium, the retailers set the standard symmetric Salop price. The result obtained for the airfare is composed of a standard double-marginalization term plus a mark-up that depends on the degree of consumer foresight and the equilibrium consumer surplus from retail activities.[12] Therefore, as the retail surplus increases, the airline optimally responds by raising its fares. Given these results, we can rewrite the retail surplus anticipated by travelers as $\mathbb{E}[CS(n)] = v - 5t/4n$ and (1.1) as $Q\left(\ell, n\right) = (z - \ell)/2s + \delta(v - 5t/4n)/2s$. In equilibrium, the assumption in (1.2) guarantees that $\mathbb{E}[CS(n)]$ is strictly positive.

First stage. In the first stage, the airport maximizes profits by setting the landing fee and choosing the number of concessions to award in the retail market. By following Flores-Fillol et al. (2018), concessions are awarded such that the retailers have no rights on a potential extra-profit, e.g., by means of a first-price auction.[13] Therefore, the airport

[11] Allowing for $\ell < 0$ would not change qualitatively our results. It can be interpreted as the aeronautical mark-up obtained by the airports. Therefore the case $\ell < 0$ corresponds to a situation in which the airport sets the fee below its marginal cost to attract more passengers with the ultimate purpose of boosting revenues from the retail activity.

[12] Notice that retailers' fixed expectations over the general demand make that the airline has internalized the retail price in its optimal strategy, while retailers have set their price independently of the airline's choice.

[13] Imposing a sharing-rule ensuring positive profits for the concessionaires does not alter qualitatively

is able to fully extract profits from retail activities and charge the airline a per-passenger landing fee for the use of the infrastructure, thus we can write its profit maximization problem as $\max_{\ell \geq 0, n \geq 2} \Pi(\ell, n) = (\ell + p_R)\, Q\,(\ell, n)$. It is important to notice that an increased number of retailers leads to two significant consequences. First, the retail price, p_R, decreases due to the fiercer competition in the retail sector. Second, the probability of a perfect match between a passenger's preferences and the services offered by a retailer increases, thus decreasing the average disutility from a mismatch, $t/4n$.

Our analysis allows to differentiate between two different scenarios with respect to consumer foresight:

i) Myopic passengers, with $0 \leq \delta \leq 4/5$,

ii) Foresighted passengers, with $4/5 < \delta \leq 1$. [14]

Propositions 1 and 2 summarize the optimal airport choices in these two scenarios. Let us denote ℓ^* and n^* the equilibrium landing fee and the optimal number of retailers allowed to operate at the terminal.

Proposition 1 *When passengers are myopic (i.e.,* $0 \leq \delta \leq 4/5$*) the optimal landing fee and number of concessions chosen by the monopoly airport are given by*

$$\ell^* = \begin{cases} \frac{z - \frac{t}{n}}{2} + \frac{\delta}{2}\left(v - \frac{5t}{4n}\right) & if\ t < t_1, \\ 0 & if t \geq t_1, \end{cases} \qquad n^* = 2\,, \tag{1.6}$$

with $t_1 \equiv \dfrac{8(z + \delta v)}{4 + 5\delta}$.

When passengers are myopic, the airport sets relatively low landing fees and induce a high retail price by keeping a concentrated market structure on the retail side. On the one hand, when making their flight decision, myopic consumers' choice is mostly driven by the airfare, whereas the expectations over the retail surplus do not play a significant role. On the other hand, the airport is indifferent about making money through the aeronautical

our findings.

[14]The threshold 4/5 comes from the maximization problem. Details can be found in the proofs of Propositions 1 and 2.

or the commercial sector. As a consequence, the airport minimizes $\mathbb{E}[CS(n)]$ by setting an extremely concentrated retail market ($n = 2$), thus yielding the highest possible retail price p_R, and attracts more demand through the aeronautical sector by charging relatively low landing fees.[15]

Furthermore, by looking at the equilibrium landing fee in (1.6), we can observe that it is composed of two components: a fixed component, independent of consumer foresight, and a variable one whose extent depends on several factors, included δ. That variable component comes from the *one-way complementarity effect* of the non-aeronautical sector over the aeronautical one. The extent of this effect strictly depends on the profitability of the retail sector for the airport. As product differentiation (t) increases, the retail sector becomes more profitable and the airport optimally responds by lowering its landing fee, which can even reach 0 for $t > t_1$.

Higher levels of consumer foresight turn the non-aeronautical sector into a valuable tool to attract passengers rather than a source of profits for the airport, as it is stated in the following proposition.

Proposition 2 *When passengers are foresighted (i.e., $4/5 < \delta \leq 1$), the optimal landing fee and number of concessions chosen by the monopoly airport are given by*

$$\ell^* = \frac{1}{2}(z + \delta v), \qquad n^* \to \infty . \tag{1.7}$$

When passengers are foresighted, at the time of making their flight decisions, they are able to almost perfectly anticipate the retail surplus ($\mathbb{E}[CS]$). As a consequence, passengers have a more realistic perception of the true retail price (p_R) and of the average disutility from a mismatch ($t/4n$). From the airport's perspective, this raises the opportunity cost of inducing a higher retail prices by limiting the number of concession to award on the retail market.

Therefore, the airport sets the most fragmented market structure, $n^* \to \infty$, thus yielding the lowest possible retail price that equals its marginal cost 0 and eliminating the

[15] By modelling à la Salop the competition in the retail sector, we have implicitly ruled out the possibility for the platform to totally control the retail market structure. We have, indeed, two dimensions of competition, t and n, and we delegated only one to the platform choice.

mismatch disutility incurred by passengers. By doing so, $\mathbb{E}[CS(n)]$ increases and boosts the demand for flights. When δ is very high, the retail market loses its function as a source of profit and it is merely used by the airport as a tool to attract demand.

1.3.2 Duopoly

In this subsection, we builds our model on Armstrong (2006a) where we consider the presence of two competing airports. Differently from the previous scenario where passengers faced a zero outside option, here they have the alternative of going to a rival airport.[16]

We consider two airports competing à la Hotelling. Either airport is composed of a retail sector and an aeronautical sector. The timing of the game is the same used in the case of a monopoly airport: in the first stage, airports simultaneously and non-cooperatively set the landing fee and the number of concessions to be awarded in the retail market; in the second stage, in each airport, retailers and the monopoly airline choose their prices; finally, travelers make their travel decisions and payoffs are collected.

Airline and airport demand. The two airports, denoted 0 and 1, compete à la Hotelling and are located at the endpoints of a linear city of unit length.[17] Airports are differentiated and there is a unitary population of consumers with $\theta \sim U[0,1]$ identifying passenger location.

Airport demand is worked out in the standard way. Passengers decide which airport to fly from depending on the following indirect utility function: $Z_i(p_A, \boldsymbol{p}_R; \theta) = z + \delta\mathbb{E}[CS_h] - p_{A_h} - s|\theta_i - A_h|$, where $A_h = \{0, 1\}$ is the airport location; and general considerations on θ_i, δ, $\mathbb{E}[CS_h]$ and p_A still hold from the monopoly case. To conclude, s is the Hotelling transportation cost and captures the intensity of the competition between

[16] We focus on the case where the joint presence of the two airports fully serves the market. Considering the case with partially-served market would imply that either airport has a geographical monopoly over its catchment area, thus leading back to the monopoly case discussed in the previous subsection.

[17] The choice of the location does not affect qualitatively our results and does not impose any bounds to the analysis as the presence of an indicator of competition intensity ($s \in \Re^{++}$) allows us to analyze the equilibrium outcomes for different degrees of airport competition.

airports. Therefore, the marginal consumer is given by

$$\hat{\theta} = \frac{p_{A_1} - p_{A_0}}{2s} + \frac{\delta}{2s}\left(\mathbb{E}[CS_0] - \mathbb{E}[CS_1]\right) + \frac{1}{2}. \tag{1.8}$$

Since traveler are uniquely identified by their taste parameter, $\hat{\theta}$ identifies the demand for airport 0 and it allows to rewrite the demand for airport h as

$$Q_h(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta) = \frac{p_{A_{-h}} - p_{A_h} + s}{2s} + \frac{\delta}{2s}\left(\mathbb{E}[CS_h] - \mathbb{E}[CS_{-h}]\right) \quad {\scriptstyle h=\{1,0\},} \; . \tag{1.9}$$

Second stage. In both airports, retailers and airlines choose prices simultaneously. For a generic airport h, retailers and airlines maximize:

$$\pi_i\left(\boldsymbol{p_A}, p_{R_j}, p_k; \delta\right) = p_{R_j} Q_R(\boldsymbol{p_A}, p_{R_j}, p_{R_k}; \delta)\, Q_h(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta) - f \tag{1.10}$$

and

$$\pi_A\left(p_A\right) = \left(p_A - \ell\right) Q(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta), \tag{1.11}$$

respectively, obtaining the following results.

Lemma 2 *The optimal retail price is given by the standard Salop symmetric equilibrium outcome and the optimal airfare is composed of a standard Hotelling term plus a component depending on δ:*

$$p_{R_h}(\boldsymbol{\ell}, n_h) = \frac{t}{n_h}, \qquad p_{A_h}(\boldsymbol{\ell}, \boldsymbol{n}) = \frac{3s + 2\ell_h + \ell_{-h}}{3} + \frac{\delta}{3}\frac{5}{4}\left(\frac{t}{n_h} - \frac{t}{n_{-h}}\right). \tag{1.12}$$

The joint analysis of Lemmas 1 and 2 suggests that retailers, independently of the airport market structure, set-up a standard Salop price. Under fixed expectations, retailers do not react to airport competition and set a price independently of the actual degree of consumer foresight. Although there is a single airline in each of the airports, airlines inherit the competition from airports and charge an airfare that embodies part of the potential passenger retail surplus.

By using (1.12), the demand for an airport h can be rewritten as

$$Q_h(\boldsymbol{\ell}, \boldsymbol{n_R}; \delta) = \frac{\ell_{-h} - \ell_h + 3s}{6s} + \frac{\delta}{6s}\left(\frac{5}{4}\frac{t}{n_h} - \frac{5}{4}\frac{t}{n_{-h}}\right) \quad {\scriptstyle h=\{1,0\}}. \tag{1.13}$$

As we can observe in (1.13), the market share for each airline depends on the gap between the airports' choice variables ($\ell_{-h} - \ell_h$ and $n_{-h} - n_h$).

First stage. Airports fully extract profits from the retail market and compete by choosing landing fees and the number of concessions to allocate. Each airport is profit maximizer and, given the results in (1.12) and (1.13), chooses its optimal strategy by solving: $\max_{\ell_h \geq 0, n_h \geq 2} \Pi_h(\boldsymbol{\ell}, \boldsymbol{n}) = (\ell_h + p_{R_h})\, Q_h(\boldsymbol{\ell}, \boldsymbol{n})$, with $h = \{0, 1\}$.

Proposition 3 *When passengers are myopic (i.e., $0 \leq \delta \leq 4/5$), the optimal landing fee and number of concessions chosen by each duopoly airport are given by*

$$\ell_h^\star = \begin{cases} 3s - \frac{t}{2} & \text{if } \; 0 < \frac{t}{s} < 6 \\ 0 & \text{if } \; \frac{t}{s} \geq 6 \end{cases} \quad , \qquad n_h^\star = 2 \qquad {}_{h=0,1} \tag{1.14}$$

where superscript * denotes equilibrium values.

When travelers are myopic, each airport awards the minimum number of retail concessions and charges a landing fee below the standard Hotelling outcome. The airports set a relatively low landing fee to attract passengers to the terminals and induce high retail prices, so that the retail business is the more profitable one. The rationale behind these results stems from the myopic nature of passengers. Myopic passengers value more a cut in the airfare rather than a lower retail price. Thus, as in the monopoly case, airports optimally react by discounting the retail price from the landing fees, i.e., ($\ell^\star = 3s - p_R$) and inducing a positive retail price.

Moreover, the results in the above proposition depend on the ratio t/s. A low (high) t/s can be explained by either an intense (soft) competition within the retail sector or by a high (low) airport geographical market power. When t/s is relatively high (case $t/s > 6$), the retail product is very differentiated and retail competition is soft (or the airport geographical market power is very low), thus reinforcing the upward pressure on retail prices and making the non-aeronautical business more lucrative than the aeronautical one. As a consequence, the airport optimally responds by setting the lowest possible landing fee ($\ell^\star = 0$). When t/s is relatively low (case $t/s < 6$), the competition in the retail market is more intense (or the airport geographical market power is higher), which mitigates the effect of having a maximal retail concentration and allows the airport to raise its landing fee above 0.

The difference between the monopoly and the duopoly market structures is found by looking at the effect of δ on $\ell^\star$. In the monopoly case, $\delta > 0$ ensures the landing fee to embody a positive mark-up through the one-way complementarity effect from the retail activity. More precisely, the assumption in (1.2) along with the zero outside option guarantee the one-way complementarity effect from the retail activity to be effective in equilibrium so that the demand is increasing in δ. A higher consumer foresight attracts farther passengers, thus boosting air-travel demand, and strengthens the market power over the closest passengers. As a consequence, the airport optimally reacts by charging higher landing fees.[18] In the duopoly case, the equilibrium landing fee does not depend on δ. The rationale can be found going back to the consumer decision process. More precisely, an increase in δ exerts an upward pressure on landing fees to drain the exceeding new surplus from passengers, but competition exerts a downward pressure of the same magnitude. As a consequence, landing fees are kept at an inefficiently low level and consumer welfare increases.[19] Second, the size of the landing fee depends on the current frictions in the retail and aeronautical market, which can be summarized by the ratio t/s. The optimal landing fee in (1.14) is composed of two components: *i)* $3s$, which is a standard Hotelling outcome, and *ii)* $-t/n^\star$, which is the standard Salop price multiplied times -1.

Now, let us consider the case with foresighted consumers ($\delta > 4/5$). In this case, travelers have a higher valuation of their retail surplus and the following proposition arises.

Proposition 4 *When passengers are foresighted (i.e.,* $4/5 < \delta \leq 1$*), the optimal landing*

[18]Interestingly, when δ increases, the yielded raise in landing fees just partially erase the increment in air travel demand. Again, it reflects the trade-off faced by the airport in finding an optimal payment scheme for the two groups of passengers.

[19]The expression in (1.9) suggests that the role of δ comes to be relevant in determining the demand only when the difference $\mathbb{E}[CS_h] - \mathbb{E}[CS_{-h}] \neq 0$.

fee and number of concessions chosen by each duopoly airport are given by

$$\ell_h = 3s, \qquad n_h \to \infty \qquad {\scriptstyle h=0,1.} \tag{1.15}$$

When passengers are foresighted, each airport awards the maximum possible number of retail concessions (inducing low retail prices) and charges a higher landing fee. More precisely, passengers value more a boost in the retail surplus rather than a cut in the airfare. Therefore, airports compete on their common catchment area by offering the travelers the maximal possible retail surplus and inducing a low retail price ($p_R^\star = 0$). Thus, it turns out that only the aeronautical business is profitable.[20]

1.4 Profit analysis

Our previous results show how consumer foresight affects airport optimal choices under monopoly and duopoly. As it has been already discussed, we can highlight some similarities between the two market structures. When consumers are myopic, airports try to attract new passengers through the aeronautical sector (the one travelers value more) and make most profits through the retail sector (the one they value less). Alternatively, when consumers are sufficiently foresighted, they are attracted through the non-aeronautical sector and airport profits are totally driven by the aeronautical business.

Although these considerations are relevant for both market structures, airport profits and their composition are sensitive to changes in consumer foresight and market structure, as shown in the following proposition.

Proposition 5 *The impact of consumer foresight on airport profits differs between monopoly and duopoly.*

i) Under monopoly, airport profits are (strictly) increasing in consumer foresight.

ii) Under duopoly, airport profits are (weakly) decreasing in consumer foresight.

[20] Far from the monopoly case where the one-way complementarity effect of the retail sector boosts the aeronautical profits, the symmetry of the duopoly model makes ineffective the effect of any exogenous increase of consumer foresight on the air-travel demand.

Figure 1.1 and 1.2 show how profits evolve with consumer foresight under both market structures. The economic intuition of the above proposition is as follows.

Under monopoly, the most profitable payment scheme from the airport's perspective is $(\ell^\star, p_R^\star) = ((z+v)/2, 0)$, which is observed in equilibrium when consumers are perfectly foresighted ($\delta = 1$). In such a situation, the airport *i)* optimally exerts its market power over the passengers with a higher willingness to pay by charging the airline a high landing fees; and *ii)* boosts the demand for flights of those farther passengers by inducing a low retail price that increases $\mathbb{E}[CS]$. By contrast, when consumers exhibit a certain degree of myopia ($\delta < 1$), they undervalue the expected retail surplus and, as a consequence, the airport is unable to implement the aforementioned optimal strategy because of the lack of consumer responsiveness to retail prices. Therefore, when passengers are not perfectly foresighted, the monopoly airport induces a sub-profitable payment scheme.

Under competition, a duopoly airport induces a sub-profitable payment scheme whatever the exhibited degree of consumer foresight. Differently from the monopoly case, increasing values of consumer foresight do not boost the airport market share because of the symmetric competition between airports in presence of a fixed size demand.[21] Competition exerts a downward pressure on the airfare as it shrinks the airports' market power. Therefore, the airport is unable to implement the optimal strategy and induces a sub-profitable payment scheme. We obtain that, under duopoly competition, profits are insensitive to changes in consumer foresight. Notably, when the retail business is relatively more lucrative ($t/s > 6$), airports find it more profitable to face a myopic demand (see Figure 1.2).[22]

[21]The presence of symmetric competition rules out the advantages of having foresighted consumers. In the symmetric equilibrium, the demand function in (1.13) does not longer depend on δ as it is equally split between the two airports. In other words, changes in consumer foresight do not affect airports' catchment areas.

[22]When $t/s > 6$, airports have no incentives to foster competition in the retail market by raising the number of the concessions to be awarded. Intuitively, a lower retail price produces two opposite effects on airport profits: *i)* it exerts a downward pressure because it lowers the profitability of the non-aeronautical business; and *ii)* it exerts an upward pressure since it attracts farther passengers, thus increasing the air-travel demand. It turns out that the airport would never be compensated for lowering the retail price.

As already stated, changes in consumer foresight affect airport strategy and, consequently, profit formation.

Myopic passengers value more a cut in the airfare rather than a lower retail price. As a consequence, the airport discounts the extent of the retail price from the landing fees, thus inducing a lower airfare and a positive retail price.[23] Therefore, with myopic consumers, airport profits are driven by non-aeronautical revenues. By contrast, foresighted passengers have a better valuation of the expected retail surplus and, consequently, airports induce the lowest possible retail price $p_R = 0$ and raise landing fees. In this case, airport profits are fully driven by the aeronautical business, whereas the non-aeronautical one is used as a mere instrument to attract passengers.[24]

Although there is a common rationale explaining the airport's strategy under monopoly and duopoly, the observation of Figure 1.3 and 1.4 reveals the presence of significant differences between the two market structures. These figures depict profit composition for different values of δ, t and s under monopoly and duopoly, respectively.[25] In both figures, three areas can be identified: one describing a scenario where the airport makes profits exclusively from the aeronautical business (i.e., $\Pi_A > 0$ and $\Pi_R = 0$); another one capturing the other extreme situation where profits come exclusively from the non-aeronautical business (i.e., $\Pi_A = 0$ and $\Pi_R > 0$) and finally, another describing the intermediate situation where both sectors are remunerative (i.e., $\Pi_A > 0$ and $\Pi_R > 0$).

