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Does add-on presence always lead to lower baseline prices? Theory and evidence

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Abstract

In many industries, firms give consumers the opportunity to add (at a price) optional goods and services to a baseline product. The aim of our paper is to clarify the effect that offering add-ons has on baseline prices. In order to do that, we develop a theoretical model of add-on pricing in competitive environments with two distinctive features. First, we discuss the choice of offering the add-on, if this entails a fixed cost. Second, we allow firms to have a varying degree of market power over the add-on. In symmetric equilibria, the presence of add-on always reduces baseline prices. In asymmetric equilibria in which only one firm offers the add-on, its presence increases the baseline price if the firm's market power over the add-on is limited. The latter prediction of the model is confirmed by a hedonic price regression using a dataset of cruises offered worldwide, a situation in which it is possible to control for the level of add-on market power.

Keywords: Add-ons, Pricing, Cruise industry, Hedonic regression

JEL classification: D43, L83

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1. Introduction

Add-ons, i.e. optional goods and services that consumers can add (at a price) to a baseline product, are ubiquitous. In the hotel industry, the price for a room typically does not include additional services such as telephone calls or minibar items. Similarly, airline tickets, especially in the case of low-cost carriers, do not include on-board meals. Appliance stores offer additional warranties to consumers after they buy. A long list of other examples could be provided. Often, prices for such add-ons are difficult (or costly) to observe before the baseline product is bought. This gives firms market power when selling add-ons even if the baseline product is offered in competitive markets. Consequently, add-on prices tend to be high and firms compete on the baseline product price, which then tends to be low. This pricing scheme is the well-known "razor and blades" strategy, named after another typical example of a baseline product (i.e. the razor) and add-on (i.e. the blade).

The literature on add-on pricing is as rich as the business practice (Lal and Matutes, 1994; Verboven, 1999; Ellison, 2005; Gabaix and Laibson, 2006; Shulman and Geng, 2013), focusing both on firms' strategy and the implications for antitrust and consumer policy (Shapiro, 1995; Gabaix and Laibson, 2006). Our focus is on the former. In particular, the aim of our paper is to clarify the effect that offering add-ons has on baseline prices. The contribution of our paper is both at the theoretical and empirical level.

At the theoretical level, we provide a model of add-on pricing in a duopoly context with two distinctive features. First, we consider the choice of offering the add-on, if this entails a fixed cost. Second, we allow firms to have varying degrees of market power over the add-on, associated with the ability to capture the value that consumers obtain from such additional goods.

The main result of our analysis is that the presence of add-ons does not necessarily lead to a lower price for the baseline product. On the one hand, when both firms offer the add-on, the price for the baseline product is lower compared to the case when the add-on is not offered. Moreover, the higher the market power over add-ons the lower the price for the baseline product. These results are intuitive and follow quite directly from the "razor and blades" argument that is frequently put forth in the literature. However, in asymmetric equilibria, in which only one firm offers the add-on, things change. The firm offering the add-on unambiguously obtains higher profits, but its price for the baseline product can be higher or lower depending on the degree of market power in the add-on market: baseline product prices are lower only when firms can extract ex-post a significant share of consumer surplus. Intuitively it can be argued on the one hand that the add-on provides higher utility to consumers, thus creating a competitive advantage for the firm offering it, which consequently can fix higher baseline product prices. On the other hand, the additional value to the firm that each consumer brings through the add-on leads to more aggressive pricing. The second effect prevails only if the proportion of surplus that the firm can appropriate is sufficiently large.

At the empirical level, we estimate a hedonic price function on a dataset of cruises offered worldwide, assessing the extent to which the offer of a specific type of add-on impacts baseline prices. Therefore, we focus on the implications of the model when the equilibrium is asymmetric, for which the cruise industry constitutes an ideal setting. In fact, in this industry, add-ons abound and the data show that the revenues associated with such add-ons are a fundamental source of profitability. However, add-ons differ with respect to the share of consumer surplus that can be captured by firms. In line with the model, as consumers have few alternatives while on board, we find those activities associated with on-board sales reducing cruise ticket prices. This is the case for casinos and shops. On the contrary, as travellers can self-organise and other businesses can compete, market power is limited for shore excursions, for which we find a positive effect on price. Our model predictions are also supported by additional regression analysis in which we introduced two proxies of market power for shore excursions.