When consumers are foresighted ($\delta > 4/5$), then $n^\star \to \infty$ under both market structures, as we can see in Propositions 2 and 4. As a consequence, $\Pi_R = 0$ and profits come exclusively from the aeronautical business. This result holds irrespective of the degree of product differentiation in the retail business.

For this reason, under such payment scheme (p_A, p_R), airports earn higher profits.

[23]Depending on the actual market structure, the airport can either decide to totally or partially discount the extent of the retail price from the landing fee.

[24]By looking at Figure 1.2, we can observe that the threshold value $\delta = 4/5$ delimits two segments in the airport's profit function. Within each of these segments, profits remain unaltered as δ changes. The reason is that there is a perfect compensation between an increase (decrease) in $\ell^\star$ and a decrease (increase) in $p_R^\star$ due to the symmetric nature of airport competition.

[25]Airport profit function can be rewritten as $\Pi = \ell Q + p_R Q$ to highlight the source of profits: aeronautical (Π_A) and retail (Π_R).

When consumers are myopic ($\delta \leq 4/5$), profits can come either uniquely from the non-aeronautical business or from both businesses. In this case, we observe different results under monopoly and duopoly. As we can see from Propositions 1 and 3, $\ell^\star$ can be 0 depending on the particular values of t and t/s, respectively. Obviously, $\Pi_A = 0$ when $\ell^\star = 0$. The observation of Figures 1.3 and 1.4 shows the followings: under monopoly, the function that delimits the area where $\Pi_A > 0$ and the area where $\Pi_A = 0$ is increasing in δ, whereas under duopoly this function is independent of δ.

By juxtaposing Figure 1.3 and 1.4, we obtain the five regions displayed in Figure 1.5, where we consider $s = 1/2$ without loss of generality (s is just a shift factor). It can be observed that market structure has a relevant impact on profit composition in Regions II and IV.

In Region II, a monopoly airport makes profits from both businesses ($\Pi_A > 0$ and $\Pi_R > 0$) whereas a duopoly airport focuses exclusively on the retail business ($\Pi_A = 0$ and $\Pi_R > 0$).

This region is characterized by relatively high levels of consumer foresight and a soft competition in the retail market (high t). In the absence of airport competition, higher levels of consumer foresight increase the extent of the anticipated $\mathbb{E}[CS]$, thus boosting travelers' demand and enhancing the airport market power. As a consequence of the enhanced market power, a monopoly airport can set positive landing fees and induce a positive retail price. In the presence of duopoly competition, higher levels of consumer foresight make passengers better off, but it does not turn into a higher travelers' demand as it is of fixed size. Competition prevents airports from gaining market power when consumers are more forward looking. Consequently, a duopoly airport induces the lowest possible airfare p_A (by setting $\ell = 0$) and a positive retail price thus making the retail business the only profitable one.

In Region IV, a monopoly airport makes profits only from the retail business ($\Pi_A = 0$ and $\Pi_R > 0$) whereas a duopoly airport does it from both businesses ($\Pi_A > 0$ and $\Pi_R > 0$).

This region is characterized by relatively low levels of consumer foresight and a fierce competition in the retail market (low t). In the absence of competition, the airport can increase its demand by inducing a low airfare and exploit the lack of consumer responsiveness to retail prices to earn higher profits through the retail business. As a consequence, a monopoly airport fosters the demand by setting a 0 landing fee and induces the highest possible retail price. Under duopoly competition, it is not profitable for an airport to cut prices and to try to attract passengers from its rival's catchment area. As a consequence, airports find it optimal to set positive landing fees and to induce a positive retail price, thus making profits from both businesses.

1.5 Managerial implications

This section offers managerial implications related to the effect of airport competition on optimal landing fees and to the strategic effect of airport advertising about retail facilities.

1.5.1 Airport competition and optimal landing fee

By looking at the airport profitability in the duopoly case (see Figure 1.4), it is possible to observe that the aeronautical business is not profitable ($\Pi_A = 0$) when consumers are myopic ($\delta \leq 4/5$) and airports compete intensively ($t/s > 6$). Differently, when consumers are foresighted ($\delta > 4/5$), the source of profit changes and the only profitable business is the retail one. The analysis is similar in the monopoly case (see Figure 1.3), except for the presence of an intermediate region where both businesses are profitable, so that the transition between the two extreme situations is more gradual.

When competition between airports is less intense ($t/s < 6$), a duopoly airport is able to make money from both businesses, whereas under monopoly $\Pi_A = 0$. In this case, it is easy to verify that landing fees are higher under duopoly competition than under monopoly, as stated in the following proposition.

Proposition 6 *When $s > \hat{s}$, airport competition leads to higher landing fees, with* $\hat{s} = \dfrac{(4-5\delta)t + 4n(\delta v + z)}{24n}$.

The rationale behind this result lies on two main reasons: *i*) airport competition is inherited by airlines that set a lower airfare p_A, thus allowing airports to set higher landing fees and *ii*) under monopoly, the airport faces a larger catchment area than under duopoly competition. Therefore, the airport optimally gives up aeronautical revenues to boost the demand and to make higher revenues through the retail sector.[26]

When there are no rivals, the lack of competition favors the airline that can exert its market power and can exploit the one-way complementarity with the retail sector, thus leaving less space to the airport to set high landing fees. In addition, the airport can benefit of a bigger catchment area; therefore, it optimally moderates the extent of the airfare by setting low landing fees and makes profits through the retail sector. The rationale of this profit-maximizing behavior can be so explained. When $0 < \delta < 4/5$, passengers are myopic and the surplus they derive on the retail side plays a marginal role in their travel decision because they are more sensitive to changes in the airfare. As a consequence, the airport sets lower landing fees under duopoly to attract more passengers and make money through the retail sector. When $4/5 < \delta < 1$, landing fees are lower than the duopoly level which is justified by the higher number of passengers the airport can attract.[27]

With airport competition, airlines cannot longer exploit the one-way complementarity with the retail sector to set high fares as passengers have a valid alternative. This is the first condition pushing airports to set higher landing fees. At this point, we can distinguish two cases depending on the extent of the airport differentiation. First, when airport differentiation is high $s > \hat{s}$, airports can enjoy of a relatively high geographical monopoly over their catchment areas, so they do not find it profitable to cut their prices to attract passengers from its rival and make profits through the retail sector. Both effects

[26]Logically, profits are higher under monopoly than under duopoly competition.

[27]However the extent of such fees is not fixed and increases with the degree of consumer foresight, δ. Indeed, from the airport's perspective, the relative profitability of the aeronautical sector over the retail sector increases with δ. When $0 < \delta < 4/5$, the airport induces high retail prices. As δ goes to 4/5, passengers become more aware of the high retail prices and the airport finds more profitable to subordinate the retail business in favour of a more profitable aeronautical business by increasing its fees. When $4/5 < \delta \leq 1$, retail prices are fixed at 0 so that the retail sector is no longer a source of profits for the airport. However, as we move toward $\delta = 1$, passengers gets increasingly aware of the benefits they derive on the retail side and the airport finds profitable to raise its fees.

push landing fees above the monopoly level. Second, when airport differentiation s is below this critical value, the two airports are more substitutable for passengers and price competition keeps the value of the landing fees below the monopoly level.

1.5.2 Airport advertising strategy

A second managerial implication can be derived from Proposition 5. A monopoly airport would be interested in facing foresighted consumers as its profit increases with δ. Instead, a duopoly airport would take advantage from serving a myopic demand, as its profits are non-increasing in δ. Although consumer foresight is assumed to be exogenous, it could be affected by the airport through advertising campaigns. In the light of our results, a monopoly airport would be clearly prone to truthfully inform passengers about its retail facilities. Instead, this strategy cannot be necessarily sustained in the presence of airport competition.

Proposition 7 *Under competition, an airport is not necessarily interested in informing passengers about its retail facilities.*

A monopoly airport is interested in informing passengers about the retail services offered at the terminal as it can exploit the complementarity between the services to increase the demand, thus strengthening its market power and making higher profits. By contrast, under duopoly, symmetric competition prevents airports from exploiting such complementarity. As a consequence, if the retail business is highly profitable, airports are more interested in facing myopic passengers and making profits through overcharged side-services.

Interestingly, while for a monopoly airport it is unambiguously profitable to truthfully inform passengers about its retail facilities, it is not that clear when considering a duopoly airport. On the one hand, a duopoly airport might find it more profitable to keep passengers uninformed and make profits by selling overcharged retail services. On the other hand, not informing passengers when the rival airport does might translate into a loss of demand and profits. The following analysis studies the information strategy of a duopoly airport.

Extension including airport advertising. Let us consider a game where the competing airports decide whether to inform potential travelers about the retail facilities in their terminals through advertising campaigns or not to inform them. By looking at the profit evolution in Figure 1.2, it is possible to observe that when the retail sector is profitable enough ($t/s > 6$), airports would be better off when facing myopic consumers ($0 < \delta < 4/5$). In the analysis that follows, we restrict our attention to a relevant case in which airport competition (t/s) is intermediate and the gross retail surplus (v) is high enough.[28] Moreover, without any loss of generality, we assume that advertising campaigns are costless for the airports.

Therefore, it is interesting to insert a stage 0 into our previous game where the airports decide whether to set an advertising campaign or not. This choice is represented by an airport-specific information-disclosure variable denoted by $\xi_h \in \{0,1\}$ with $h \in \{0,1\}$. Consequently, the profits of airport h can be expressed by $\Pi_h(\xi_h, \xi_{-h})$, giving rise to the game displayed in Figure 1.6.

From the point of view of airport h, consumers turn to have the following indirect utility function: $Z_i(p_A, \boldsymbol{p}_R, \xi; \theta) = z + \xi_h \delta \mathbb{E}[CS_h] - p_{A_h} - s|\theta_i - A_h|$. More specifically, we can identify two cases: *i)* $\xi_h = 0$, the airport does not set advertising campaigns and consumers are not informed at all about the retail facilities in the terminal; and *ii)* $\xi_h = 1$, consumers are informed and they are characterized by their innate degree of consumer foresight.[29]

The payoffs presented in Figure 1.6 refer to the results we derive from the duopoly case in Section 4.2, where we implicitly assume that both airports exogenously do inform/not inform travelers about the retail services ($\Pi_h(0,0), \Pi_h(1,1)$). The results for the asymmetric case in which one airport informs the consumers and the other does not

[28]More precisely, we consider $6 < t/s < 18$ and $v > \frac{45st-180s^2}{4t}$.

[29]Despite related, consumer foresight and consumer information are not the same concept as the myopia defines the characteristic that is inherent to a consumer who might fail to perfectly anticipate a utility she will derive in the future. Therefore, it cannot be chosen by the airport. Differently, consumer information can more easily be affected by the airport. In this particular case, a lack of information ($\xi_h = 0$) corresponds to a fully myopic case, while informed consumers ($\xi_h = 1$) still exhibit their natural degree of consumer foresight.

$(\Pi_h(1,0), \Pi_h(0,1))$ are derived in the appendix.

As in the previous sections, we consider the case of myopic and foresighted consumers. When $0 < \delta < 4/5$, travelers are myopic and they can anticipate a small percentage of the $\mathbb{E}[CS]$ and airports can induce a high price for the retail services and make profits rather than use them as an instrument to boost the demand. However, by looking at the profit evolution in Figure 1.2, we find that airports airports are indifferent about ξ as they will end up making the same profits. Instead when $4/5 < \delta < 1$, travelers are foresighted and they can anticipate a high percentage of $\mathbb{E}[CS]$, thus *forcing* the airports to induce a price for the retail services equal to the marginal cost (0 in this case) and use them to boost the demand. In this specific case, airports have an unambiguous incentive to not set any advertising campaign and keep passengers uninformed. As a consequence, the following proposition can be derived.

Proposition 8 *Airport h profits are ordered as follows:* $\Pi_h(1,0) > \Pi_h(0,0) > \Pi_h(1,1) > \Pi_h(0,1)$. *Consequently, airports face a Prisoner's Dilemma as they are better off facing uninformed passengers, but they end up informing them by choosing* $\xi_0 = \xi_1 = 1$.

The intuition of the above result deals with the $\mathbb{E}[CS]$. When v is high enough ($v > v^\star$), the extent of the expected retail surplus $\mathbb{E}[CS]$ is significant and boosts the demand that is attracted by the airport that decides to inform the passengers. Therefore, although a non informing airport could exploit the hidden nature of the retail products and keep their price at the maximum without affecting the passengers' decision, the demand would be too low and $\Pi_h(1,1) > \Pi_h(0,1)$. Therefore, informing passengers creates such an important advantage for the informing airport that the rival is forced to align and inform passengers as well.

1.6 Conclusion

In a framework where a multi-product airport faces passengers exhibiting a certain degree of consumer foresight, competition leads to significant implications. Our paper tries to capture some of them and yields the following results. First, the airports' strategy is insensitive to changes in market structure: in the presence of myopic passengers, it is optimal to charge low landing fees and induce high retail prices, so that the main source of profits is the retail business. Instead, when passengers are foresighted, airports optimally charge higher landing fees and induce lower retail prices. Second, the relationship between profits and consumer foresight strictly depends on the considered market structure. A monopoly airport can exploit the complementarity of the retail business to attract more passengers and, consequently, the effect of consumer foresight on airport profits is positive. Instead, under duopoly, the threat of competition prevents airports from using the aforementioned strategy and a weakly-negative correlation between airport profits and consumer foresight is observed.

These results yield two main managerial implications. First, airport competition can lead to higher landing fees. Second, under competition, an airport is not necessarily interested in informing passengers about its retail facilities. However, the huge investments in advertising campaigns operated by airports suggest two possible scenarios: *i)* a first one where passengers are foresighted and airport competition in most catchment areas is not very intense; and *ii)* a second one characterized by myopic passengers and harsh airport competition.

Moreover, the main findings of the model suggest two testable hypotheses about the implications that the digital revolution have on the air-travel industry. With more informed passengers, airports have an incentive to expand the commercial area and to enhance the passenger overall travel experience. From the retailers' perspective, facing more informed customers translates into a harsher retail competition to offer the best personalized experience and to drive down prices.

Nonetheless, this model just partially captures the complexity of multi-sided platforms and consumer foresight. Primary activities are usually supported by a notable amount of complementary services and add-ons, each one with a different degree of complementarity. Heterogeneity in the degree of complementarity between services and primary activities can lead to the formation of more complex strategies.[30] Furthermore, this paper assumes

[30]For example, the *non-aeronautical sector* is composed of numerous services, e.g, car parking, shops and restaurants, real estate services, ground connections and so forth. Each one has a different degree of

consumer foresight to be homogeneous across passengers. The reality suggests that airports face a wide diversity of travelers, who are, among all, characterized by different degrees of consumer foresight. Moreover, we assume that airports do not have to compete for retailers. Actually, airports can make use of exclusive contracts to exclusively attract retailers at the airport. These limitations suggest extensions of our model which are left for future research.

complementarity with the aeronautical sector.

Appendix A: Proofs

Proof of Proposition 1 and 2.

The airport profit function $\Pi(\ell, n) = \left(\ell + \frac{t}{n}\right) Q(\ell, n)$ yields the following first-order derivatives:

$$\frac{\partial \Pi(\ell, n)}{\partial \ell} = Q(\ell, n) + \frac{\partial Q(\ell, n)}{\partial \ell}(\ell + \frac{t}{n}), \tag{A-1}$$

$$\frac{\partial \Pi(\ell, n)}{\partial n} = -\frac{t}{n^2}Q(\ell, n) + \frac{\partial Q(\ell, n)}{\partial n}(\ell + \frac{t}{n}). \tag{A-2}$$

Furthermore, notice that $\Pi(\ell, n)$ is concave in ℓ and that, as long as $t < \frac{8(z+\delta v)}{4+5\delta}$, $\lim_{\ell \to 0} \frac{\partial \Pi(\ell,n)}{\partial \ell} > 0$ and $\lim_{\ell \to \infty} \frac{\partial \Pi(\ell,n)}{\partial \ell} < 0$. These conditions along with continuity of $\Pi(\ell, n)$ imply that for an interior solution to exist, the following condition has to be satisfied: $\frac{\partial \Pi(\ell,n)}{\partial \ell}|_{\ell=\ell^*(n)} = 0$. Then, from (A-1) we can work out $\ell^*(n)$. By substituting it in (A-2), we obtain

$$\left.\frac{\partial \Pi(\ell, n)}{\partial n}\right|_{\ell=\ell^*(n)} = -\frac{t}{n^2}Q(\ell^*(n), n) + \left.\frac{\partial Q(\ell, n)}{\partial n}\right|_{\ell=\ell^*(n)}(\ell^*(n) + \frac{t}{n}), \tag{A-3}$$

where $\ell^*(n) = \frac{(4-5\delta)t+(4n(\delta v+z))}{8n}$, $\left.\frac{\partial Q(\ell, n)}{\partial n}\right|_{\ell=\ell^*(n)} = \frac{5\delta t}{8n^2 s}$, $Q(\ell^*(n), n) = \frac{(4-5\delta)t+(4n(\delta v+z))}{16ns}$.

By rearranging (A-3) and defining $\phi(\delta) \equiv \frac{(5\delta-4)t}{4(z+\delta v)}$ and $\psi(\delta) \equiv \frac{(z+\delta v)(5\delta-4)t}{16n^3 s}$, we obtain

$$\frac{\partial \Pi(\ell, n)}{\partial n} = \psi(\delta)\left[n - \phi(\delta)\right], \tag{A-4}$$

where

$$\phi(\delta) \begin{cases} < 0 & if\ 0 \le \delta < \frac{4}{5} \\ = 0 & if\ \delta = \frac{4}{5} \\ > 0 & if\ \frac{4}{5} < \delta \le 1 \end{cases}, \qquad \psi(\delta) \begin{cases} < 0 & if\ 0 \le \delta < \frac{4}{5} \\ = 0 & if\ \delta = \frac{4}{5} \\ > 0 & if\ \frac{4}{5} < \delta \le 1 \end{cases}. \tag{A-5}$$

The case of $\delta = \frac{4}{5}$ yields $\frac{\partial \Pi(\ell,n)}{\partial n} = 0\ \forall n$ and, therefore, has not been considered.
Now, consider first the case in Proposition 2, i.e., $0 \le \delta < \frac{4}{5}$. An interior would exist if

satisfying the condition

$$n = \phi(\delta). \tag{A-6}$$

When $0 \leq \delta < \frac{4}{5}$, $\phi(\delta) < 0$ so that an interior solution for n cannot exist because it can obtain only positive values. Indeed, by looking at the sign of (A-4):

$$\frac{\partial \Pi(\ell, n)}{\partial n} = \underbrace{\psi(\delta)}_{<0} \left(\underbrace{n - \phi(\delta)}_{>0} \right) < 0. \tag{A-7}$$

As we can observe, the expression in (A-7) is negative $\forall n \in [2, +\infty)$ as $\phi(\delta) < 0$ is always negative for that range of δ. Therefore, we obtain a corner solution, namely $n = 2$.
Now consider the case in Proposition 2, i.e., $\frac{4}{5} < \delta < 1$. Here, $\phi(\delta) > 0$ so that a critical point could exist if $\phi(\delta) \geq 2$. The function $\phi(\delta)$ is strictly increasing in δ and t; thus, by evaluating it at $\delta = 1$ and $t \to t^{max}$, it is possible to find un upper bound for $\phi(\delta)$. It is necessary to recall that $v < 24z/5$ and $v > 5t/8$ and, therefore, $t < 192z/25$.