The rest of the paper is organised as follows. Section 2 reviews the theoretical and empirical literature on add-on pricing. The model is described and solved in Section 3, while the empirical analysis is conducted in Section 4. Section 5 provides further implications arising from our results. Finally, Section 6 concludes.

2. Literature review

2.1 The economics of add-ons: the theory

The economic analysis of add-ons represents a quite consolidated stream of literature. A broad division can be made between contributions that posit consumers' full rationality and those, more recent, which rather assume bounded rationality and cognitive biases on the demand side. In both streams of literature, predictions are usually derived concerning the impact that offering add-ons has on baseline prices. This Section focuses on such predictions.

One of the first contributions in the "full-rationality" camp is the work by Lal and Matutes (1994). The authors frame their problem in the context of loss-leader pricing, i.e. the strategy by which retailers advertise some goods at a price below the marginal cost to attract customers and then make profits on other goods in store for which prices are not advertised. In their model, loss-leader pricing is an equilibrium when advertising costs are sufficiently large: in this case, one good (corresponding to the baseline product) is advertised at a low price, while a second good (corresponding to the add-on) is not advertised and highly priced. In addition, the authors formalise the so-called Chicago argument, in which the profit gain from the good sold at a high price (the add-on) simply compensates for the loss on the advertised good (the baseline product). Another important early contribution is that by Verboven (1999), who develops a model in which firms offer baseline and premium products (the latter including add-ons) in a context of vertical and horizontal differentiation, and consumers may have limited information on the prices for premium versions. He finds that mark-ups for premium products are higher than mark-ups for baseline products, since "firms compete vigorously for consumers through base product prices, in anticipation of the large monopoly profits to be earned from the premium products" (Verboven, 1999, p. 411). More recently, Ellison (2005) has shown that the add-on pricing strategy (in which add-on prices are not observed) leads to expensive add-ons and base line products possibly sold at a loss. However, differently from Lal and Matutes (1994), the add-on pricing strategy can indeed be profit-enhancing in a context in which the consumers' willingness to pay for the baseline product and the add-on are positively related. In this case, the large profit that firms obtain through the add-on from consumers with high valuation willingness to pay reduces the incentive to price the baseline product aggressively, which disproportionally attracts consumers with low evaluations.

A related body of literature considers a foremarket for durable goods (e.g. printers, videogame consoles) and an aftermarket for non-durable goods and services (e.g. ink cartridges, spare parts, games). In this case, special attention is paid to antitrust policy implications for firms' market power over the aftermarket when the foremarket is competitive but consumers are locked in after buying, in particular following the well-known Kodak case (Shapiro, 1995). A common finding in the literature is that firms have the incentive to sell above the marginal cost in the aftermarket and at a low price (possibly below cost) in the foremarket (Chen and Ross, 1999; Borenstein et al., 2000; Carlton and Wadman, 2010; Cabral, 2014; Zegners and Kretschmer, 2016). The logic of this result is summarized by Shapiro (1995): "The key point is that sellers are surely aware of the life cycle profits associated with a selling piece of equipment, even if buyers are poorly informed about aftermarket costs. Therefore, systems competition pushes manufacturers to discount their equipment to capture any aftermarket "monopoly" profits … The idea of giving away the razor to make money on sales of razors blades is just too obvious, and intuitive, for companies to miss it." (p. 493-494). The social evaluation of this outcome has been instead debated. Some inefficiencies due to above-cost pricing in the aftermarket, such as the excessive cost of replacing durable goods, may have a small impact when the reduced price in the foremarket is taken into account (Shapiro, 1995). In other cases, as when the aftermarket is characterised by increasing returns, market power over the aftermarket can instead be beneficial in terms of social and possibly consumer surplus (Cabral, 2014).[1] On the other hand, aftermarket rents and aggressive pricing in the foremarket may lead to inefficient outcomes (in terms of profits and consumer and social welfare) if there are consumers whose willingness to pay for the base good is lower than cost (Zegners and Kretschmer, 2017). However, in a recent contribution, Miao (2010) has suggested that aftermarket profit might not be dissipated in the primary market in contexts where the price in the aftermarket (e.g. the price of a cartridge) is bounded by the price on the primary market (e.g. the price of a printer system, including a cartridge and a printer).

[1] Carlton and Waldman (2010) identify other mechanisms through which aftermarket monopolisation can be efficiency enhancing.