By replacing them in $\phi(1)$, we obtain $\phi^{max} = \frac{192z/25}{z+24z/5} < 1$, where $\phi^{max} < n^{min} = 2$, so that an interior solution is not possible.
Again, by analyzing the sign of (A-4):

$$\frac{\partial \Pi(\ell, n)}{\partial n} = \underbrace{\psi(\delta)}_{>0} \left(\underbrace{n + \phi(\delta)}_{>0} \right) > 0. \tag{A-8}$$

From (A-8) we notice that the first-order derivative is positive, meaning that $n \to \infty$. Q.E.D.

Proof of Proposition 3 and 4.

The proof of these propositions follows the same intuition as in the proof of Propositions 3 and 4.
The profit function of a generic airport h is defined as $\Pi_h(\boldsymbol{\ell}, \boldsymbol{n}) = (\ell_h + p_{R_h})\, Q_h\, (\boldsymbol{\ell}, \boldsymbol{n})$ and

yields the following first-order derivatives:

$$\frac{\partial \Pi(\boldsymbol{\ell},\boldsymbol{n})}{\partial \ell_h} = Q_h(\boldsymbol{\ell},\boldsymbol{n}) + \frac{\partial Q_h(\boldsymbol{\ell},\boldsymbol{n})}{\partial \ell_h}(\ell_h + \frac{t}{n_h}), \tag{A-9}$$

$$\frac{\partial \Pi(\boldsymbol{\ell},\boldsymbol{n})}{\partial n_h} = -\frac{t}{(n_h)^2} Q_h(\boldsymbol{\ell},\boldsymbol{n}) + \frac{\partial Q_h(\boldsymbol{\ell},\boldsymbol{n})}{\partial n_h}(\ell_h + \frac{t}{n_h}). \tag{A-10}$$

By following the same framework of the previous proof, notice that $\Pi_h(\boldsymbol{\ell},\boldsymbol{n})$ is strictly concave in ℓ_h; furthermore, as long as $\frac{t}{s} < 6$, $\lim_{\ell_h \to 0} \frac{\partial \Pi(\boldsymbol{\ell},\boldsymbol{n})}{\partial \ell_h} > 0$ and $\lim_{\ell_h \to \infty} \frac{\partial \Pi(\boldsymbol{\ell},\boldsymbol{n})}{\partial \ell_h} < 0$. These conditions along with continuity of $\Pi_h(\boldsymbol{\ell},\boldsymbol{n})$ implying that, for an interior solution to exist, the following condition has to be satisfied: $\frac{\partial \Pi(\boldsymbol{\ell},\boldsymbol{n})}{\partial \ell_h}|_{\ell_h} = \ell_h^*(\boldsymbol{n},\ell_{-h}) = 0$. Because of the symmetry of the problem, the first-order derivatives can be, generically, rewritten as a function of ℓ and n, i.e.,

$$\frac{\partial \Pi(\ell,n)}{\partial \ell} = Q(\ell,n) + \frac{\partial Q(\ell,n)}{\partial \ell}(\ell + \frac{t}{n}), \tag{A-11}$$

$$\frac{\partial \Pi(\ell,n)}{\partial n} = -\frac{t}{n^2} Q(\ell,n) + \frac{\partial Q(\ell,n)}{\partial n}(\ell + \frac{t}{n}). \tag{A-12}$$

Thus, from (A-11), we can easily work out $\ell = \ell^*(n)$. By substituting it in (A-12) we obtain:

$$\left.\frac{\partial \Pi(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)} = -\frac{t}{n^2} Q(\ell^*(n),n) + \left.\frac{\partial Q(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)}(\ell^*(n) + \frac{t}{n}), \tag{A-13}$$

where: $\ell^*(n) = 3s - \frac{t}{n}$, $\left.\frac{\partial Q(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)} = \frac{5\delta t}{24 n^2 s}$, $Q(\ell^*(n),n) = \frac{1}{2}$.

By rearranging (A-13), we get

$$\left.\frac{\partial \Pi(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)} = \frac{(5\delta - 4)t}{8n^2}. \tag{A-14}$$

When $0 \leq \delta < \frac{4}{5}$ (the case relative to Proposition 3), we notice that, once applied symmetry, the $\left.\frac{\partial \Pi(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)} < 0$, so that we end up having the corner solution $n = 2$. Instead, when $\frac{4}{5} < \delta \leq 1$ (the case analyzed in Proposition 4), $\left.\frac{\partial \Pi(\ell,n)}{\partial n}\right|_{\ell=\ell^*(n)} > 0$ and the function tends to its maximum as $n \to \infty$. Q.E.D.

Appendix B: Extension including airport advertising

From the above analysis, we already know that $\Pi_h(0,0) > \Pi_h(1,1)$ when $t/s > 6$ and $4/5 < \delta \leq 1$. Therefore, in order to establish the ordering of profits in Proposition 8, we need to derive the payoffs for the asymmetric case in which just one of the two competing airports informs passengers about the retail facilities, i.e., $\xi_h \neq \xi_{-h}$ with $h \in \{0,1\}$.

Airline and airport demand. As in the previous section, the two airports compete à la Hotelling and are located at the endpoints of a linear city of unit length and $\theta \sim U[0,1]$ identifies passenger location. Differently from the previous section, travelers have the following indirect utility function:

$$Z_i(p_A, \boldsymbol{p}_R; \theta) = \begin{cases} z + \delta \mathbb{E}[CS_h] - p_{A_h} - s|\theta_i - A_h| & \text{if the airport-h provides information,} \\ z - p_{A_h} - s|\theta_i - A_h| & \text{otherwise.} \end{cases} \tag{B-1}$$

where, general considerations on θ_i, δ, $\mathbb{E}[CS_h]$ and p_A still hold from the previous sections. If passengers are not informed about the presence of retail facilities at the terminal, they behave in a fully myopic way. However, it is important to make two observations: *i)* since $\mathbb{E}[CS_h] > 0$ by construction, when $p_{A_h} = p_{A_{-h}}$ passengers derive a higher utility by joining the airport providing information and *ii)* when considering the *non-informing* airport, passengers do not take into account the price charged in the retail sector, which acts as a hidden cost.

By assuming that the airport located at h is the informing one, airports' demand turn to be

$$Q_h(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta) = \frac{p_{A_{-h}} - p_{A_h} + s}{2s} + \frac{\delta}{2s}\mathbb{E}[CS_h], \tag{B-2}$$

$$Q_{-h}(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta) = \frac{p_{A_h} - p_{A_{-h}} + s}{2s} - \frac{\delta}{2s}\mathbb{E}[CS_h]. \tag{B-3}$$

Second stage. In both airports, retailers and airlines choose prices simultaneously. For a generic airport h, retailers and airlines maximize:

$$\pi_j\left(\boldsymbol{p_A}, p_{R_j}, p_{R_k}; \delta\right) = p_{R_j} Q_R(\boldsymbol{p_A}, p_{R_j}, p_{R_j}; \delta)\, Q_h(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta) \tag{B-4}$$

and

$$\pi_A\left(p_A\right) = \left(p_A - \ell\right)\ Q_h(\boldsymbol{p_A}, \boldsymbol{p_R}; \delta), \tag{B-5}$$

respectively, obtaining the following results.

Claim 1 *The optimal retail price is given by the standard Salop symmetric equilibrium outcome and the optimal airfare is composed of a standard Hotelling term plus a component depending on* δ*:*

$$p_{R_h}(\boldsymbol{\ell}, \boldsymbol{n}) = \frac{t}{n_h}, \qquad p_{A_h}(\boldsymbol{\ell}, \boldsymbol{n}) = \frac{3s + 2\ell_h + \ell_{-h}}{3} + \frac{\delta}{3}\frac{5}{4}\frac{t}{n_h}, \tag{B-6}$$

$$p_{R_{-h}}(\boldsymbol{\ell}, \boldsymbol{n}) = \frac{t}{n_{-h}}, \qquad p_{A_{-h}}(\boldsymbol{\ell}, \boldsymbol{n}) = \frac{3s + 2\ell_{-h} + \ell_h}{3} - \frac{\delta}{3}\frac{5}{4}\frac{t}{n_h}. \tag{B-7}$$

From the analysis of Lemma 1, we observe that retailers, independently of the information provided by the airport, set-up a standard Salop price. Indeed as specified in the previous sections, under fixed expectations, retailers do not react to airport competition and set a price independently of the actual degree of consumer foresight. Differently, by looking at the prices set by the airlines, it is possible to observe that they are affected by the information provided by the airports. Indeed, if the airport provides information, travelers anticipate the surplus from the retail sector and the airline can set a higher airfare; otherwise, it has to set a lower airfare to attract more passengers.

By using (B-7), airports' demand can be rewritten as

$$Q_h(\boldsymbol{\ell}, \boldsymbol{n}; \delta) = \frac{\ell_{-h} - \ell_h + 3s}{6s} + \frac{\delta}{6s}\frac{5}{4}\frac{t}{n_h}, \tag{B-8}$$

$$Q_{-h}(\boldsymbol{\ell}, \boldsymbol{n}; \delta) = \frac{\ell_h - \ell_{-h} + 3s}{6s} - \frac{\delta}{6s}\frac{5}{4}\frac{t}{n_h} \quad . \tag{B-9}$$

First stage. Airports compete by choosing landing fees and the number of concessions to allocate. Each airport is profit maximizer and, given the results in (B-6), (B-7) and (B-3), chooses its optimal strategy by solving: $\max_{\ell_h \geq 0, n_h \geq 2} \Pi_h(\boldsymbol{\ell}, \boldsymbol{n}) = \left(\ell_h + p_{R_h}\right) Q_h\left(\boldsymbol{\ell}, \boldsymbol{n}\right)$, with $h = \{0, 1\}$.

Claim 2 *When passengers are myopic (i.e., $0 \leq \delta \leq 4/5$), the optimal landing fee and number of concessions chosen by the airports are given by*

$$\ell_h^\star = \begin{cases} 3s - \frac{t}{2} + \frac{\delta}{3}(v - \frac{5}{4}\frac{t}{2}) & \textit{if } \ 0 < \frac{t}{s} < \frac{72}{12-5\delta} \\ \frac{1}{2}(3s - \frac{t}{2} + \delta(v - \frac{5}{4}\frac{t}{2})) & \textit{if } \ \frac{t}{s} > \frac{72}{12-5\delta} \end{cases}, \tag{B-10}$$

$$\ell_{-h}^\star = \begin{cases} 3s - \frac{t}{2} - \frac{\delta}{3}(v - \frac{5}{4}\frac{t}{2}) & \textit{if } \ 0 < \frac{t}{s} < \frac{72}{12-5\delta} \\ 0 & \textit{if } \ \frac{t}{s} \geq \frac{72}{12-5\delta} \end{cases}, \qquad n_h^\star = n_{-h}^\star = 2. \tag{B-11}$$

where superscript * denotes equilibrium values.

When travelers are myopic, each airport awards the minimum number of retail concessions and charges a relatively low landing fee, although the one charged by the informing airport might be above the standard Hotelling outcome.[31] Analogously to the airfare in the second stage, the landing fees embody the informative role of the airport. Indeed, as in the monopoly case, the informing airport can benefit of a positive mark-up given by the one-way complementarity with the retail sector, whereas the opposite holds for the non informing airport.

Generally, the rationale is the same of the monopoly and duopoly model observed in the previous sections: when consumers are myopic, they value more a lower airfare rather than a cut in the retail prices. Therefore, both airports induce the highest possible retail price by allowing for a concentrated retail sector and set relatively low landing fees to attract more passengers.

Also in this case, the results in the above claim depend on the ratio t/s. However, differently from the previous sections, we focus the explanation around the changes in s, that can be considered the airport geographical market power. When t/s is relatively high (case $t/s > \frac{72}{12-5\delta}$), because of the high competition, the airport geographical market power is very low, thus strengthening the position of the informing airport that can increase its customer base through the retail sector and set a positive landing fee and deteriorating the position of the non informing airport that responds by setting the lowest possible landing fee ($\ell_{-h}^\star = 0$). When t/s is relatively low (case $t/s < \frac{72}{12-5\delta}$), the competition is

[31] When $v > \frac{12t+5\delta t}{8\delta}$, the mark-up given by the one-way complementarity with the retail sector through $\mathbb{E}[CS_h]$ is so high that the airport can set landing fee above the standard Hotelling outcome.

less intense and the airport geographical market power is higher, high levels of s enhance the role of local monopolist held by either airports which can set positive landing fees.

It is worthy to observe that, when studying the asymmetric duopoly, we recover the role of δ on $\ell^\star$ which we found in the monopoly case. While in the symmetric case the airports make identical choices, thus off-setting the effect on the landing fees of the one-way complementarity, in the asymmetric case airports behavior when setting landing fees critically changes depending on whether passengers were informed or not.

Now, let us consider the case with foresighted consumers ($\delta > 4/5$). In this case, travelers have a higher valuation of their retail surplus and the following claim arises.

Claim 3 *When passengers are foresighted (i.e.,* $4/5 \leq \delta \leq 1$*), the optimal landing fee and number of concessions chosen by the airports are given by*

$$\ell_h^\star = \frac{3s + \delta v}{2}, \qquad n_h^\star \to \infty, \tag{B-12}$$

$$\ell_{-h}^\star = 0, \qquad n_{-h}^\star = 2. \tag{B-13}$$

When passengers are foresighted, they value more a decrease in the retail price rather than a cut in the airfare, but if not informed, they just focus on the airfare.

On the one hand, the strategy of the informing airport is not different from what we observed in the monopoly and symmetric duopoly cases, since passengers value more a decrease in the retail price, the airport allows concessions to make the retail sector as fragmented as possible, thus inducing a low retail price (zero in this case) and set high landing fees. Therefore, it turns out that only the aeronautical business is profitable.

On the other hand, the strategy of the non informing airport changes totally from what we have observed in the previous sections as the airport keeps the retail sector concentrated and set landing fees at the marginal cost (zero in this case). The rationale for this strategy can be explained through the passenger behavior. First, since passengers are not informed about the presence of the retail facilities, they are not aware about the presence of a retail price. Indeed, the retail price for a non informing airport cannot be used as an instrument to boost the demand by attracting travelers, thus it turns out that it would be unprofitable to induce a $p_{R_{-h}}^\star \neq p_{R_{-h}}^{max}$. Therefore, the non informing airport award the minimum possible number of concessions. Finally, to boost the demand and try to compete with the informing airport, the airport sets the lowest possible landing fees $\ell^\star_{-h} = 0$ and makes profits through the non-aeronautical sector.

It is now possible to make a precise ordering of the profits when $t/s > 6$. Consistently with the rest of the paper, we consider the case for myopic and foresighted consumers. For the sake of notation, let us use the subscript "S" to refer to the case in which just a single airport provides information and, for simplicity, we refer to airport h as the airport that informs travelers about its retail services, when the other doesn't.

When $0 < \delta < 4/5$ and both airports behave in the same way ($\xi_h = \xi_{-h}$), the equilibrium values are the same $n^\star_h = n^\star_{-h}$ and $\ell^\star_h = \ell^\star_{-h} = 0$ and the demand is perfectly split, therefore $Q^*_h = Q^*_{-h} = 1/2$, with $h \in \{0,1\}$. When $0 < \delta < 4/5$ and airports' choice is different ($\xi_h \neq \xi_{-h}$), we derive from the observation of (B-10), (B-11) and (1.15) that $n^\star_h = n^\star_{-h} = n^\star_{S,h} = n^\star_{S,-h} = 2$, but $\ell^\star_{S,h} > \ell^\star_h = \ell^\star_{-h} > \ell^\star_{S,-h} = 0$ and, by replacing the equilibrium values in (B-8) and (B-9), we have that $Q_h > 1/2 > Q_{-h}$.

Therefore, taking into account that the profit function for airport h is $\Pi_h = (\ell^\star_h + t/n^\star_h)Q^\star_h$ and the considerations above, we can straightforwardly derive that $\Pi_h(1,0) > \Pi_h(0,0) > \Pi_h(1,1) > \Pi_h(0,1)$, with $h \in \{0,1\}$.

When $4/5 < \delta < 1$ and both airports behave in the same way ($\xi_h = \xi_{-h}$), also in this case the equilibrium values are the same and $Q^*_h = Q^*_{-h} = 1/2$. When $4/5 < \delta < 1$ and airports' choice is different ($\xi_h \neq \xi_{-h}$), we derive from the observation of the equilibrium values in (B-12), (B-13) and (1.15) that $\ell^\star_{S,h} > \ell^\star_h = \ell_{-h} > \ell_{S,-h} = 0$ and that $n^\star_{S,h} = n^\star_h = n^\star_{-h} > n^\star_{S,-h} = 2$ (so that, the retail sector is profitable only for the airport that does not inform travelers when the other does). Moreover, by replacing the equilibrium values in the demand function, it is easy to see that $Q^\star_{S,h} > 1/2 > Q^\star_{S,-h}$.

Differently from the previous case, the ordering is not that straightforward as not all the scenarios are directly comparable. However, by replacing the equilibrium values in the profit function, we obtain:

$$\Pi_h(1,0) = \frac{(3s+\delta v)^2}{24s}, \tag{B-14}$$

$$\Pi_h(1,1) = \frac{3s}{2}, \tag{B-15}$$

$$\Pi_h(0,0) = \frac{t}{4}, \tag{B-16}$$

$$\Pi_h(0,1) = \frac{t(9s-\delta v)}{24s}. \tag{B-17}$$

Then, it is easy to verify that: $\Pi_h(1,0) > \Pi_h(0,0) > \Pi_h(1,1) > \Pi_h(0,1)$, with $h \in \{0,1\}$.
Q.E.D.

Figures

Figure 1.1: Monopoly airport profit function. Thick line ($v = 3$, $s = 0.5$ and $t = 1$).

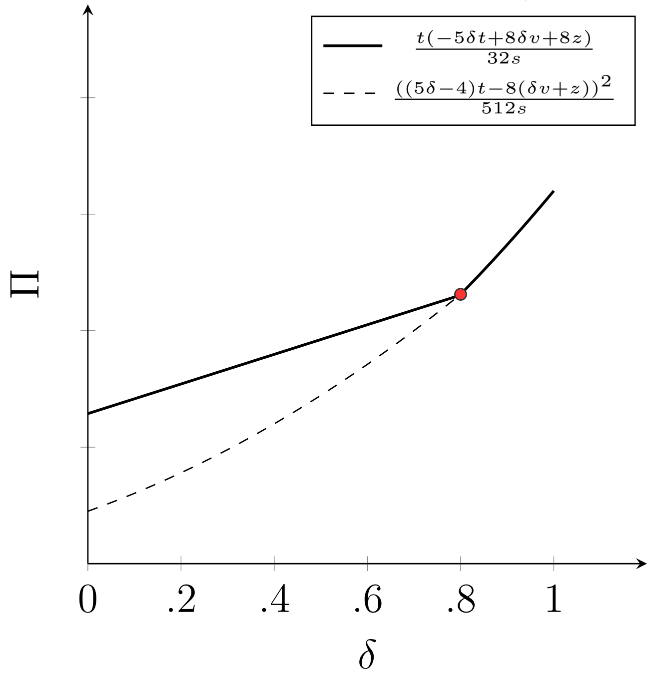

Figure 1.2: Duopoly airport profit function. Thick line ($t/s > 6$); Dashed line ($t/s \leq 6$).

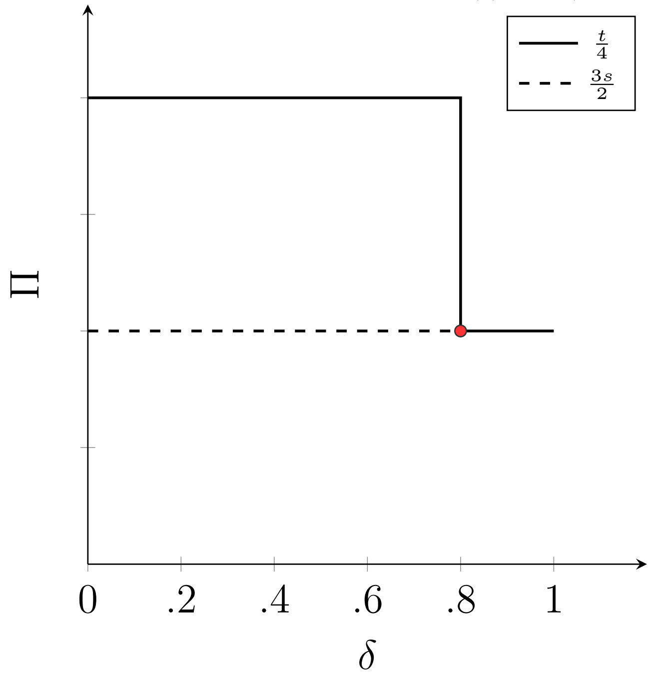

Figure 1.3: Profit composition of a monopoly airport ($z = 1$, $s = 0.5$ and $v = 3$)

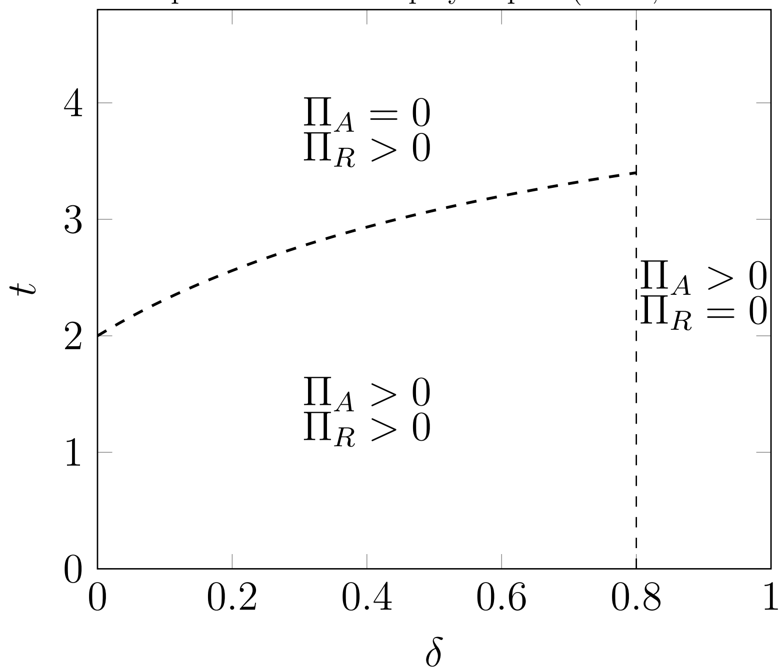

Figure 1.4: Profit composition of a duopoly airport ($z = 1$, $s = 0.5$ and $v = 3$)

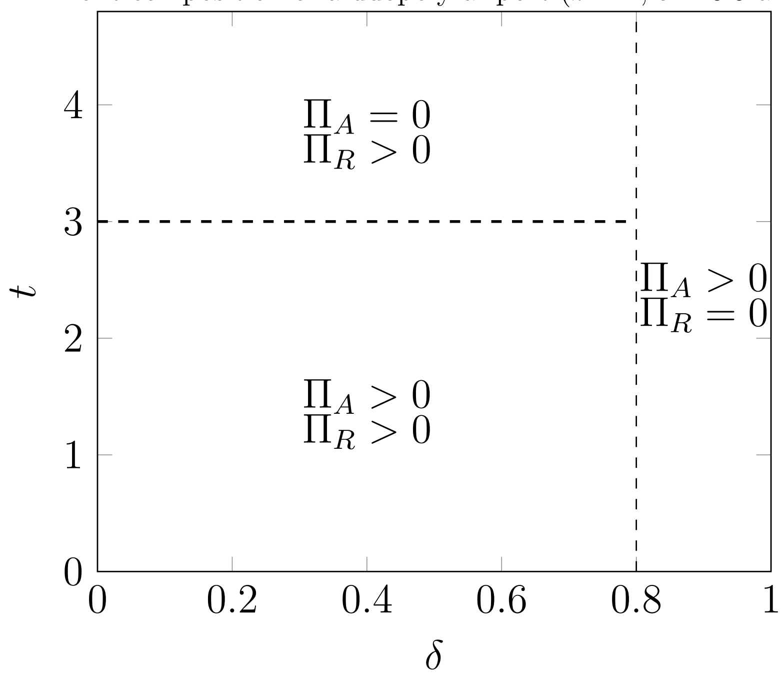

Figure 1.5: Comparison of profit composition between a monopoly and a duopoly airport ($z = 1$, $s = 0.5$ and $v = 3$)

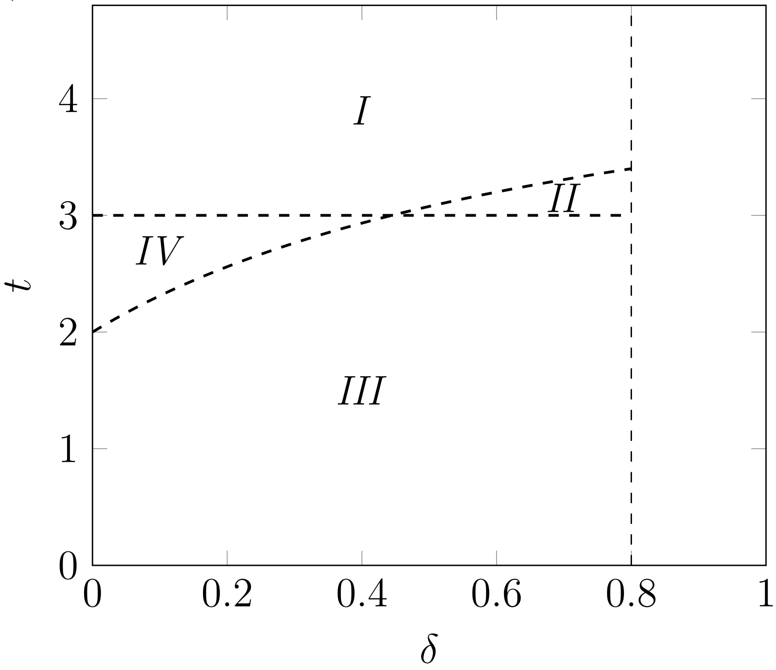

Figure 1.6: Payoff matrix of the stage 0 of the game.

		Airport 1	
		Ad ($\xi_1 = 1$)	No Ad ($\xi_1 = 0$)
Airport 0	Ad ($\xi_0 = 1$)	$\Pi_0(1,1), \Pi_1(1,1)$	$\Pi_0(1,0), \Pi_1(1,0)$
	No Ad ($\xi_0 = 0$)	$\Pi_0(0,1), \Pi_1(0,1)$	$\Pi_0(0,0), \Pi_1(0,0)$

Chapter 2

Self versus delegated distribution in digital platforms: The case of Amazon

Abstract

Within the e-book market, the self-publishing business model that has been boosted by digitalization has become increasingly important. Although self-publishing circumvents distribution intermediaries, consequently yielding unambiguous advantages both for authors and consumers, it also raises some concerns related to Amazon's accrued market dominance. This paper proposes a model to analyze the pros and the cons of this emerging business by delving into the internal organization of platforms. Consumers are ex ante uncertain about their true preferences on the content, while each content provider sells a differentiated product variety and determines its price around a Salop circle. Two alternative business models are compared: self-distribution and delegated distribution. Our results suggest that: *i*) self-publishing results in higher e-book prices for consumers under certain circumstances; *ii*) Amazon would benefit from driving publishing companies out of the e-book market in the segment of non-specialized books or novels written by emerging authors; *iii*) Amazon's dominance over traditional publishing companies should not cause damage to final consumers and, consequently, does not call for regulatory action.

2.1 Introduction

The importance of two-sided digital platforms has been increasing during the last decade and they have become dominant in many sectors such as Internet browsers (Google), social networks (Facebook), books and retail (Amazon), mobile apps (Apple), video streaming (Netflix), music streaming (Spotify), etc. A major concern about these markets of digital services is that they tend to be dominated by a single large platform (Ducci, 2020). More precisely, in the e-book industry, Amazon has undoubtedly become the leading platform.

In 2017, e-books represented 30% of all books sold in the US and a worldwide revenue of $13,436 millions (Statista, 2021). Amazon has enjoyed near-monopoly status over this industry since it launched the Kindle e-book reader in 2007, controlling between 60 and 80 percent of all e-book sales.[1] While such monopolization has the advantage of yielding clear positive network externalities for consumers who can virtually find any available content on a single platform (that becomes a true marketplace), it also gives rise to concerns related to potential abuse of market power such as tying practices or foreclosure (Ciriani & Lebourges, 2018; Ducci, 2020; Iacobucci & Ducci, 2019; Peitz, 2008).[2] This paper provides an overall assessment on the welfare implications of such monopolized two-sided digital platforms by delving into their internal organization.

Within the e-book market, two publishing models coexist: *i*) the traditional model and *ii*) self-publishing. In the traditional model, authors sell their rights to a publishing company that, in turn, negotiates with the platform the economic conditions for the distribution. The self-publishing model, enabled by the digitalization, allows a direct interaction author-platform. This model has experienced an unquestionable success, as the number of self-published works has grown by almost 300% between 2006 and 2014, exceeding the number of traditionally published works Waldfogel & Reimers, 2015. Since the launch of Kindle Direct Publishing (KDP), Amazon has become the dominant self-publishing company.[3] On the one hand, self-publishing circumvents distribution intermediaries and, consequently, conveys unambiguous advantages both for authors and consumers.[4] On the other hand, it also raises concerns related to an accrued market dominance by Amazon.[5]

[1]Amazon does not provide detailed information on its sales data. According to Magnolia Media Network, Amazon's market share would be 67%. However, other independent analysts provide estimations suggesting a larger figure reaching 80% (BookSliced, 2021).

[2]Despite its reputation for low prices, Amazon rose prices in 2018 by almost 5% in the US retail toy market following the shut down of Toys R Us, which was a major competitor (see He et al., 2021).

[3]For example, the number of titles sold by Amazon in the US during 2018 reached 1.4 million units while its closest competitor (Smashwords) sold about 70,000.

[4]KDP allows authors to sell their works through Amazon receiving (typically) 70% of the sales price as a royalty (authors also pay Amazon some delivery fees).

[5]As Paul Krugman puts it himself, Amazon has not been exploiting its monopoly power so far. Instead, it has used its monopsony power to put a squeeze on publishers, in effect driving down the price

The future consequences of Amazon's immense dominance in this market remains an open question.

More precisely, the following *questions* arise: *i*) Is Amazon's self-publishing business model (KDP) beneficial or detrimental to consumer welfare?, *ii*) Is there a risk for traditional publishing companies to be driven out of the e-book market by Amazon?, and *iii*) Should Amazon's dominance over traditional publishing companies in the e-book market be a concern for policy makers? The answer must lie in unraveling the implications of the traditional and the self-publishing models on price formation (both for e-readers and e-books).

Inspired by this reality, this study focuses on a monopoly platform that sells a core good (e.g., Kindle e-reader) to final users, which allows them to get access to a side good or content (e.g., e-books) provided by third-party firms. In this ecosystem, content providers can be either independent agents (*self-distribution*) or, alternatively, distribution companies *(delegated distribution)*. More precisely, we propose a baseline platform model where users are ex ante uncertain about their true preferences on the content and each content provider sells a differentiated product variety and determines its price around a Salop circle under the aforementioned two scenarios: self-distribution and delegated distribution. In the first case, content providers behave competitively (capturing the situation in which authors publish their books directly using Amazon's KDP). Instead, in the second case, authors transfer their copyright to a publisher (such as Penguin Random House, Harper Collins, Macmillan, Hachette or Simon & Shuster) that bargains bilaterally with Amazon on the final terms of the distribution.

In terms of modeling, under self-distribution each side-good seller provides a specific variety and chooses its price without affecting the general demand for the bundle. Instead, under delegated distribution, the distribution company behaves as a multiproduct monopolist that provides and determines the price of all varieties affecting the general demand for the bundle.

Although one could expect that an interaction between a platform and a single distribution company would translate into higher content prices to final users, this is not always

for e-books (Krugman, 2014).

the case. In fact, both organizational structures have advantages and drawbacks from the viewpoint of the platform and the final users.[6] On the one hand, individual agents have less market power under self-distribution as compared to delegated distribution, so that content prices are expected to be lower under self-distribution. On the other hand, under self-distribution, content providers generate a negative externality on the platform as they do not take into account the effect of their pricing decisions on the general demand. In consequence, the platform is obliged to internalize this externality when making its pricing decisions in the core-good market. Differently, when content is provided through distribution companies, these firms take into account the effect of their pricing decisions on the general demand and, therefore, the aforementioned externality does not emerge.[7] The tradeoff between pros and cons associated to these two organizational structures is essential to assess the pricing effects of this type of two-sided platforms.

From the platform perspective, self-distribution implies the advantage of dealing with a fragmented content market, but the inconvenient that content providers exert a certain local-monopoly power and do not internalize the effect of their pricing decisions on the general demand. On the other hand, dealing with a distribution company has the advantage derived by the fact that this company internalizes the effect of its pricing decisions on the general demand but the drawback of dealing with a maximally concentrated content market. For low values of product differentiation, the local-monopoly power exerted by independent content providers under self-distribution is rather small. Thus, the platform finds it more profitable to deal with a fragmented content market. For high values of product differentiation, the local-monopoly power exerted by independent content providers under self-distribution is strong, so that they focus on *business stealing* and generate a costly externality to the platform from neglecting the effect of their pricing decisions on the general demand. Therefore, the platform prefers to deal with a distribution

[6] In a general platform setting, Teh (2019) considers the effect of different fee instruments on seller competition. Instead, our focus is not on the fee structure but on comparing self- vs. delegated distribution (from the platform and the consumers viewpoint) in a model where the platform sells a core good and content providers sell a side good.

[7] This mechanism recalls to some extent the *double marginalization externality* that is internalized after a merger of firms producing complentary goods.

company that internalizes such externality, thereby avoiding any *cannibalization* between rival content providers.

The interests of the platform are aligned with those of final users except for intermediate values of product differentiation. For small values of product differentiation, the platform finds it more profitable to deal with a fragmented content market and consumers are also better off under this structure as they can take advantage of these lower prices. For intermediate levels of product differentiation, platform and consumer interests are not aligned because consumers prefer a monopoly side-seller market structure, while the platform is better off under a competitive side-seller market structure to avoid bargaining with the distribution company. Finally, for high values of product differentiation, the platform takes advantage of the internalized pricing decisions by this distribution company which gives rise to lower content prices that end up benefiting both consumers and the platform.

Our results give rise to the following implications on Amazon's business model in response to the research *questions* formulated above. Regarding the question on whether Amazon's self-publishing business model (KDP) is beneficial or detrimental to consumer welfare, our results show that Amazon can use KDP to circumvent publishing companies under certain circumstances, which would result into higher e-book prices for consumers. On whether there is a risk for publishing companies to be driven out of the e-book market by Amazon, our results indicate that this risk is limited to the segment of non-specialized books or novels written by emerging authors. This trend can be clearly observed in the segment of romance novels (or romantic fiction), as pointed out in Peukert & Reimers (2021) and Waldfogel & Reimers (2015). Finally, regarding the question on whether Amazon's dominance over traditional publishing companies in the e-book market should be a concern for policy makers, our analysis indicates that Amazon's dominance over traditional publishing companies in the e-book market should not cause damage to final consumers and, consequently, does not call for regulatory action.

Our paper relates to the literature on two-sided markets started by Rochet & Tirole (2003) and Armstrong (2006a). Within this rather wide literature on platform economics, our analysis relates closest to studies that deal with the interaction between platforms and content providers (or complementors). In a descriptive setting, Yoffie & Kwak (2006) focus on the conflicts that characterize the relationship between platforms and complementors. Hagiu (2009) highlights the endogenous nature of network effects within platforms stemming from the interaction between content providers and consumers. Galeotti & Moraga-González (2009) study a two-sided platform that attracts content providers and consumers, finding that an increase in product differentiation raises the value of the platform for consumers but weakens competition among content providers, thereby creating incentives for the platform to raise fees to both consumers and content providers. Using US data, Cennamo & Santalo (2013) highlight that, besides taking advantage of positive network effects related to market dominance, platforms need to manage successfully the incentives of content providers to stimulate the ecosystem growth. From a different perspective, Parker & Van Alstyne (2018) focus on the optimal levels of platform openness and the duration of intellectual property rights granted to content providers within a platform ecosystem. To the best of our knowledge, our paper is the first one that models explicitly the challenge derived by the emerging self-distribution business model (self publishing) as compared to the traditional business model based on distribution companies (publishers).

There are some other papers that have studied different issues directly related to Amazon's business model. Zhu & Liu (2018) analyze Amazon's incentives to compete directly with content providers. Wang & Miller (2020) compare the incentives of publishing companies to provide content either as e-books or physical printed books. Finally, De los Santos et al. (2018) examine the transition from wholesale to agency contracts in the e-book industry after the expiration of a ban on agency contracting (imposed in the antitrust settlement between US Department of Justice and the major publishers), concluding that the empirical evidence they obtain is best explained by a Nash bargaining model.

The paper is organized as follows. Section 2 presents the model and Section 3 carries out the equilibrium analysis under both scenarios. The platform choice between these two organizational structures is studied in Section 4. Section 5 analyzes the welfare implications of each organizational structure and compares private and social incentives.