The departure from consumers' full rationality is the starting point of more recent contributions, which are part of a broader, emerging literature on the implications of consumers' bounded rationality for industrial organisation theory (e.g. Wang and Yang, 2010; Chioveanu and Zhou, 2013). The seminal paper by Gabaix and Laibson (2006) looks at incentives for firms to "shroud" information on add-on prices. They consider the co-existence of myopic consumers, who consider the add-on only if information on its existence and its price is "unshrouded", and sophisticated consumers, who rationally predict add-on prices when information is shrouded and can avoid a (costly) purchase if they expect the add-on price to be too high. The authors find that if the share of myopic consumers is sufficiently large, shrouding equilibria (in which firms adopt an add-on pricing strategy) are possible, even if unshrouding is costless: "Our model reproduces the well-known results that high mark-ups for the add-on are offset by low or negative mark-ups on the base good" (Gabaix and Laibson, 2006, p. 518). In their model, myopic consumers are worse off (because of the high price of the add-on) and sophisticated consumers are better off (because they can take advantage of a low base price and avoid the high-price add-on). The model has been extended in several directions, analysing for instance the role of competition in unshrouding information (Wenzel, 2014), the role of consumer education as a long-term strategy (Dahremöller, 2013) and regulatory intervention (Kosfeld and Schuwer, 2017), the case of asymmetric firms (Shulman and Geng, 2013), or identifying the conditions under which high add-on prices may also benefit myopic consumers (Zenger, 2013). In all these papers, as in Gabaix and Laibson (2006), the presence of add-ons reduces base product prices. De Meza and Reyniers (2012), in a model of unavoidable surcharges**,** show that lack of information of consumers (shrouded attributes) might even benefit them through lower upfront prices.

Two contributions that propose psychological mechanisms inducing a positive impact of add-ons on baseline prices are Erat and Bhaskaran (2012) and Bertini et al. (2009). In the former, the willingness to pay for the add-ons is positively affected by the price of the base product due to mental accounting. In the latter, alignable and non-alignable add-ons are distinguished. Alignable add-ons improve existing characteristics, while non-alignable ones add new features or capabilities. Alignable add-ons should reduce the value of the baseline product by increasing consumers' reference point. Non-alignable add-ons could instead increase evaluations, due to a halo effect.

With respect to the existing literature, in most of our analysis we adopt a full rationality approach. Therefore, unsurprisingly we find an irrelevance result for the add-on pricing strategy in terms of profits, along the lines of Lal and Matutes (1994) and consistent with the Chicago view. Also, in line with Lal and Matutes (1994), Verboven (1999) and Ellison (2005), we assume add-ons are valued by consumers. This contrasts with most of the recent "behavioural" approaches, which focus on add-ons that represent utility reductions consumers can avoid at a cost (Gabaix and Laibson, 2006).

However, we contribute to the literature in two particular ways: first by focusing on the relationship between the degree of market power in the add-on market and the price of the baseline product in symmetric and asymmetric situations; second by making the decision to offer the add-on endogenous and allowing for different degrees of market power when supplying the add-on *at the same time*. Our modelling framework is similar to that of Shulman and Geng (2013), Geng and Shulman (2015) and Zegners and Kretschmer (2017). We share with them the Hotelling representation of horizontal differentiation and one-unit demand for both baseline products and add-ons, and we represent market power for add-ons as Zegners and Kretschmer (2017) do. In addition to this, all three papers allow for heterogeneous consumers. In Zegners and Kretschmer (2017), this is the key element through which aftermarket power can backfire. Shulman and Geng (2013) extend the analysis to firms' asymmetries in baseline products and add-on valuations, while Geng and Shulman (2015) model the firms' decision between an add-on pricing strategy (where the add-on has a separate price), or an all-inclusive one. However, none of these papers consider the decision of firms to offer the add-on, which is an important ingredient in our model as the relationship between the degree of market power in the add-on market and the price of the baseline product differ between symmetric and asymmetric situations.

Two recent contributions which make the choice of offering the add-on endogenous, as we do, are Lin (2017) and Balachander et al. (2017). They analyse different variants of a model where offering the add-on does not entail a fixed cost, but baseline products are vertically differentiated. They show that when the marginal cost of the add-on is sufficiently high, an asymmetric equilibrium exists where the high-quality firm only offers the add-on. This provides an alternative explanation for asymmetric configurations, but neither paper considers the role played by market power over the add-on in affecting the baseline product price.