A discussion of the implications of our results on the e-book market is contemplated in Section 6. Finally, Section 7 concludes the paper. The appendix contains supplementary material and an extension of the model.

2.2 Model

Consumers. Consumers purchase a bundle $S \equiv \{A + B\}$ at a single platform, which is composed of a core good (A) directly provided by the platform (e.g., Kindle e-reader) and a side good (B) provided by a number of content providers (e.g., e-books). Each consumer i has willingness to pay for the bundle v_i and is characterized by a side-service taste parameter θ_i, which is uniformly distributed over the unit-length Salop circle.[8] More precisely, they make their purchase decision according to the following expected utility function:

$$\mathbb{E}_\theta[V_i(p_A, p_B^e; \theta)] = v_i - p_A - p_B^e - \int_0^{\frac{1}{2n}} t\theta d\theta = v_i - p_A - t/\left(8n^2\right) - p_B^e, \qquad (1)$$

where p_A is the price of the core good, p_B^e is the expected price of the side good, $n \geq 2$ is the number of existing varieties of the side good which are equidistantly spaced around the Salop circle, and t stands for the degree of product differentiation among varieties with $t/\left(8n^2\right)$ capturing consumers' average mismatching cost.[9] The degree of product differentiation is assumed to be positive and bounded from above, i.e., $t \in [0, \bar{t}]$ with $\bar{t} \equiv \frac{8\bar{v}n^2}{8n+1}$.[10]

Consumers' purchase decision regarding the side good is as follows. First, they decide whether or not to purchase depending on their willingness to pay but being unaware of their actual taste for the side good (i.e., their location on the Salop circle). This decision

[8]See Salop (1979).

[9]It could be argued that traditional publishers reduce consumers' average mismatching cost as they classify content trying to reduce their search costs. However, it is also true that Amazon KDP makes use of big data techniques to learn from consumer preferences with the purpose of offering them tailor-made content.

[10]The condition $t < \bar{t}$ guarantees that equilibrium prices are always positive, i.e., $p_A^C > 0$, $p_A^M > 0$, $p_B^C > 0$, and $p_B^M > 0$ (see expressions (10), (11), and (20)).

is based on the expected side-good price p_B^e, as shown in equation (1). Second, they decide which variety to purchase once they learn their actual taste at the moment in which side-good sellers determine their equilibrium price p_B.

To understand this purchasing-decision process, it is important to have in mind that the degree of product differentiation identifies a certain product category (in the case of e-books, this would refer to textbooks, comics, mystery, romance novels, etc.). In this context, having consumers that are ex ante unaware of their taste refers to a situation in which they cannot anticipate which particular variety they will like to purchase within a given product category, i.e., for a given degree of product differentiation (in the case of e-books, e.g., this would refer to which textbook manual they would like to purchase within the category of Intermediate Microeconomics).[11,12]

Moreover, consumers have a zero outside option and their willingness to pay for the bundle (v) is uniformly distributed over the support $[0, \bar{v}]$ and has a density function $f(v) = 1/\bar{v}$. Denoting $\hat{v} = p_A + t/(8n^2) + p_B^e$ the willingness to pay of the marginal consumer, the demand for the bundle is given by

$$Q(p_A, p_B^e) = \int_{\hat{v}}^{\bar{v}} f(v)dv = \frac{\bar{v} - p_A - t/\left(8n^2\right) - p_B^e}{\bar{v}}. \quad (2)$$

Side-good sellers. Side-good sellers (i.e., content providers) provide a horizontally differentiated good unaware of consumers' willingness to pay v_i, so that they cannot price discriminate.[13,14]

At this point, side-good sellers assume that a consumer located in θ_i is associated

[11] In reality, consumers purchase many e-books to read on a single e-reader. A simple way to include this feature in our model would be to imagine several Salop circles, each one for a particular e-book category.

[12] In behavioral economics, there are models where uninformed consumers do not know their ideal taste ex ante and, therefore, they are uncertain about the product they will finally purchase Heidhues & Kőszegi, 2010; Karle & Peitz, 2014

[13] In the analysis that follows, side-good sellers and content providers are used iterchangeably.

[14] There is no *hold-up problem* as side-good sellers do not take into account consumers' platform adoption in their pricing decisions.

with a willingness to pay $v_i \in [\hat{v}, \bar{v}]$ with the same probability.[15] As a consequence, side-good sellers expect any consumer to have an average willingness to pay given by $\mathbb{E}v \equiv \int_{\hat{v}}^{\bar{v}} v \cdot f(v)\, dv$. Thus, a consumer located at θ_i with an average willingness to pay $\mathbb{E}v$ that purchases side-good variety $k \in \{1, ..., n\}$ obtains an utility

$$V_i(p_A, p_{B_k}; \theta_i) = \mathbb{E}v - p_A - p_{B_k} - t|\theta_i - \theta_k|, \tag{3}$$

where p_{B_k} is the price set by the k^{th} side-good seller. The indifferent consumer between firm k and its nearest rival, say firm j, is $\widehat{\theta}_i = (2n)^{-1} + (p_{B_j} - p_{B_k})/(2t)$, such that the demand of side-good seller k is given by

$$Q_k(p_{B_k}, p_{B_j}, p_A, p_B^e) = \left(\frac{1}{n} + \frac{p_{B_j} - p_{B_k}}{t}\right) Q(p_A, p_B^e), \tag{4}$$

where the first term denotes k's market share. Without loss of generality, all operation costs are assumed to be zero so that prices denote mark-ups.[16] Consequently, side-good seller k's profits are

$$\pi_{B_k}(p_{B_k}, p_{B_j}, p_A, p_B^e) = p_{B_k} Q_k(p_{B_k}, p_{B_j}, p_A, p_B^e) - \phi, \tag{5}$$

where ϕ is a fixed access fee that side-good sellers pay to the platform.[17]

The platform. The platform directly sells the core good and chooses p_A, while the side-good price p_B is determined by independent sellers that operate in the platform network after paying a fixed access fee ϕ. Again, all platform operation costs are assumed to be zero. Consequently, platform profits are

$$\pi_A(p_A, p_B^e) = p_A Q(p_A, p_B^e) + \phi K, \tag{6}$$

[15] A similar theoretical framework has been used in Katz & Shapiro (1985), where sellers cannot price-discriminate, but they can perfectly predict the aggregate consumer behavior.

[16] It could be argued that operation costs under self-distribution are actually higher than under delegated distribution, as independent content providers may lack experience in publishing and would probably incur higher costs in marketing their work. Introducing asymmetric costs between both organizational structures would rescale our results without affecting qualitatively our main findings.

[17] In the case of KDP, Amazon offers the authors a combination of a fixed and a per-sale fee, being the fixed fee quantitatively more important for most e-books.

where K denotes the number of side-good sellers. Each variety located at a certain point in the Salop circle is provided by a seller located at the same point (i.e., $K = n$).

The platform chooses between two possible side-good market structures: *i*) self-distribution (case C), where there is competition among content providers that use the platform to sell directly the side good to final consumers; [18] and *ii*) delegated distribution (case M), where a multiproduct monopoly provides all varieties produced by side-good sellers.[19,20]

The determination of the fixed access fee ϕ is modeled via the alternative-proposal framework of Rubinstein (1982)). The platform offers the content provider a share of the total profits that is generated in the bilateral relationship. If the side-good seller accepts the offer, the process ends. Otherwise, the side-good seller makes a counter offer, which the platform can either accept or reject, where the process ends in the former case and proceeds to the next bargaining stage in the latter. Binmore et al. (1986) have shown that Rubinstein (1982) alternating-offer model approximates the Nash bargaining solution where the bargaining powers can be related, for example, to the discount rate. Under scenario C, content providers bargain directly with the platform on the payment ϕ. Under scenario M, content providers bargain with the distribution company on the payment ψ in a first move, and then the distribution company bargains bilaterally with the platform on the payment ϕ in a second move. Individual content providers are assumed to have zero bargaining power and γ and $1 - \gamma$ stand for the bargaining powers of the platform and the distribution company. The outside options of all agents are normalized to zero. Appendix B considers an extension of the model where content providers have a positive

[18]Boudreau (2012) identifies a tight link between the number of content providers and the number of varieties in the US software industry.

[19]Naturally, authors have a veto-right on the platform choice between self and delegated distribution. However, it will be shown at a later stage that they are indifferent between both scenarios, so that they will not exert this veto-right. Consequently, this is tantamount to assuming that the platform can fully determine the choice between the two structures.

[20]Having an oligopoly market structure of distribution companies would be an intermediate situation between the considered polar cases (C and M). However, the implications of such an intermediate market structure are rather straightforward. The reason is that it would be equivalent to a setting in which the multiproduct monopolist has a lower bargaining power in the framework of our model.

bargaining power.

Timing of the game. The timing of events is as follows. In stage 1, the platform determines the side-good market structure, i.e., either scenario C or M. In stage 2, the required fixed access fee ϕ charged by the platform to side-good sellers (scenario C) or to the distribution company (scenario M) is determined. The compensation ψ offered by the distribution company to the content providers under scenario M is also resolved at this stage. In stage 3, the platform chooses p_A and side-good sellers choose p_{B_k} simultaneously.[21] Finally, consumers decide which variety to purchase. As usual, the game is solved by backwards induction.

2.3 Equilibrium analysis

The analysis that follows distinguishes between the self and delegated distribution business models (i.e., cases C and M).

2.3.1 Self-distribution business model (scenario C)

Under scenario C, in stage 3, each of the $K = n$ side-good sellers provides a specific variety k and chooses p_{B_k} and the platform determines p_A. Side-sellers pricing decisions cannot affect consumers' general demand for the bundle $Q(p_A, p_B^e)$ because it depends on consumer's prior expectations on the side-good prices p_B^e, so that $\partial p_B^e / \partial p_{B_k} = 0$.[22]

[21] There is no apparent reason to consider a sequential choice in this stage, as the determination of the core-good price and the side-good price are similar from an strategic viewpoint (as it is observed in the case of e-readers and e-books).

[22] The modeling assumption $\partial p_B^e / \partial p_{B_k} = 0$ under scenario C means that content providers do not internalize at all the negative externality they generate on the platform (as they do not take into account the effect of their pricing decisions on the general demand). However, the results would not change qualitatively as long as $\partial p_B^e / \partial p_{B_k} << 1$.

Therefore, the platform and the side-good sellers solve

$$\max_{p_A} \pi_A(p_A, p_B^e) = p_A Q(p_A, p_B^e) + \phi n, \tag{7}$$

$$\max_{p_{B_k}} \pi_{B_k}(p_{B_k}, p_{B_j}, p_A, p_B^e) = p_{B_k} \left(\frac{1}{n} + \frac{p_{B_j} - p_{B_k}}{t} \right) Q(p_A, p_B^e) - \phi, \tag{8}$$

yielding the following reaction functions:

$$p_A = \frac{1}{2} \left(\bar{v} - p_B^e - \frac{t}{8n^2} \right) \text{ and } p_{B_k} = \frac{1}{2} \left(p_{B_j} + \frac{t}{n} \right) \quad \text{for } \forall k, j \neq k, \tag{9}$$

which show that side-good sellers choose their optimal prices independently of the platform pricing decision, while the platform optimal price decreases with consumer's prior expectations on the side-good prices p_B^e. Expressions in (9) show that p_A decreases with t through consumers' average mismatching cost $(t/(8n^2))$, whereas p_{B_k} increases with t as higher product differentiation translates into an accrued local-monopoly power.

As in Gans (2012), the solution concept is a *rational expectations equilibrium*, i.e., the consumer's expectation of the side-good price p_B^e in equilibrium will equal the chosen price of side-good sellers contingent on those expectations, i.e., $p_B^e = p_{B_k}^C(p_B^e)$. Therefore, stage-3 equilibrium prices for the side and the core good are

$$p_A^C = \frac{1}{2} \left(\bar{v} - \frac{t}{n} - \frac{t}{8n^2} \right), \tag{10}$$

$$p_{B_k}^C = p_B^C = \frac{t}{n} \quad \text{for } \forall k, \tag{11}$$

where p_B^C is the standard Salop price and p_A^C is the platform monopoly price discounted by consumers' average mismatching cost and side-good expenditures. Substituting equations (11) and (10) into (2), we obtain the equilibrium quantity

$$Q^C = \frac{1}{2} - \frac{1+8n}{2\bar{v}} \frac{t}{8n^2}, \tag{12}$$

which can be used to write the stage-3 equilibrium profits as follows:

$$\pi_A = \bar{v} \left(Q^C \right)^2 + \phi n, \tag{13}$$

$$\pi_{B_k} = \frac{t}{n^2} Q^C - \phi. \tag{14}$$

Next, in stage 2, the platform chooses the required fixed access fee ϕ charged to side-good sellers that offer their products using the platform network by solving

$$\max_{\phi} \pi_A = \bar{v}\left(Q^C\right)^2 + \phi n$$
$$\text{s.t.} \quad \pi_{B_k} \geq 0. \tag{15}$$

In equilibrium, as content providers do not have any bargaining power, it follows straightforwardly that the platform will fully extract their profits by setting $\phi^C = Q^C t/n^2$. Consequently, the stage-2 platform profits are given by

$$\pi_A^C = \left(\bar{v}Q^C + \frac{t}{n}\right)Q^C. \tag{16}$$

2.3.2 Delegated distribution business model (scenario M)

Under scenario M, in stage 3, a single distribution company provides all varieties n and selects the price of every variety p_{B_k}. As varieties are equidistantly spaced around the Salop circle, the multiproduct monopolist avoids competition among varieties and determines a unique price for side goods, i.e., $p_{B_k} = p_B$. Consequently and differently to scenario C, the multiproduct monopolist can affect consumers' general demand for the bundle $Q(p_A, p_B^e)$ because $p_B^e = p_B$. Therefore, the platform and the multiproduct monopolist solve, respectively,

$$\max_{p_A} \pi_A(p_A, p_B) = p_A Q(p_A, p_B) + \phi, \tag{17}$$
$$\max_{p_B} \pi_B(p_A, p_B) = p_B Q(p_A, p_B) - \phi - K\psi, \tag{18}$$

where ϕ is the fee charged by the platform to the distribution company and ψ is the compensation offered by the distribution company to the K content providers. Profit maximization yields the following reaction functions:

$$p_A = \frac{1}{2}\left(\bar{v} - p_B - \frac{t}{8n^2}\right) \text{ and } p_B = \frac{1}{2}\left(\bar{v} - p_A - \frac{t}{8n^2}\right), \tag{19}$$

which show that optimal prices are strategic substitutes and decrease with consumers' average mismatching cost $(t/\left(8n^2\right))$. It should be noticed that, while the platform reaction function under both scenarios is the same, the second reaction function is markedly different. The rationale explaining this relevant difference between scenarios is found on the fact that side-good sellers only care about their local-monopoly power under scenario C, while the multiproduct monopolist under scenario M internalizes the consequences of its pricing decisions in the side-good market on the general demand for the bundle. As a result, p_{B_k} is increasing in t under scenario C (see (9)) but p_B is decreasing in t under scenario M (see (19)). This difference is essential in the analysis that follows.

Stage-3 equilibrium prices for the side and the core good are as follows:[23]

$$p_A^M = p_B^M = \frac{1}{3}\left(\bar{v} - \frac{t}{8n^2}\right). \tag{20}$$

Comparing platform prices between scenarios, i.e., (10)-(11) and (20), it can be observed that $p_A^C > p_A^M$ and $p_B^C < p_B^M$ for $t \in (0, \widetilde{t})$, while $p_A^C \leq p_A^M$ and $p_B^C \geq p_B^M$ for $t \in [\widetilde{t}, \bar{t})$, where $\widetilde{t} \equiv \frac{8\bar{v}n^2}{24n+1}$.[24] When product differentiation in the side-good market is low, competition among sellers is intense and they set low prices in equilibrium, which allows the platform to set higher prices.

Looking at side-good pricing decisions (i.e., expressions (11) and (20)), it can be observed that the effect product differentiation across varieties (t) is clearly different. Under self-distribution (scenario C), side-good prices rise when t increases as a standard (local) market-power exploitation in a Salop circle (as already ascertained from inspection of (9)). Instead, under delegated distribution (scenario M), side-good prices fall when t increases, as the distribution company attempts to compensate a negative effect on the general demand produced by higher t through boosted consumers' average mismatching cost.

The platform pricing decisions on the core good can be understood as the consequence

[23] Even though the prices of core and side goods differ in reality (e.g., Kindle e-readers are more expensive than e-books), it should be recalled that prices denote mark-ups as marginal costs are normalized to zero.

[24] Specifically, the price comparison between scenarios yields

$$\begin{aligned} p_A^C - p_A^M &= \frac{1}{48}\frac{\widetilde{t} - t}{n^2(24n+1)}, \\ p_B^C - p_B^M &= \frac{1}{24}\frac{t - \widetilde{t}}{n^2(24n+1)}. \end{aligned}$$

of the side-market pricing decisions described above. Precisely, under scenario C, the side-good sellers generate a negative externality on the platform as they do not take into account the effect of their pricing decisions on the general demand. In consequence, the platform internalizes this externality when making its pricing decisions in the core-good market. Differently, under scenario M, both the multiproduct monopolist and the platform take into account the effect of their pricing decisions on the general demand.

Substituting equations (20) into (2), we obtain the equilibrium quantity

$$Q^M = \frac{1}{3\bar{v}}\left(\bar{v} - \frac{t}{8n^2}\right). \tag{21}$$

Comparing platform demands between scenarios, i.e., (12) and (21), it can be observed that $Q^C > Q^M$ for $t \in (0, \widetilde{t})$, while $Q^C \leq Q^M$ for $t \in [\widetilde{t}, \overline{t})$.[25] As it can be seen in (2), the demand depends on the sum of core and side-good prices, with the price effect coming from the side-good market being dominant, i.e., $sign(p_A^C + p_B^C - p_A^M - p_B^M) = sign(p_B^C - p_B^M)$. Consequently, low (high) values of p_B imply a high (low) demand. This result highlights the strategic and relevant role of the side-good market structure.

Using (21), allows writing the stage-3 equilibrium profits as follows:

$$\pi_A = \bar{v}\left(Q^M\right)^2 + \phi, \tag{22}$$

$$\pi_B = \bar{v}\left(Q^M\right)^2 - \phi - K\psi. \tag{23}$$

Next, in stage 2, content providers bargain with the distribution company in a first move, and then the distribution company bargains bilaterally with the platform in a second move. As individual content providers are assumed to have zero bargaining power, the equilibrium fee paid by the distribution company to content providers is given by $\psi = 0$.