2.2 The economics of add-ons: the empirical evidence

Pricing strategies involving add-ons have also been investigated in a wide array of empirical studies. A few of them are directly related to the focus of this paper, concerning the impact of add-ons on baseline prices. Verboven (1999) tests his model against data from the automobile market and finds that in the low-class part of the market, where brand rivalry is intense, the prices for premium versions exhibit larger mark-ups, as predicted by the model assuming limited information on add-ons. Brueckner et al. (2015) provide a theoretical and empirical analysis of baggage fees impact on airline fares, focusing on the US airline industry. They find that baggage fees have a negative impact on airline fares, although the overall price, paid by whom who chooses to check the bag, increases.

Other contributions, instead, have investigated the impact of add-on pricing strategies on profits. In the older literature, Walters and MacKenzie (1988) find that loss leader pricing has no effect on profit in the case of two US supermarket chains, thus confirming the Chicago view. More recent empirical works are in general more favourable to the idea of add-on pricing strategy profitability. By using field and natural experiments in online auctions, Brown et al. (2010) find that firms enjoy higher revenues by increasing hidden charges. Based on a field experiment in a large Turkish bank, Alan et al. (2015) find that SMS messages announcing a large discount on overdraft interest rates reduce overdraft usage, while those messages that mention overdraft availability without referring to prices increase it. Therefore, firms lack incentives to draw attention to or otherwise compete on prices of overdrafts (an add-on for banks). Ellison and Ellison (2009) provide further evidence on the profitability of add-on pricing as an obfuscation strategy frustrating a consumer's search. Furthermore, consumers are found to underreact to monetary costs that are not salient, as shown by Chetty et al. (2009) in a study looking at the effect on demand when taxes are not included in the price. However, Hartmann and Nair (2009) find that manufacturers may profitably shift margins between the primary and aftermarket good, but cannot exploit customers in the aftermarket without suffering decreased primary good adoption.[2]

In line with the theoretical model, on the empirical side we are not interested in evaluating the impact of add-on pricing on profits, but rather we start from the observation that in our empirical context, i.e. the cruise industry, we do observe add-on pricing. By estimating a hedonic price function for this controlled environment, we can differentiate the effects on baseline product price for add-ons (characteristics) endowed with different measures of firms' market power. Thus, we test the implications of the model when one firm offers the add-ons and the other not, i.e. the equilibrium is asymmetric.

3. The model

In this section, the model is described (Section 3.1) and solved (Section 3.2). Attention is paid to the relationship between the baseline product price and the degree of add-on surplus appropriability (market power), which is tested in Section 4. In Section 3.3 we extend the model in two directions: first, we allow firms to bundle the baseline product and the add-on; second, we introduce consumers' biased beliefs, through which the profit equivalence between the add-on pricing strategy and bundling no longer holds.

3.1 Model description

Two firms compete. Each firm offers a baseline product, denoted B, for which it *may* offer an add-on A. Each consumer buys at most one unit of B and A. Moreover, consumers can buy A only from the firm from which they bought product B.

Baseline products are horizontally differentiated. Horizontal differentiation is captured by assuming the existence of a standard Hotelling segment of unit length, where firms are located at the extremes (0 and 1) and a unit mass of consumers is uniformly distributed along the segment (x_i is the location of the generic consumer i). We will refer to firms as firm 0 and 1 based on their location. The gross surplus

[2] Also, there are a few laboratory experimental papers on add-ons (Wenzel and Normann, 2015) and the related issue of product attribute complexity and buyer confusion (Kalaycı and Potters, 2011).

generated by the baseline product is u^B, the unit cost of production for B is 0, while the outside option value of not buying is also normalised to 0. If firms offer the baseline product only, the utility of consumer *i* buying from firms 0 and 1 is respectively given by:

$$u_i(0) = u^B - p_0^B - \tau x_i \quad (1)$$

$$u_i(1) = u^B - p_1^B - \tau(1 - x_i) \quad (2)$$

where p_0^B and p_1^B are the prices for the baseline product and $\tau > 0$ is a standard "transport cost" parameter inversely related to the intensity of price competition. We shall assume that the market is covered, which is guaranteed if u^B is sufficiently large.[3]

Consumers' preferences for the add-on are homogeneous, although our model can easily accommodate heterogeneous consumers, without affecting our main results.[4] If a firm offers A, the gross surplus the consumer obtains from A is u^A; therefore, the utility of consumer *i* buying B and A from firms 0 and 1 when they offer A in addition to B are given respectively by:

$$u_i(0) = u^A - p_0^A + u^B - p_0^B - \tau x_i \quad (3)$$

$$u_i(1) = u^A - p_1^A + u^B - p_1^B - \tau(1 - x_i) \quad (4)$$

where p_0^A and p_1^A denote the prices for product A offered by firms 0 and 1, respectively. The unit cost for producing A is also nil, while a firm deciding to offer A incurs a fixed cost *k*.[5] If the firm from which they bought the baseline product offers the add-on, *and only in this case*, consumers can also take advantage (i.e. get utility) from other firms offering lower quality alternatives to the add-on. More specifically, we assume the existence of a competitive fringe offering an outside option, each providing

[3] We shall assume that $\tau > \frac{u^A}{3}$, which guarantees positive profit for both firms in all possible configurations.

[4] Our model turns out to be equivalent to a few instances in which consumers are (ex-ante or ex-post) heterogeneous with respect to add-on surplus. Suppose there are two types of consumers: a type with $u^A > 0$ and a type with $u^A = 0$, with probability ρ that a consumer is type-u^A (independent of consumers' horizontal preferences of baseline product). The type is known to consumers but unobservable by the firm. It can be shown that this model is equivalent to the basic version of the model if we define $u'^A = \rho u^A$. In the two-type model just described, assume that individual consumers are ex-ante uncertain of their own type, which they discover after buying the baseline product. The consumer is type-u^A with probability λ. In this case, the model is equivalent to the basic version redefining $u'^A = \lambda u^A$.

[5] The assumption that the unit cost of production for A is zero is not restrictive, since all the results of interest for this paper are unaffected if we assume positive unit cost. Moreover, as we do not model the decision as to whether offer the baseline product, the fixed cost associated with this decision is not considered.

a utility $\underline{u} \leq u^A$ at zero marginal cost (and then at zero price). The assumption that consumers can benefit from alternatives to A only if a firm offers the add-on is crucial, since it turns out to be a necessary condition for baseline prices to be higher when the add-on is offered.[6]

A few examples can clarify the kind of situations our model aims to represent:

- Consider the case of the cruise industry, investigated in the empirical part and thus discussed in greater detail in Section 4. Examples of add-ons are casinos and other on-board activities (e.g. beauty salon, shops, etc.) and shore excursions. For on-board activities, offering such add-ons may entail a fixed cost in terms of physical investment and dedicated personnel. When the opportunities for shore excursions increase by adding intermediate ports to the itinerary (or ports of call, as they are known), firms incur dockage and other service fees at the port. In the case of on-board activities, consumers have in fact limited alternative options (low, or nil $\underline{u}$). In the case of shore excursions, however, travellers may opt for self-organised trips or specialised tour-operators, thus implying a higher value of $\underline{u}$. Still, it is the decision of the cruise company to add an intermediate port that allows consumers to obtain this positive surplus. Tourists cannot value the services of a specialised tour operator in a destination, if this is not a port of call in the itinerary.
- Consider mobile phones. In this case, the add-on can be given by additional items like a new battery and the relevance of alternatives depends on the degree of compatibility between the phone and non-proprietary battery (and their quality relative to the original battery). Phones with non-removable batteries can be conceived as baseline products without add-ons.
- Even a canonical example such as razor and blades can be analysed through the lens of our model. In the case of razors, the add-on is given by replacement blades, with varying degree of compatibility between the heads of razors and non-proprietary blades. Disposable razors can be

[6] Suppose that consumers could get the utility from the outside option ($\underline{u}$), even if a firm did not offer the add-on. For a given price of the baseline product, and given the equilibrium in the add-on market, consumers would get the same utility buying from a firm, with or without the add-on. This does not occur in our set up, where the consumers prefer that the add-on is included (unless $\underline{u} = u^A$).

interpreted as baseline products without the add-on. Consumers do not benefit from the existence of non-proprietary blades, if they bought a disposable razor.

As for the timing of the game, we consider a three-stage game as follows:

- At *t*=0, firms simultaneously decide whether to offer add-on A or not.
- At *t*=1, firms simultaneously post their prices for B, having observed the decisions of both firms at *t=0*. Based on posted prices for B and the expectations for product A prices (if they are offered), consumers choose from which firm to buy B.
- At *t=2*, firms decide their prices for product A, in the case it is offered.

Some observations are in order. First, we assume that consumers are forward-looking in that they correctly anticipate the decision taken by each firm at *t*=2 when deciding from which firm to buy at *t*=1. We relax this assumption in Section 3.3.1, allowing for consumers with biased beliefs. Second, the assumption that the price for product A is fixed at *t*=2 is equivalent to assuming that the firms cannot commit to future prices. We also analyse in Section 3.3.1 what happens when firms can commit by selling A and B in a single bundle.