The bargaining problem between platform and the distribution company (publisher) in a second move is given by

$$\max_{\phi}\left(\bar{v}\left(Q^M\right)^2 + \phi\right)^{\gamma}\left(\bar{v}\left(Q^M\right)^2 - \phi - K\psi\right)^{1-\gamma}$$

[25] Specifically, the quantity comparison between scenarios yields

$$Q^C - Q^M = \frac{24n+1}{48n^2\overline{v}}\left(\widetilde{t} - t\right).$$

which yields

$$\phi^M = (2\gamma - 1)\,\bar{v}\left(Q^M\right)^2 \tag{24}$$

and the following stage-2 equilibrium profits:

$$\pi_A^M = \gamma 2\bar{v}\left(Q^M\right)^2, \tag{25}$$

$$\pi_B^M = \phi^M = (1-\gamma)\,2\bar{v}\left(Q^M\right)^2, \tag{26}$$

$$\pi_{B_k}^M = 0, \tag{27}$$

where the platform and the distribution company receive a share of the total profit, which is proportional to their respective bargaining powers.

2.4 Platform choice of side-good market structure

In stage 1, the platform determines the side-good market structure (choosing between scenario C and scenario M) by comparing the profits in (16) and (25). Substituting (12) and (21) into (16) and (25), respectively, yields:

$$\Delta\pi \equiv \pi_A^C - \pi_A^M = \frac{(1-8\gamma/9)\left[\bar{v} - t/(8n^2)\right]^2 - (t/n)^2}{4\bar{v}} \begin{cases} > 0 & \text{for } 0 < t < t^* \\ < 0 & \text{for } t^* < t < \bar{t} \end{cases}, \tag{28}$$

where $t^* = \frac{8\bar{v}n^2(9-8\gamma)^{1/2}}{24n+(9-8\gamma)^{1/2}}$, giving rise to the following result.

Proposition 1 *The platform adopts a self-distribution business model (scenario C) when the degree of product differentiation is low ($0 < t < t^*$). Instead, the platform adopts a delegated distribution business model (scenario M) when the degree of product differentiation is high ($t^* < t < \bar{t}$).*

This result highlights the strategic and relevant role of the side-good market structure. From a more general perspective, it can be seen that the profit comparison carried out in the above proposition follows a similar pattern as the one shown in the comparison of equilibrium quantities, which ultimately depends on the comparison of equilibrium side-good prices i.e., $p_B^C < p_B^M$, $Q^C > Q^M$, and $\Delta\pi \equiv \pi_A^C - \pi_A^M > 0$ for sufficiently small values of t.

The key economic insight behind this result has to do with the fact that p_B^C is increasing in t under scenario C (see (11)) but p_B^M is decreasing in t under scenario M (see (20)) because side-good sellers only care about their local-monopoly power under scenario C, while the multiproduct monopolist under scenario M internalizes the consequences of its pricing decisions on the general demand for the bundle.

Looking now at the choice of side-good market structure, the platform takes into consideration the advantages and disadvantages inherent to each market structure. From the platform perspective, Scenario C has the advantage of dealing with a fragmented side-good sector, but the inconvenience related to the exploitation of local-monopoly power by side sellers that focus on *business stealing* and do not internalize the effect of their pricing decisions on the general demand. On the other hand, scenario M has the advantage of dealing with a multiproduct side-good monopolist that internalizes the effect of its pricing decisions on the general demand (thereby avoiding any *cannibalization* between rival content providers) but the drawback of facing a maximally concentrated side-good market.

For low values of product differentiation, the local-monopoly power exerted by independent side-good sellers under scenario C is rather small. Thus, the platform finds it more profitable to deal with a fragmented side-good market, i.e., $\pi_A^C > \pi_A^M$ for $0 < t < t^*$. For high values of product differentiation, the local-monopoly power exerted by independent side-good sellers under scenario C is strong. Consequently, the externality stemming from neglecting the effect of their pricing decisions on the general demand is costly for the platform. Therefore, the platform prefers do deal with a side-good multiproduct monopolist that internalizes such externality, i.e., $\pi_A^C < \pi_A^M$ for $t^* < t < \bar{t}$. The corollary that follows describes how the threshold t^* depends on the platform's bargaining power.

Corollary 1 *The threshold t^* decreases with the bargaining power of the platform, where $t^*|_{\gamma\to 0} = \bar{t}$ and $t^*|_{\gamma\to 1} = \widetilde{t}$.*

When the platform has no bargaining power with respect to the distribution company, (i.e., $\gamma = 0$), then $t^* = \bar{t}$. Naturally, the platform is not interested in dealing with the distribution company when it does not have any bargaining power. Consequently, the platform always prefers scenario C. Instead, when the platform has full bargaining power with respect to the distribution company (i.e., $\gamma = 1$), then $t^* = \widetilde{t}$. This means that the platform prefers the organizational structure yielding lower content prices (as $p_B^C < p_B^M$ for $t \in (0, \widetilde{t})$ and $p_B^C \geq p_B^M$ for $t \in [\widetilde{t}, \overline{t})$). However, as the platform's bargaining power decreases (with $0 < \gamma < 1$ so that $\widetilde{t} < t^* < \overline{t}$), the range under which a competitive side-seller market is more profitable for the platform expands (even though $p_B^C \geq p_B^M$ can occur). The reason is found in the asymmetry between content providers under scenario C (who do not have any bargaining power) and the distribution company under scenario M (that has some bargaining power when $0 < \gamma < 1$). In such a case, the platform has to give up a share of its profits in favor of the distribution company. This is unprofitable for the platform when $0 < t < t^*$, as it prefers dealing with a fragmented side-good market to avoid sharing its profits with the distribution company.

2.5 Welfare analysis

Consumer welfare can be written as

$$\begin{aligned} CS &= 2n \int_{\hat{v}}^{\bar{v}} \int_0^{1/2n} \left(v_i - p_A - p_B^e - t\theta\right) f(v) d\theta dv \\ &= \left(\frac{\bar{v} Q(p_A, p_B^e)}{2} + \frac{t}{8n^2} - \frac{t}{4n} \right) Q(p_A, p_B^e), \end{aligned} \tag{29}$$

where $t/\left(8n^2\right)$ is the consumers' average mismatching cost and $t/\left(4n\right)$ is the total consumers' mismatching cost (i.e., $2n$ times the average mismatching cost). It should be noticed that the demand in (2) is formed by consumers' ex-ante expectations (as shown in (1)), while the consumer surplus takes into account the realized utility. An analysis of (29) under the two considered scenarios reveals that this difference between ex ante expectations and realized utility can turn consumer surplus negative for large values of product differentiation. The analysis that follows abstracts away from this case by assuming $t < \widehat{t} \equiv \frac{8\bar{v}n^2}{16n-3}$.[26]

With the purpose of comparing consumer welfare under both scenarios, $\Delta CS \equiv CS^C -$

[26] A complete explanation can be found in Appendix A.

CS^M can be written in the following way using expression (29):

$$\Delta CS \equiv CS^C - CS^M = \frac{\bar{v}}{2}\left(Q^C\right)^2 - \frac{\bar{v}}{2}\left(Q^M\right)^2 - \left(\frac{t}{4n} - \frac{t}{8n^2}\right)\left(Q^C - Q^M\right). \tag{30}$$

Looking at (30), it can be observed that the difference in the first two terms (which ultimately depends on total demand) determines the sign of the expression when product differentiation is small. In this case, $Q^C > Q^M$ and $\Delta CS > 0$, so that consumers are better off with a competitive side-services market where they can purchase side-services at lower prices (as $p_B^C < p_B^M$). Instead, for higher levels of product differentiation, $Q^C \leq Q^M$ is observed and the sign of ΔCS cannot be determined straightforwardly. Substituting (12) and (21) into (29) yields:

$$\Delta CS \equiv CS^C - CS^M = \frac{\left(40\overline{v} + \frac{7t}{n^2} - \frac{48t}{n}\right)\left(8\overline{v} - \frac{t}{n^2} - \frac{24t}{n}\right)}{2^9 3^2 \overline{v}} \begin{cases} > 0 & \text{for } 0 < t < \widetilde{t} \\ < 0 & \text{for } \widetilde{t} < t < \widehat{t} \end{cases}, \tag{31}$$

giving rise to the following result.

Proposition 2 *Consumers are better off facing a competitive side-service market when the degree of product differentiation is low ($0 < t < \widetilde{t}$). Instead, they are better off under a monopoly multiproduct side-service market when the degree of product differentiation is high ($\widetilde{t} < t < \widehat{t}$).*

The larger surplus observed under self-distribution for a low degree of product differentiation ($0 < t < \widetilde{t}$) is consistent with the findings in Reimers & Waldfogel (2017), who estimate a substantial increase in consumer surplus associated to cost-reductions in the distribution of e-books.[27] These cost-reductions are mostly explained by the success of the self-distribution model that has achieved its largest impact in the segment of romance novels (which can be considered as non-specialized e-books having as potential readers the general public) where self-published works account for almost a third.

For levels of product differentiation above $\widetilde{t}$, then $Q^C \leq Q^M$. Consequently, the difference between the first two terms in (30) is negative, while the difference between the

[27] Waldfogel & Reimers (2015) estimate an increase in consumer surplus of \$3.5 billion between 2008 and 2012 (and a cumulative increase of \$5.7 billion).

last two terms is positive. As it turns out, for $\widetilde{t} < t < \widehat{t}$, the first difference dominates and consumers are better off under a multiproduct monopolist. A comparison of Propositions 1 and 2 yields the following result.

Corollary 2 *Platform and consumer interests are compared in the following way:*

$$\begin{array}{ll} \Delta\pi > 0;\ \Delta CS > 0\ (C \succ M \text{ platform and consumers}) & \text{for } 0 < t < \widetilde{t} \\ \Delta\pi > 0;\ \Delta CS < 0\ (C \succ M \text{ platform; } M \succ C \text{ consumers}) & \text{for } \widetilde{t} < t < \min\{t^*, \widehat{t}\} \\ \Delta\pi < 0;\ \Delta CS < 0\ (M \succ C \text{ platform and consumers}) & \text{for } t^* < t < \widehat{t},\ \gamma' \leq \gamma \leq 1, \end{array}$$

where $\gamma' \equiv \frac{9(2n-1)(6n-1)}{8(4n-1)^2}$ *solves* $t^*(\gamma') = \widehat{t}$.

The intuition behind this result is as follows. For small values of product differentiation ($0 < t < \widetilde{t}$), the local-monopoly power exerted by independent content providers under self-distribution is rather modest and prices are low. Thus, the platform finds it more profitable to deal with a fragmented content market and consumers are also better off under this structure as they can take advantage of these lower prices. For larger levels of product differentiation ($\widetilde{t} < t < \min\{t^*, \widehat{t}\}$), platform and consumer interests are not aligned. Consumers prefer a monopoly side-seller market structure because of the mentioned price coordination effect, while the platform is better off under a competitive side-seller market structure to avoid bargaining with the distribution company. Finally, for high values of product differentiation ($t^* < t < \widehat{t}$), the local-monopoly power exerted by independent content providers under self-distribution is strong, thereby creating an upward pressure on content prices. In this situation, when dealing with a distribution company, the platform takes advantage of the internalized pricing decisions by this distribution company whenever its bargaining power is high enough ($\gamma' \leq \gamma \leq 1$). This gives rise to lower content prices, which ends up benefiting both consumers and the platform (that can raise core-good prices).

2.6 Discussion: Implications for the e-book market

Our results in Propositions 1-2 and Corollary 2, give rise to the following implications on Amazon's business model in response to the research questions formulated in the introduction of this paper.

Regarding the question on whether Amazon's self-publishing business model (Kindle Direct Publishing) is beneficial or detrimental to consumer welfare, the answer derived from our analysis is non-trivial, as pointed out in Proposition 2. We conclude that Kindle Direct Publishing (KDP) benefits consumers through lower content and bundle prices when product differentiation across e-books is low. Therefore, as long as authors do not have much influence over e-book prices, KDP should be beneficial for both consumers and Amazon. However, for intermediate values of product differentiation across e-books, our analysis suggests that Amazon uses KDP to circumvent publishing companies, which results into higher e-book prices for consumers.

On whether there is a risk for publishing companies to be driven out of the e-book market by Amazon, our results indicate that this is not the case as long as product differentiation among e-books is high. Under such scenario, the intermediation of publishing companies results into lower e-book prices, which is beneficial for Amazon as it can raise the price of Kindle e-readers (as shown in Proposition 1). For instance, in the segment of specialized books (such as academic textbooks) or novels written by well-known authors, our results suggest that publishing companies will continue playing a relevant role in their distribution. Instead, in the segment of non-specialized books or novels written by emerging authors, publishing companies are at risk of being driven out of the e-book market by Amazon. This finding is corroborated by the works of Peukert & Reimers (2022) and Waldfogel & Reimers (2015), who show that the role of publishing companies has declined over the last decade in the segment of romance novels (or romantic fiction) where self-published works account for almost a third.

Regarding the question on whether Amazon's dominance over traditional publishing companies in the e-book market should be a concern for policy makers, our analysis indicates that this is not the case. Looking at Corollary 2, the following implications can be derived. First, this dominance is irrelevant as long as authors do not have much influence over e-book prices because both Amazon and consumers prefer KDP. Second, Amazon's dominance is not a problem as well when authors have substantial influence over e-book prices because both Amazon and consumers are interested in making use of the intermediation of a publishing company. Finally, for moderate influence of authors over e-book prices, Amazon's dominance should not be a concern for policy makers even though there is a misalignment between Amazon's and consumer interests. The reason is that this misalignment is generated by the publishers' market power and not by Amazon's market power. In fact, the higher the dominance of Amazon with respect to publishing companies, the more aligned become Amazon's and consumer interests. All in all, we can conclude that Amazon's dominance over traditional publishing companies in the e-book market should not cause damage to final consumers and, consequently, does not call for regulatory action.

Regarding this last policy implication, a final caveat should be taken into account. Our analysis derives results on the internal organization of Amazon e-book business (i.e., self-distribution vs. publishing companies) under the actual market structure where Amazon is the sole leading platform.

There is a current debate in the US initiated by L. M. Khan (2016) suggesting the adoption of a new antitrust law framework based on *common carrier obligations and duties*. Under this view, antitrust recommendations concerning dominant platforms should take into account the potential effects of platform competition and consider innovative regulatory measures such as giving access to Amazon's infrastructure to independent operators at *just and reasonable rates*. This revised antitrust approach based on common carrier obligations would be similar to the one adopted to essential network industries (such as railroads, telecommunications or electric distribution).[28] However, such an antitrust approach seems hard to implement given the extraordinarily and long-lasting low prices of Amazon's books (both physical and e-books), which seems to rule out any possible concern about predatory pricing.[29]

Of course, deriving regulatory implications from our results in the light of this new antitrust perspective would require to consider additional counterfactuals involving platform

[28]See L. Khan (2018) and Eeckhout (2021) for further discussion on this new approach to antitrust policy.

[29]One may wonder if this low-price startegy can be maintained indefinitely, as it represents a source of surplus for consumers but not for shareholders.

competition, which most likely would result into a better outcome for final consumers. Therefore, our conclusion on the fact that Amazon should not cause damage to final consumers (so that no regulatory action is needed) should be revised accordingly.

2.7 Conclusion

The proposed model allows providing an overall assessment on the welfare implications associated with the two main organizational structures in digital platforms: self-distribution and delegated distribution. Bringing the analysis to the e-book industry helps unraveling some relevant implications regarding Amazon's self-publishing business model (Kindle Direct Publishing). Our results suggest that: *i*) self-publishing can result into higher e-book prices for consumers under certain circumstances; *ii*) publishing companies could be driven out of the e-book market by Amazon in the segment of non-specialized books or novels written by emerging authors; *iii*) Amazon's dominance over traditional publishing companies should not cause damage to final consumers and, consequently, does not call for regulatory action.

Although the e-book industry represents the main motivation for our analysis, there are other settings to which the model could be applied. For instance, in the video-game industry there are three main platforms (Nintendo, Sony, and Microsoft) with a considerable degree of monopoly power due to technical incompatibilities and high switching costs. In this industry, consumers purchase consoles (core good) from the platform while video games (side goods) are provided by game developers. These platforms allow developers to provide their video-games directly or, alternatively, making use of a distribution company (e.g., Tencent Games or Activision Blizzard). Therefore, the implications derived from the above analysis would apply to this industry as well.

Instead, there are other industries where multihoming is a generalized practice and platform competition becomes an issue. For instance, in the streaming industry, digital platforms (e.g., Netflix, HBO, Amazon, Disney or Filmin) compete for content (movies and series) provided either by independent studios or distribution companies (e.g., Paramount Pictures, Warner Bros., Universal or 20th Century Fox). An adaptation of our setting to accommodate platform competition could be used to analyze the managerial and welfare implications within this industry. This constitutes an interesting avenue for future research.

Appendix A: Negative consumer surplus

Consumers decide to join a platform depending on their expected mismatching cost. Instead, consumer surplus takes into account the realized mismatching cost. This explains the fact that consumer surplus can end up being negative for relatively high levels of product differentiation. There are therefore consumers with low willingness to pay who, after purchasing the core good, cannot find a product that matches their preferences closely enough to offset the fixed cost of the core good. This result is encapsulated in the following proposition.

Proposition 3 *Under both scenarios, consumers can end up worse off as a result of their purchasing decisions for relatively high levels of product differentiation* t *(i.e.,* $CS^C < 0$ *for* $t > t^C \equiv \frac{8\overline{v}n^2}{16n-3}$ *and* $CS^M < 0$ *for* $t > t^M \equiv \frac{8\overline{v}n^2}{12n-5}$*). Moreover, while consumer surplus is monotonically decreasing in* t *under scenario* M*, it is U-shaped under scenario* C*.*

Proof 1 *Substituting (12) and (21) into (29) yields:*

$$CS^C = \frac{\left(8\overline{v} - t/n^2 - 8t/n\right)\left(8\overline{v} + 3t/n^2 - 16t/n\right)}{2^9\overline{v}}, \tag{A-1}$$

$$CS^M = \frac{\left(8\overline{v} - t/n^2\right)\left(8\overline{v} + 5t/n^2 - 12t/n\right)}{2^7 3^2\overline{v}}. \tag{A-2}$$

It follows that

$$CS^C \begin{cases} > 0 & \text{for } 0 < t < t^C \\ < 0 & \text{for } t^C < t < \overline{t} \end{cases},$$

$$CS^M \begin{cases} > 0 & \text{for } 0 < t < t^M \\ < 0 & \text{for } t^M < t < \overline{t} \end{cases},$$

which proves the first statement in the proposition. Differentiation of (A-1) and (A-2) yields

$$\begin{aligned}
\frac{\partial CS^C}{\partial t} &= -\frac{\left(3 - 128n^2 + 8n\right)t - 8n^2\overline{v} + 96n^3\overline{v}}{2^8 n^4 \overline{v}} \begin{cases} < 0 & \text{for } 0 < t < t^C_{\min} \\ < 0 & \text{for } t^C_{\min} < t < \overline{t} \end{cases}, \\
\frac{\partial^2 CS^C}{\partial t^2} &= \frac{\left(8n+1\right)\left(16n-3\right)}{2^8 n^4 \overline{v}} > 0, \\
\frac{\partial CS^M}{\partial t} &= -\frac{\left(12n-5\right)\left(\overline{t} - t\right) + 8n^2\overline{v}\frac{48n^2-22n+3}{8n+1}}{2^6 3^2 n^4 \overline{v}} < 0 \quad \forall t \in \left(0, \overline{t}\right),
\end{aligned}$$

where $t^C_{\min} \equiv \frac{12n-1}{16n-3}\bar{t}$, *thereby proving the second statement in the proposition.* ■

Given that $t^C < t^M$, the condition $t < t^C \equiv \widehat{t}$ ensures simultaneously $CS^C > 0$ and $CS^M > 0$.