3.2. Model solution

As usual in multi-stage games with complete information, the relevant solution concept is subgame perfection. Proceeding by backward induction, we solve stage 2 (Section 3.2.1), and then stage 1 (Section 3.2.2) and stage 0 (Section 3.2.3).

3.2.1. Pricing the add-ons: firms' behaviour at t=2

The solution of the add-on price game is easily determined as $p_0^A = p_1^A = u^A - \underline{u} \geq 0$. In equilibrium, consumers will always buy product A, if offered. For the rest of the analysis, it is useful to define $\alpha = \frac{u^A - \underline{u}}{u^A}$, where $0 \leq \alpha \leq 1$ denotes the share of the consumer surplus that accrues to the firm (since $p_0^A = p_1^A = \alpha u^A$). α also stands for the degree of a firm's market power in the add-on market, as affected by the level of substitutability and competition between the add-on and alternative products or services offered by third parties.

3.2.2. Pricing the baseline products: firms' behaviour at t=1

At *t*=1, both firms and consumers correctly predict the outcome at *t*=2. From the point of view of consumers, if the firms offer A, the utility functions that are used to compare the two firms' offers are obtained by putting $p_0^A = p_1^A = \alpha u^A$ into (3) and (4), yielding:

$$u_i(0) = (1-\alpha)u^A + u^B - p_0^B - \tau x_i \quad (5)$$

$$u_i(1) = (1-\alpha)u^A + u^B - p_1^B - \tau(1-x_i) \quad (6)$$

while equations (1) and (2) are the relevant ones when A is not offered.

For the analysis of firms' behaviour at stage *t*=1, four cases must be considered: a) no firm offers A; b) only firm 0 offers A; c) only firm 1 offers A; d) both firms offer A.

The following proposition reports equilibrium prices for B and equilibrium profits for the four cases (proofs are in Appendix A).

Proposition 1. *Equilibrium prices for B and equilibrium profits can be summarised as follows:*

a) If no firm offers A, then $p_0^B = p_1^B = \tau$ *and* $\Pi_0(i) = \Pi_1(i) = \frac{\tau}{2}$

b) If only firm 0 offers A, then $p_0^B = \tau + \frac{u^A}{3}(1-3\alpha)$, $p_1^B = \tau - \frac{u^A}{3}$ *and*

$\Pi_0(ii) = \left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - k$ *and* $\Pi_1(ii) = \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right)$

c) If only firm 1 offers A, then $p_1^B = \tau + \frac{u^A}{3}(1-3\alpha)$, $p_0^B = \tau - \frac{u^A}{3}$ *and*

$\Pi_1(iii) = \left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - k$ *and* $\Pi_0(iii) = \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right)$

d) If both firms offer A, then $p_0^B = p_1^B = \tau - \alpha u^A$ *and* $\Pi_0(iv) = \Pi_1(iv) = \frac{\tau}{2} - k$

Proposition 1 suggests a number of considerations. By comparing cases *a)* and *d)*, we notice that when both firms offer the add-on, profits do not change with respect to the case in which the add-on is not offered: firms remain symmetric (each obtaining half of the market) and the price of the baseline product is reduced by an amount exactly equal to the price of the add-on. This effect mimics well-known irrelevance results present in the literature (Lal and Matutes, 1994): when product A is offered, each consumer is more valuable (because he or she yields an additional profit αu^A) and this leads firms to compete more aggressively on the baseline product.[7]

The most interesting insight, which is the novel contribution of our work and the basis of our empirical analysis, comes from comparing the pricing strategies of firms in the asymmetric equilibrium, where firm 0 offers the add-on and firm 1 does not (case *b)*, with the comparison for case *c)* being perfectly symmetric). Such a comparison leads the following proposition.[8]

Proposition 2. *Suppose that only firm 0 offers A. The difference in the baseline prices is given by:*

$$p_0^B - p_1^B = \frac{u^A}{3}(2 - 3\alpha) \tag{7}$$

i.e. firm 0 posts a higher price if $\alpha < 2/3$ and a lower price otherwise.