Appendix B: Content providers with positive bargaining power

The material that follows provides an extension of the proposed model to a richer setting in which content providers have positive bargaining power. The analysis departs from the *traditional model* where content providers make use of a distribution company to deal with the platform (i.e., scenario M). This was the situation in the book market before the irruption of the self-distribution business model leaded by Amazon KDP (i.e., scenario C).

Therefore, this extension studies first the bargaining process under scenario M and then the bargaining process under scenario C. In such a way, the considered outside option both for the platform and each content provider in their bilateral bargaining process under scenario C is given by their respective profits under scenario M.

In the baseline model, the final choice of the side-good market structure in stage 1 is made exclusively by the platform. The reason is that content providers do not have any bargaining power and, consequently, are indifferent between scenarios M and C. Instead, in this extension where content providers are characterized by a positive bargaining power, this choice is ultimately determined both by platform and content providers, meaning that the self-distribution business model will only be adopted if both the platform and content providers are better off as compared to the traditional model.

2.7.1 Bargaining process under delegated distribution (scenario M)

Consider first the *traditional model* given by scenario M. As before, the stage-3 equilibrium quantity is given by (21), i.e.,

$$Q^M = \frac{1}{3\bar{v}}\left(\bar{v} - \frac{t}{8n^2}\right). \tag{B-1}$$

In stage 2, each content provider bargains with the distribution company in a first move, while there is a bilateral bargaining process between the distribution company and the platform in a second move. Let us denote γ_A, γ_B, and γ_k the bargaining power of the platform, the distribution company, and content providers, respectively.

Looking at the bargaining process between individual content providers and the distribution company (i.e., first move)

$$\max_{\psi}\left(\bar{v}\left(Q^M\right)^2/K - \phi/K - \psi\right)^{\gamma_B}(\psi)^{\gamma_k}, \tag{B-2}$$

allows obtaining the optimal compensation paid by the distribution company to each content provider

$$\psi^M = \frac{\gamma_k}{(\gamma_k + \gamma_B)K}\left(\bar{v}\left(Q^M\right)^2 - \phi\right). \tag{B-3}$$

Looking now at the bargaining problem between the platform and the distribution company (i.e., second move)

$$\max_{\phi}\left(\bar{v}\left(Q^M\right)^2 + \phi\right)^{\gamma_A}\left(\bar{v}\left(Q^M\right)^2 - \phi - K\psi^M\right)^{\gamma_B}, \tag{B-4}$$

yields the optimal access fee

$$\phi^M = \frac{\gamma_A - \gamma_B - \gamma_k}{\gamma_A + \gamma_B + \gamma_k}\bar{v}\left(Q^M\right)^2. \tag{B-5}$$

Plugging (B-3) and (B-5) into the profits in (B-2) and (B-4) yields stage-2 equilibrium profits

$$\pi_A^M = \frac{\gamma_A}{\gamma_A + \gamma_B + \gamma_k}2\bar{v}\left(Q^M\right)^2, \tag{A8}$$

$$\pi_B^M = \frac{\gamma_B}{\gamma_A + \gamma_B + \gamma_k}2\bar{v}\left(Q^M\right)^2, \tag{A9}$$

$$\pi_{B_k}^M = \psi^M = \frac{\gamma_k}{\gamma_A + \gamma_B + \gamma_k}2\bar{v}\left(Q^M\right)^2/K, \tag{B-6}$$

where it can be checked that the corresponding expressions of the baseline model given by (25)-(27) are recovered when $\gamma_k = 0$, where $\gamma_A = \gamma$ and $\gamma_B = 1 - \gamma$.

2.7.2 Bargaining process under self-distribution (scenario C)

Now consider scenario C. Under self-distribution, each content provider bargains directly with the platform. As before, the stage-3 equilibrium quantity is given by (12), i.e.,

$$Q^C = \frac{1}{2} - \frac{1+8n}{2\bar{v}} \frac{t}{8n^2}, \tag{B-7}$$

such that the stage-3 equilibrium profits are

$$\pi_A = \bar{v}\left(Q^C\right)^2 + \phi n, \tag{B-8}$$

$$\pi_{B_k} = \frac{t}{n^2} Q^C - \phi. \tag{B-9}$$

In stage 2, the platform chooses the required fixed access fee ϕ charged to each content provider by solving the bargaining problem

$$\max_{\phi} \left(\bar{v}\left(Q^C\right)^2 + n\phi - \pi_A^M\right)^{\gamma_A} \left(\frac{t}{n^2} Q^C - \phi - \pi_{B_k}^M\right)^{\gamma_k}, \tag{B-10}$$

where π_A^M and $\pi_{B_k}^M$ are given by (A8) and (B-6) and denote the profits of the platform and the content providers under scenario M, i.e., their respective outside option in this bargaining process.

The optimal fee charged by the platform to each content provider is given by

$$\phi^C = \frac{\gamma_A \frac{t}{n} Q^C - K\gamma_A \pi_{B_k}^M - \gamma_k \bar{v}\left(Q^C\right)^2 + \gamma_k \pi_A^M}{\left(\gamma_k + \gamma_A\right) n}. \tag{B-11}$$

Plugging (B-11) into the profits in (B-10) yields stage-2 equilibrium profits

$$\pi_A^C = \frac{\gamma_A}{\gamma_A + \gamma_k} \left[\bar{v}\left(Q^C\right)^2 + \frac{t}{n} Q^C - \frac{\gamma_A + \gamma_k}{\gamma_A + \gamma_B + \gamma_k} 2\bar{v}\left(Q^M\right)^2\right], \tag{B-12}$$

$$\pi_{B_k}^C = \frac{\gamma_k}{\left(\gamma_A + \gamma_k\right) K} \left[\bar{v}\left(Q^C\right)^2 + \frac{t}{n} Q^C - \frac{\gamma_A + \gamma_k}{\gamma_A + \gamma_B + \gamma_k} 2\bar{v}\left(Q^M\right)^2\right], \tag{B-13}$$

where the platform's equilibrium profit of the baseline model given by (16) is recovered when $\gamma_k = 0$, which also yields $\pi_{B_k}^C = 0$.

2.7.3 Platform and content providers' choice of side-good market structure

In stage 1, both platform and content providers decide on the side-good market structure (i.e., either scenario C or scenario M) by comparing the profits in (A8) and (B-6) with those given by (B-12) and (B-13). The result of such comparison is encapsulated in the proposition that follows.

Proposition 4 *Both platform and content providers adopt a self-distribution business model (scenario C) when the degree of product differentiation is low ($0 < t < t^*$). Instead, they adopt a delegated distribution business model (scenario M) when the degree of product differentiation is high ($t^* < t < \bar{t}$).*

Proof 2 $\pi_A^C > \pi_A^M$ *and* $\pi_{B_k}^C > \pi_{B_k}^M$ *iff*

$$\Psi \equiv \frac{t}{n}Q^C + \bar{v}\left(Q^C\right)^2 - 2\bar{v}\zeta\left(Q^M\right)^2 > 0, \tag{A18}$$

where $\zeta \equiv \frac{\gamma_A+\gamma_k}{\gamma_A+\gamma_B+\gamma_k}$ *with* $0 < \zeta < 1$*. Substituting (B-1) and (B-7) into (A18) yields*

$$\Psi = \frac{(1-8\quad/9)\left[\bar{v}-t/(8n^2)\right]^2-(t/n)^2}{4\bar{v}}\begin{cases} > 0 & \text{for } 0 < t < t^* \\ < 0 & \text{for } t^* < t < \bar{t}\end{cases}, \tag{A19}$$

where $t^* = \frac{8\bar{v}n^2(9-8\zeta)^{1/2}}{24n+(9-8\zeta)^{1/2}}$. ■

It is easy to check that the result from the baseline model is recovered for $\gamma_k = 0$. More precisely, considering $\gamma_A = \gamma$ and $\gamma_B = 1-\gamma$, then $\zeta = \frac{\gamma_A}{\gamma_A+\gamma_B} = \gamma$ and $\Psi = \frac{(1-8\gamma/9)\left[\bar{v}-t/(8n^2)\right]^2-(t/n)^2}{4\bar{v}} = \Delta\pi$ as indicated in (28). In terms of interpretation, the main message derived from Proposition 1 and Corollary 1 in the baseline model remains valid.

Carrying out a simple comparative-static exercise to ascertain the effect of γ_A, γ_B, and γ_k over t^*, it is obtained that the range for t under which scenario C is preferred by platform and content providers expands with the bargaining power of the distribution company (i.e., $\frac{\partial t^*}{\partial \gamma_B} > 0$) and shrinks with the bargaining powers of platform and content providers (i.e., $\frac{\partial t^*}{\partial \gamma_A} < 0$ and $\frac{\partial t^*}{\partial \gamma_k} < 0$). The reason is that platform and content providers are more inclined: *i*) to circumvent the distribution company when it has a stronger bargaining position, and *ii*) to deal with the distribution company when they have a stronger bargaining position vis-à-vis the distribution company.

Chapter 3

Selling customer information or using them?

Abstract

With the digital revolution, the increased use of AI and the new information technology has facilitated the collection of a huge amount of data which constitute a valuable asset for the firms. This paper analyzes the case of two horizontally differentiated firms which are uncertain about the true degree of substitutability of a certain product and that can buy more accurate data from a data owner. The paper has two main purposes. The first one is to characterize and compare the pricing strategy and the profits of the sellers under the case of no information, asymmetric information and perfect information. The second one is to derive the optimal strategy chosen by the data owner who can either *i)* sell (under exclusive agreements or not) such information to the sellers or *ii)* keep the information and enter the market. We find that there is not a dominant strategy and the data owner's decision to enter the market or sell the information ultimately depends on to what extent the sellers underestimate or overestimate the true value of product differentiation.

3.1 Introduction

With the digital revolution, the increased use of AI and the new information technology has facilitated the collection of a huge amount of data which constitute a valuable asset for the firms. Nowadays, the quality and quantity of customer information held by a firm are determinant factors for its performance in a competitive environment.

An extensive body of literature has analyzed the advantages arising from having detailed customer data. Some researchers have focused on the role of detaining detailed information about consumers as a source of incumbency advantage (Biglaiser et al., 2019; Aguirre et al., 1998; Jakopin & Klein, 2012). In these studies, the authors remark that, under certain conditions, an already established seller (or an established coalition) might use data to implement pricing and marketing strategies to lock-in consumers and create high entry barriers to potential entrants, with severe implications for consumer welfare (Stucke, 2017; Esteves & Carballo-Cruz, 2021).

Other studies have focused on the possibility to use customer data to implement first degree price discrimination (Shiller et al., 2013; Montes et al., 2019). More specifically, when sellers have perfect information about consumer characteristics, they would be able to set personalized prices that perfectly match their maximum willingness-to-pay for that product (Varian, 1985).

Actually, first degree-price discrimination, or, more generally, personalized pricing is hard to be implemented and there are only a few empirical evidence (Waldfogel, 2015).[1] A report from OECD in 2018 states that, although sufficient conditions for personalized pricing are satisfied in many markets, companies are to some extent reluctant to engage in such a practice for fear of gaining a bad reputation among customers. Lastly, there are some evidence that companies use customer data to steer consumers toward specific product lines (Hannak et al., 2014).

It is worth noticing that all of these studies assume that sellers have perfect information about the degree of product differentiation. Nevertheless, this is not a minor assumption. In the business marketing literature, several scholars have focused their attention on the *customer-perceived value*, stressing the importance for organizations to understand what are the key factors which create value for consumers to build a competitive advantage (Lapierre, 2000; Sánchez-Fernández & Iniesta-Bonillo, 2007).

Therefore, despite being overlooked, having correct information about the consumers' perception of the products substitutability is significantly important. In this paper, we propose an alternative theory on the type of information that sellers can infer when purchasing customer data.

More specifically, we analyze the case of two horizontally differentiated firms which are uncertain about the true degree of substitutability of a certain product and that can buy

[1] Against the theory of personalized pricing, some studies have shown that in many cases the perception of personalized pricing is actually due to extreme volatility of prices (Bourreau & De Streel, 2018).

more accurate data from a data owner. The paper has two main purposes. The first one is to characterize and compare the pricing strategy and the profits of the sellers under the case of no information, asymmetric information and perfect information. The second one is to derive the optimal strategy chosen by the data owner who can either *i)* sell (under exclusive agreements or not) such information to the sellers or *ii)* keep the information and enter the market.

As expected, we find that uncertainty has an ambiguous effect on prices and, consequently, on consumer welfare. Specifically, if the sellers underestimate (overestimate) the true degree of product differentiation, consumers are better off (worse off) when sellers are asymmetrically informed than under a perfect information scenario. This result is partially in contrast with the findings of Taylor & Wagman (2014) who show that a scenario with perfectly informed sellers lowers prices and enhances consumer welfare. The main difference with their findings relies on the type of information the sellers are endowed with. Indeed, in their study, after having purchased information, the sellers have perfect information about consumers' location and compete more fiercely. The intensified competition lower prices, thus enhancing consumer welfare and lowering industry profits. While in our study, after having purchased information, sellers get to know the actual degree of product differentiation, which leads to higher consumer welfare only if sellers overestimated its true value.

With respect to the optimal strategy of the data owner, we find that there is not a dominant strategy and the data owner's decision to enter the market or sell the information ultimately depends on to what extent the sellers underestimate or overestimate the true value of product differentiation.

In the economic literature, there are just a few studies which depart from the standard assumption of a perfectly known degree of product differentiation. In Harrington Jr (1992), the author characterizes the equilibrium strategies in a pricing game à la Bertrand in which two firms are uncertain about the actual homogeneity of their products. Coherently with our findings, the author finds that there exists a Markov perfect equilibrium in which both the firms can sustain prices above the marginal cost.

Other contributions (Jentzsch et al., 2013; Baye et al., 2018) assume that consumers are heterogeneous in both their *degree of flexibility* and brand preferences. In these papers (which are methodologically similar), the authors analyze the combined effect of sharing information about brand preferences and the degree of flexibility. They conclude that while sharing data only about brand preference leads to a clear positive effect on consumer welfare, as remarked in (Taylor & Wagman, 2014), sharing data about consumers' degree of flexibility leads to an ambiguous effect on consumer welfare. Finally, in Armstrong (2006b), the author provides a comprehensive survey about the different practices of price discrimination and analyzes the pricing behavior of a firm dealing with two segments of consumers with different transportation costs.

With respect to the topic of the information sale, this paper partially relates to the works of Braulin & Valletti (2016) and Montes et al. (2019). However, in both the papers the data owner acts as a pure data broker and sells information about consumer location.

The paper is structured as follows. Section 2 describes the framework of the model and provides the relevant assumptions. In Section 3, we characterize the equilibrium prices and profits under the two business models. Finally, Section 4 provides a comparison of the the possible scenario and Section 5 concludes the paper.

3.2 Framework

Consumers. Consider a Hotelling setup. Consumers have a unit demand and are characterized by horizontal preferences θ which are uniformly distributed with support $[0, 1]$. From their purchase, consumers receive a gross utility $v > 0$. We assume that v is high enough such that the market is fully covered. When moving from their position, consumers incur in a transportation cost $t > 0$. Therefore if, say, seller i is located at $x \in [0, 1]$, each consumer derives a utility $U_i(p_i; x, \theta) = v - p_i - t(|x - \theta|)^2$.

In this context, the transportation costs t should not be considered as physical costs, but as the perceived differentiation among the attributes of two given products. In this sense, t can represent the consumer loyalty to a certain brand or his responsiveness to marketing campaign (Jentzsch et al., 2013).

*Sellers.*There are two sellers located at the extremes of the unit line, say, seller 1 is located at 0 while seller 2 at 1. The products sold are horizontally differentiated, but sellers misperceive the true degree of product differentiation t.

We consider that t can assume the value $\bar{t}$ with probability $\frac{1}{2}$ and $\underline{t}$ with probability $\frac{1}{2}$ and $\bar{t} > \underline{t} > 0$. The probability distribution of t is common knowledge.[2]

In this model, we assume that sellers are *naive* in the sense that they cannot learn the true value of t unless they acquire information from the data owner.

Data owner. Consider a data owner which has collected data about customers preferences. In what follows, we assume that the data owner can either negotiate the sale of the information with the two competing sellers or he can use his superior knowledge to enter the market and sell directly to the consumers.[3] We assume that the data seller owns data about consumer preferences from which it is always possible to infer at zero cost and with perfect accuracy the true value of t.[4]

In the case of the selling mode, the data owner derives its profits by selling information at a price f to either one or both the sellers. In the case of competing with other sellers, he sets a price for the product p^S and chooses its optimal location on the Hotelling line (the product space). The adopted solution concept is Perfect Bayesian Equilibrium.

The timing of the game is:

1. The data owner observes the sellers' priors. Under the selling mode, he acts as a pure data broker and decides whether to sell the information under exclusivity or not. Under the competing mode, he acts as a third seller and chooses its location on the Hotelling line;

2. In the selling mode, after the negotiation, both sellers set prices. In the competing mode, both the sellers and the data owner simultaneously set prices;

3. Consumers make their purchase decision and profits are realized.

[2]It could be possible to argue that sellers might attach higher probabilities Probabilities can be replaced with more general α and $1-\alpha$ without alter

[3]In fact, the data owner can be considered a potential entry seller which has collected a huge amount of data and that has to decide how to use his information.

[4]We do not assume that the competing sellers have zero information. Nevertheless, we can think of a scenario in which sellers' datasets are incomplete.

3.3 Model

The analysis that follows distinguishes the two business models that can be implemented by the data owner. In the first section, we analyze the case of a pure data broker who sells his information to two competing sellers, while in the second section, we consider the case of a data owner who decides to enter the market and sell directly to consumers.

3.3.1 Selling mode

Symmetric information provision

We first consider the symmetric case in which both sellers hold or do not hold information. In the last stage, the sellers compete á la Hotelling, the marginal consumer between seller i and seller j is implicitly given by $v - p_i - t\theta^2 = v - p_j - t(1-\theta)^2$ and is located at $\theta(p_i, p_j) = \left(\frac{1}{2} + \frac{p_j - p_i}{2t}\right)$. Therefore we can derive sellers' market share:

$$Q^i(p_i, p_j) = \theta(p_i, p_j), \qquad Q^j(p_i, p_j) = 1 - \theta(p_i, p_j). \tag{1}$$

Seller i maximizes expected profits $E[\pi_i(p_i, p_j; t)] = \frac{1}{2}(p_i)Q^i(p_i, p_j; \bar{t}) + \frac{1}{2}(p_i)Q^i(p_i, p_j; \underline{t})$. As no seller owns the information, under such assumptions, we derive standard symmetric equilibrium prices

$$p_i^{*B} = p_j^{*B} = 2\frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}, \tag{2}$$

and profits

$$\pi_i(p_i^{*B}, p_j^{*B}; t) = \pi_j(p_i^{*B}, p_j^{*B}; t) = \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}, \tag{3}$$

where the superscript "B" stands for biased. Interestingly, the results obtained by the maximization of the expected profits are identical to the results we would obtain if sellers maximized profits by taking expectation over the true value of t, more specifically considering its harmonic mean $(E\left[\frac{1}{t}\right])^{-1} = 2\frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}$. Therefore, to provide a better comparison, we define $\tilde{t} \equiv \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}$ and we say that an uninformed seller *underestimates the true value of* t when $(t = \bar{t})$ and that *overestimates the true value of* t when $(t = \underline{t})$.