The intuition underlying this result goes as follows. From the point of view of firm 0, offering the add-on has two effects. On the one hand, by providing higher utility to consumers (compared to firm 1), firm 0's demand increases due to a vertical differentiation effect, thus making higher prices more attractive. As α decreases, i.e. the larger the proportion of the surplus is that the consumer can appropriate, this effect increases. On the other hand, when the firm can appropriate a large surplus from the add-on, it has strong incentives to reduce its price to attract additional consumers, since each consumer is particularly valuable in this case. Here, as α increases, i.e. the larger the proportion of the

[7] This result, together with the related conclusion that profits are independent of α, relies on inelastic demand for A and B.

[8] A similar result is obtained if we compare the case in which only one firm offers the add-on, say firm 0 (case b), and the case in which no firm offers the add-on (case a). In this case, firm 0 posts a higher price in case b) if $\alpha < 1/3$ and a lower price otherwise. Firm 1, instead, unambiguously fixes a lower price. The intuition is shared with the case of asymmetric equilibrium. We also verify how including the add-on leads to a higher baseline price for low α in a non-competitive setting, where B products are offered by a single firm, for the same logic described here.

surplus is that the firm can appropriate, this effect increases. When α is sufficiently low, the first effect prevails and consequently the firm offering the add-on posts a higher price.[9]

In Figure 1, we provide the best response representation of the asymmetric equilibrium for "low" α ($\alpha < 2/3$), so that the price fixed by the firm offering the add-on is higher than the competitor's price, and "high" α ($\alpha > 2/3$), in which the opposite occurs.[10]

INSERT FIGURE 1 ABOUT HERE

3.2.3. Choosing whether to offer the add-on: firms' behaviour at t=0

At *t*=0, firms must choose simultaneously whether to offer the add-on A at a common fixed cost *k* (action *OffA*) or not (action *NotOffA*). By applying backward induction, at this stage we need to solve a 2x2 game, the payoffs of which are computed using profit levels determined in the previous subsection. The payoff matrix is represented in Table 1.

INSERT TABLE 1 ABOUT HERE

The Nash equilibria of the game represented in Table 1 coincide with the subgame perfect equilibria (SPE) of the overall game and are summarised in Proposition 3 (proof in Appendix A).

Proposition 3*. The subgame perfect equilibria are determined as follows:*

1. If $k < \frac{u^A}{3} - \frac{(u^A)^2}{18\tau}$*, the SPE is such that at t=0 both firms choose OffA.*

2. If $\frac{u^A}{3} - \frac{(u^A)^2}{18\tau} < k < \frac{u^A}{3} + \frac{(u^A)^2}{18\tau}$*, there are two SPE such that at t=0 one firm only chooses OffA.*

3. If $k > \frac{u^A}{3} + \frac{(u^A)^2}{18\tau}$*, the unique SPE is both firms choosing NotOffA.*

[9] It is important to observe that this result does not hinge upon the existence of a single add-on with inelastic demand. On one hand, it extends to the case of multiple add-ons if the utility provided by add-ons is additive. On the other hand, in a more general model with generic values for add-on profit and consumer surplus (which includes the case of elastic demand), it shows that that the price for the baseline product is lower for the firm offering the add-on only if the profit/consumer surplus ratio is above 2.

[10] Best responses are formally derived in Appendix A.

The interpretation of Proposition 3 is straightforward. Whenever k is large (case 3), firms prefer not to offer the add-on A. If k is low, both firms offer A. Note that in this case firms are in fact "entrapped" in a prisoner's dilemma situation. Although for both firms it is individually rational to offer A, firms would be jointly better off by not offering A. Finally, for intermediate values of k, asymmetric equilibria emerge in which only one firm offers A. In this case, it is easy to show that the firm offering the add-on obtains higher profit (see the proof of Proposition 3 in Appendix A). Moreover, the region of asymmetric equilibria expands the larger u^A is and the lower τ is, since the size of the interval is $\frac{(u^A)^2}{9\tau}$. In Figure 2, we present graphically the regions of each equilibrium for $\tau = 1$.

INSERT FIGURE 2 ABOUT HERE

3.3. Extensions

3.3.1. Extension I: the bundling case

In the first extension of the model we consider, we suppose that the firm offering an add-on can commit to its future price, or equivalently in our framework, it can sell the baseline product and the add-on as a bundle. This extension has two motivations. The first one is theoretical, since bundling constitutes a natural comparison for the add-on strategy, i.e. when prices for baseline product and the add-on are distinguished. The second motivation is directly related to our empirical exercise. In fact, some of the activities by the cruise companies are offered for free (i.e. their price is included in the baseline product price). Therefore, the analysis of bundling allows us to make a prediction regarding the relationship between offering this kind of activity and the baseline product price.