Straightforwardly, when both the sellers are informed, we derive standard Hotelling prices $p_i^* = p_j^* = t$ and profits $\pi_i(p_i^*, p_j^*) = \pi_j = t/2 - f$ with $t \in \{\underline{t}, \bar{t}\}$.

Only one seller has information

In case of exclusive dealing, the data owner decides to sell information only to one of the two sellers by offering a TIOLI contract. Consider that seller i is offered to buy information exclusively, he can either accept the offer or reject it. Assume that seller i accepts the deal. When seller i observes the new value of t, he updates its information about the market shares.

At the time of choosing prices, seller j knows that his rival owns exclusive information. However, this is not strategically relevant for seller j as he does not know the content of such information and cannot update his beliefs over t. Therefore, seller j's price does not change from the no information case in (2), i.e., $p_j^{*B} = \tilde{t}$.

This is one of the main differences with the case in which sellers can purchase information about consumer location. In that case, the uninformed seller, despite not being aware of the content of the information, knows with certainty the pricing strategy of his rival and responds by lowering his prices.

In this case, instead, the uninformed seller is uncertain about the optimal response function of his rival as it strictly depends on the true value of t. Indeed, from seller i's maximization process we have that:

$$p_i^*(\bar{t}) = \frac{\bar{t} + \tilde{t}}{2}, \qquad p_i^*(\underline{t}) = \frac{\underline{t} + \tilde{t}}{2}, \tag{4}$$

$$\pi_i(p_i^*, p_j^{*B}; \bar{t}) = \frac{(\bar{t} + \tilde{t})^2}{8\bar{t}} - f, \qquad \pi_i(p_i^*, p_j^{*B}; \underline{t}) = \frac{(\underline{t} + \tilde{t})^2}{8\underline{t}} - f, \tag{5}$$

$$\pi_j(p_i^*, p_j^{*B}, \bar{t}) = \frac{\tilde{t}(3\bar{t} - \tilde{t})}{4\bar{t}}, \qquad \pi_j(p_i^*, p_j^{*B}, \underline{t}) = \frac{\tilde{t}(3\underline{t} - \tilde{t})}{4\underline{t}}, \tag{6}$$

When comparing the profits in (5) with the no information case profits in (3), it is possible to observe that, gross of the information price f, one seller is always better off when holding correct information independently of the realization of t. Nevertheless, such an advantage is higher when $t = \underline{t}$ rather than when $t = \bar{t}$. Indeed, when the uninformed seller overestimates the true value of t ($t = \underline{t}$), he sets a price that is higher than the complete information case. As a consequence, the informed seller slightly cuts his prices below his rival's level (the no information scenario) and increases its market share. In this scenario, the informed seller can benefit of a larger market share and makes higher profits.

Alternatively, when $t = \bar{t}$, the rival underestimates the true value of t and sets a price that is lower than the complete information case. By purchasing information and knowing the true value of t, the informed seller renounces a share of his demand by setting higher prices, thus softening price competition. As a result, the downward pressure on prices exerted by the uninformed seller lowers the profits of the informed seller.

Interestingly, there exist two cases in which holding the exclusivity over the data does not always guarantee the highest profits. In the first case, when ($\tilde{t} < \bar{t}$), the uninformed seller keeps prices at a lower level than the perfect information case. In this case, the informed seller would rather prefer to share his information with the rival in order to relax price competition.

In the second case, when ($\tilde{t} > \underline{t}$ and $\bar{t}/\underline{t} < 5$), the uninformed seller makes higher profits than the informed seller. When the uninformed seller underestimates t, he sets a price lower than the perfect information case. As a consequence, the informed seller optimally responds by raising the price above his rival's level. Such a response is optimal for the informed seller, who makes higher profits than the no information case, but advantages more his rival who can benefit of a higher market share.

Differently from our findings, when sellers can purchase information about consumers' location, a seller always makes higher profits under exclusivity.

Information sale

In order to determine the price of the information, as the data owner holds the whole bargaining power, he sets a price that makes the sellers indifferent between accepting the offer and declining it. Interestingly, we find that seller i is not always interested in detaining exclusive information.

When considering whether to buy the information, both the sellers are unaware of the actual content of the data and do not know whether they will face a scenario with

$\bar{t}$ or $\underline{t}$. Therefore, they will make their purchase decision by maximizing their expected profits. However, we model the payment so that the data owner anchors the price of the information to the future profit realizations of the sellers. Such payment modality is not uncommon in those markets with few agents and repeated interactions (Koutroumpis et al., 2020).

In order to make their purchase decision, both the sellers compare their expected profits.

$$E[\pi_i(p_i^*, p_j^*; t)] = \frac{\bar{t} + \underline{t}}{4} - f, \qquad E[\pi_i(p_i^{*B}, p_j^*; t)] = \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}, \tag{7}$$

$$E[\pi_i(p_i^*, p_j^{*B}; t)] = \frac{14\underline{t}\bar{t} + \bar{t}^2 + \underline{t}^2}{16(\bar{t} + \underline{t})} - f, \qquad E[\pi_j(p_i^{*B}, p_j^{*B}; t)] = \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}. \tag{8}$$

Expressions in (7) and (8) report the expected profits. Interestingly, the expected profits of the uninformed seller in the asymmetric case in 7 do not change from the case in which both sellers are uninformed in 8. Moreover, gross of the price for the information, a seller makes higher expected profits when informed independently on the exclusivity conditions. This implies that, independently of the sale modality chosen by the data owner, a seller always has an incentive to buy information as summarized in the following Lemma.

Lemma 1 *When considering their expected profits, sellers always have a unilateral incentive to buy information.*

Consider the scenario of exclusive dealing. In this case, the data owner proposes a contract exclusively to one seller, if the seller, say seller i, accepts the offer, he derives the exclusive profits in (5). Alternatively, if he rejects the offer, the negotiation process ends and both the sellers make the profits of the no information scenario in (3). Therefore, the data owner proposes a price that makes the seller i indifferent about buying the information or not, formally:

$$f^{i,*} = \max\{\pi_i(p_i^*, p_j^{*B}; t) - \pi_i(p_i^{*B}, p_j^{*B}; t), 0\}, \tag{9}$$

which can assume values

$$f^{i,*}(\bar{t}) = \frac{(\bar{t} - \tilde{t})^2}{8\bar{t}} > 0, \qquad f^{i,*}(\underline{t}) = \frac{(\underline{t} - \tilde{t})^2}{8\underline{t}} > 0 \tag{10}$$

Now, consider the scenario where the data owner sells the information to both the sellers. As we said before, gross of the price for the information, buying the information is a dominant strategy. Therefore, the data owner proposes a contract that makes either seller indifferent about buying the information or not, formally:

$$f^{i,*} = \max\{\pi_i(p_i^*, p_j^*; t) - \pi_i(p_i^{*B}, p_j^*; t), 0\}, \tag{11}$$

which can assume values

$$f^{i,*}(\bar{t}) = \frac{(2\bar{t} - \tilde{t})(\bar{t} - \tilde{t})}{4\bar{t}} > 0, \qquad f^{i,*}(\underline{t}) = 0. \tag{12}$$

By comparing the information prices in (10) and (12), it is possible to observe that the selling strategy implemented by the data owner changes depending on the actual realization of t. More specifically, when the $t = \bar{t}$, the data owner finds it more profitable to sell the information to both the sellers. When $t = \underline{t}$ instead, the data owner prefers the exclusive selling strategy.

The main reason for such a result is that while the sellers' purchase decision depends on the nature of the expected profits, the payment to the data owner is linked to the future realizations of the profits. On the one hand, this payment strategy allows the data owner to extract the maximum possible surplus from sellers. On the other hand, the drawback is that the data seller implicitly commits himself to ensuring the sellers a certain level of profits whenever possible. Therefore, when the profits that the data owner should guarantee overcomes the actual profits, he derives no profits from the information sale. In other words, the data owner sets a sort of royalty on the future benefits that sellers derive from the purchase of information.

When selling exclusive information, the data owner can sell the information at a positive price. Indeed, as said in the previous section, concerning the no information case, a seller holding exclusive information is always better off. The rationale is that he can exploit his superior knowledge against the uncertainty of his rival and sets more accurate price. Therefore, the data owner can set a price for the information which extracts the sellers' extra profits until the point where the seller is indifferent between buying and not buying information.

Differently from the previous case, when selling information to both sellers, the data owner can set a positive price only when $t = \bar{t}$, whereas he sets the price for the information at zero when $t = \underline{t}$. The rationale behind this result relies on the fact that, as already stated in the previous section, being informed does not always guarantee the highest profits.

Therefore, from the comparison of (10) and (12), we can characterize the optimal selling strategy of the data owner under the two possible scenarios $t = \bar{t}$ and $t = \underline{t}$.

When $t = \bar{t}$, the uninformed seller underestimates the true t and sets a price lower than the perfect information case, thus creating downward pressure on the price of the informed seller. Although, as said in the previous paragraph, a seller is always better off by holding exclusive information than being uninformed, he would rather prefer to "share" such information with his rival in order to relax price competition (Armstrong, 2006b). In this case, both sellers would benefit more from competing under perfect information and selling information to both sellers is an optimal strategy for the data owner.

When $t = \underline{t}$, instead, both the sellers find it more profitable a scenario with asymmetric information than a scenario with perfect information. The rationale behind this result is that, under perfect information, the price competition is harsher than under asymmetric information. As already stated in the previous section, whenever the uninformed seller overestimates the true t, the informed seller's optimal response seller is to slightly undercut his prices below the level of his rival but above the one obtained under perfect information. In this situation, both sellers make higher profits than under perfect information. Consequently, the data owner cannot extract any extra profits by selling to both the sellers as they would have rather preferred to stay uninformed. In this case, the data owner decides to sell information only to one seller.

The following Proposition summarizes this result and describes the data owners' optimal selling strategy, formally:

Proposition 1 *The selling strategy chosen by the data owner depends on the actual degree of product differentiation. When* $t = \underline{t}$*, the data owner chooses to sell the information exclusively and makes profits* $\Pi^{SELL}(\underline{t}) = \frac{(\underline{t}-\tilde{t})^2}{8\underline{t}}$*. When* $t = \bar{t}$*, the data owner chooses to sell the information to both the sellers and makes profits* $\Pi^{SELL}(\bar{t}) = \frac{(2\bar{t}-\tilde{t})(\bar{t}-\tilde{t})}{2\bar{t}}$*.*

3.3.2 Competing mode

In this section, we consider the case in which a data owner decides to not sell customer data and sell directly to the consumers by entering as a third seller. In such a case, he is the only agent who is perfectly informed about the true value of t and, for convenience, we refer to him as seller S. To focus on the pure difference between the two modes, we assume that there are no entry costs.

Concerning the selling mode, the only change is that now consumers have more choices. Therefore, a buyer decides to buy at seller i rather than at seller S if $v - p_i - t\theta^2 > v - p_S - t(x-\theta)^2$, where $x \in [0,1]$ defines the location of the data owner on the Hotelling line. Symmetrically, a buyer decides to buy at seller i rather than at seller S if $v - p_S - t(\theta - x)^2 < v - p_j - t(1-\theta)^2$.

Therefore we can define with $\theta^1(p_i, p_S) = \left(\frac{x}{2} + \frac{p_S - p_i}{2tx}\right)$ the location of the consumer indifferent between seller i and seller S and with $\theta^2(p_j, p_S) = \left(\frac{1+x}{2} + \frac{p_j - p_S}{2t(1-x)}\right)$ the location of the consumer indifferent between seller S and seller j. The new sellers' market shares are:

$$Q^i(p_i, p_S, x) = \theta^1(p_i, p_S), \tag{13}$$

$$Q^S(p_i, p_j, p_S, x) = \theta^2(p_j, p_s, x) - \theta^1(p_i, p_j, x), \tag{14}$$

$$Q^j(p_i, p_j, x) = 1 - \theta^2(p_j, p_S, x). \tag{15}$$

Price setting and location decision

In the second stage, the three sellers simultaneously set their prices. As seller S is the only informed seller, their rivals maximize expected profits $E[\pi_i(p_i, p_S; t)] = \frac{1}{2}(p_i)Q^i(p_i, p_S(\bar{t}); \bar{t}) + \frac{1}{2}(p_i)Q^i(p_i, p_S(\underline{t}); \underline{t})$, while seller S maximizes $\Pi^{COMP}(p_i, p_j, p_S) = p_S Q^S(p_i, p_j, p_S)$.

From the maximization process, we derive that the optimal response function of the sellers

$$p_i(p_S(\underline{t}), p_S(\bar{t}), x) = \frac{p_S(\underline{t})\, \bar{t} + \underline{t}(p_S(\bar{t}) + 2\bar{t}x^2)}{2(\bar{t} + \underline{t})} \tag{16}$$

$$p_j(p_S(\underline{t}), p_S(\bar{t}), x) = \frac{p_S(\underline{t})\, \bar{t} + \underline{t}(p_S(\bar{t}) + 2\bar{t}(1-x)^2)}{2(\bar{t} + \underline{t})} \tag{17}$$

$$p_S(p_i, p_j; \bar{t}, x) = \frac{p_i(1-x) + p_j(x) + \bar{t}(1-x^2)}{2} \tag{18}$$

$$p_S(p_i, p_j; \underline{t}, x) = \frac{p_i(1-x) + p_j(x) + \underline{t}(1-x^2)}{2} \tag{19}$$

By solving them simultaneously, we obtain the following equilibrium prices:

$$p_i(x) = \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}} x \equiv \tilde{t}x \qquad p_i(x) = \frac{\bar{t}\,\underline{t}}{\bar{t} + \underline{t}}(1-x) \equiv \tilde{t}(1-x) \tag{20}$$

$$p_S(\underline{t}) = \frac{x(1-x)(\underline{t} + \tilde{t})}{2} \qquad p_S(\bar{t}) = \frac{x(1-x)(\bar{t} + \tilde{t})}{2} \tag{21}$$

Finally, in the first stage, the entry seller chooses its optimal location on the Hotelling line. Formally, seller S chooses the x which maximizes $\Pi^{COMP}(x;t) = \frac{(1-x)x(t+\tilde{t})^2}{8t}$ with $t \in \{\underline{t}, \bar{t}\}$. Given the quadratic transportation costs, it is easy to verify that this function is concave in x, therefore, from first-order conditions we derive that the entrant (the data owner) in the spirit of th principle of maximum product differentiation chooses its optimal location at $x = \frac{1}{2}$.

This finding is not surprising, given the overall symmetry of the model. However, by locating in the center of the two sellers we derive the following equilibrium profits:

$$\pi_i(\bar{t}) = \pi_j(\bar{t}) = \frac{\bar{t} + \tilde{t}}{32}, \qquad \Pi^{COMP}(\bar{t}) = \frac{(\bar{t} + \tilde{t})^2}{32\bar{t}}, \tag{22}$$

$$\pi_i(\underline{t}) = \pi_j(\underline{t}) = \frac{\underline{t} + \tilde{t}}{32}, \qquad \Pi^{COMP}(\underline{t}) = \frac{(\underline{t} + \tilde{t})^2}{32\underline{t}}, \tag{23}$$

and we summarize this result in the following proposition.

Proposition 2 *When the data owner decides to use its information to sell directly to the consumers, he derives profits* $\Pi^{COMP}(t) = \frac{(t+\tilde{t})^2}{32t}$ *with* $t \in \{\underline{t}, \bar{t}\}$.

3.4 Equilibrium analysis

In this section, we compare the equilibrium profits under the two business models, characterize the optimal choice for the data owner.

First, the comparison of the equilibrium profits in Proposition (1) and Proposition (2) yields the following result.

Proposition 3 *When the sellers underestimate the true value of product differentiation ($t = \bar{t}$), a data owner is always better off by selling the information to both the sellers (Selling mode). When the sellers overestimate the true value of product differentiation ($t = \underline{t}$), the optimal strategy of a data owner depends on the ratio $\frac{\bar{t}}{\underline{t}}$. When $\frac{\bar{t}}{\underline{t}} < \hat{t}$, the data owner is better off by entering the market (Competing mode). When $\frac{\bar{t}}{\underline{t}} \geq \hat{t}$ the data owner is better off by selling the information exclusively (Selling mode). With $\hat{t} = \frac{3+\sqrt{33}}{4}$*

From Proposition 3, it is possible to derive that a data owner, although he does not have a dominant strategy, is more prone to sell his information rather than exploiting them to operate in the market. This result remarks the relevance of the sale of information.

The rationale behind this result relies on the type of customer information. Indeed, such information only reveals the true degree of consumer flexibility, but neither affects the perceived value of a product nor provides any quality advantage. Therefore, a data owner is more prone to sell his information rather than facing a competitive environment.

More specifically, when ($t = \bar{t}$), the sellers act as they underestimate the true degree of product differentiation by setting a lower price than under perfect information. In this case, the value of the information reaches its maximum when all the sellers are informed as a logical consequence of more relaxed price competition. If the data owner decided to enter the market instead of selling information, he would face an extremely competitive environment and would find it more profitable to share his information for free. However, also in this case he would make lower profits than under the selling mode.

When ($t = \underline{t}$) instead, the situation is reversed as the value of the information reaches its maximum when only one seller is informed. On the one hand, operating in the market by detaining exclusive information is profitable for the data owner. On the other hand, selling exclusive information becomes more valuable as more the sellers overestimate the true t. In this case, from the point of view of the data owner, the advantages of entering the market and detaining exclusive information are softened by the effect of the competition. For this reason, the data owner finds it profitable to directly operate in the market only if sellers' expectations are not too "biased" ($\frac{\bar{t}}{\underline{t}} < \hat{t}$), otherwise if ($\frac{\bar{t}}{\underline{t}} > \hat{t}$) he prefers to sell information.

3.5 Concluding remarks

To conclude, in this paper we provide an overall assessment of the effect of the sale of information on sellers' prices and profits. We find that when the data provide information about the degree of product differentiation detaining exclusive information does not always guarantee the highest profits to the sellers. This result is in contrast with the scenario in which a seller detains exclusive information about consumer location, in which case the informed seller unambiguously makes the highest profits under the asymmetric information scenario (Thisse & Vives, 1988). Moreover, along the paper we show that selling information about the degree of product flexibility affects the sellers' prices and the pricing strategies in a different way with respect to the sale of information about consumers' location. This might raise some regulatory concerns about the sale of information.

Finally, we characterize the optimal strategy of a data owner under two business models: a selling mode and a competing mode. We find that the data owner does not have a dominant strategy and his decision crucially depends on to what extent the sellers underestimate or overestimate the true value of product differentiation.

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