Let us define as p^{AB} the price for the bundle A+B, fixed at t=1. In the symmetric case in which both firms offer the add-on, utility is given by:

$$u_i(0) = u^A + u^B - p_0^{AB} - \tau x_i \quad (8)$$

$$u_i(1) = u^A + u^B - p_1^{AB} - \tau(1 - x_i) \quad (9)$$

It can immediately be seen that the demand functions in this case are equivalent to case a) described in Section 3.2.2 and so prices are $p_0^{AB} = p_1^{AB} = \tau$, yielding $\Pi_0^* = \Pi_1^* = \frac{\tau}{2}$.

The asymmetric case, in which firm 0 offers the bundle A+B and firm 1 offers B only, yields the following utility functions:

$$u_i(0) = u^B + u^A - p_0^{AB} - \tau x_i \tag{10}$$

$$u_i(1) = u^B - p_1^B - \tau(1 - x_i) \tag{11}$$

Again, this case turns out to be isomorphic to case b) in Section 3.2.2 with $\alpha = 0$. Therefore, equilibrium prices are $p_0^{AB} = \tau + \frac{u^A}{3}$ and $p_1^B = \tau - \frac{u^A}{3}$. The first implication of this result is that when firms can commit (bundle), adding A has an unambiguously positive impact on the (single) price posted by the firm, which comes from the higher quality offered by the firm.

As for the second implication, we observe that if firm 0 offers the add-on through the add-on pricing strategy, it obtains a total price equal to $p_0^B + p_0^A = \tau + \frac{u^A}{3}(1-3\alpha)+\alpha u^A=\tau+\frac{u^A}{3}$. Therefore, we obtain a second irrelevance result: bundling has no effect on the total price paid and consequently on profits.[11] This implies that the model in its present form cannot account for the decision to bundle B and A or to use an add-on pricing strategy instead. While modelling this decision is not at the core of our paper, in the following section we briefly describe an extension with consumer biased beliefs which provides a possible answer to this issue.

3.3.2. Extension II: consumer biased beliefs

In the basic version of the model, firms and consumers base their decision on the same proportion of add-on surplus appropriated by the firm (α). This implies a profit equivalence between adopting the add-on strategy and bundling. We shall now assume that the proportion relevant to firms (α) and the proportion relevant to consumers (γ) may differ. Following the industrial organisation literature with

[11] As for the first irrelevance result presented in Section 3.2.2, also this one is not new to the literature, and hinges on the assumption of inelastic demand, and thus no output distortion from a high add-on price (Borenstein et al., 1995).

boundedly rational consumers (Spiegler, 2011), we interpret α as the *actual* value and γ as the value *perceived* by the consumer. It follows that $\alpha > \gamma$ can be interpreted as consumer over-optimism in that consumers may underestimate the price paid or overestimate the surplus from the add-on.[12] $\alpha < \gamma$, instead, occurs if consumers are overly pessimistic, i.e. they overestimate the price paid or underestimate the surplus from the add-on.

Focusing on the asymmetric case in which firm 0 offers the add-on, the firms' best response functions become:

$$p_0^B = \frac{\tau + p_1^B + (1-\alpha-\gamma)u^A}{2} \tag{12}$$

$$p_1^B = \frac{\tau + p_0^B - (1-\gamma)u^A}{2} \tag{13}$$

Solving the system (12)-(13) yields the equilibrium prices:

$$p_0^B = \tau + \frac{u^A}{3}(1-2\alpha-\gamma) \tag{14}$$

$$p_1^B = \tau - \frac{u^A}{3}(1+\alpha-\gamma) \tag{15}$$

For the firm offering the add-on, the equilibrium profit is:

$$\left[\tau + \frac{u^A}{3}(1+\alpha-\gamma)\right]\left[\frac{1}{2} + \frac{u^A}{6\tau}(1+\alpha-\gamma)\right] - k \tag{16}$$

For the firm offering a bundle of A and B (competing with a firm offering B only), the equilibrium profit is:

$$\left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - k \tag{17}$$

Comparing (14) and (15), we find that $p_0^B > p_1^B$ if $2 - \alpha - 2\gamma > 0$. Therefore, when consumers are overly optimistic, it is more likely that the baseline product price is higher for the firm offering the add-on. The intuition is that the perceived differentiation effect is stronger in this case, since consumers (wrongly) believe to be able to appropriate a large part of the add-on surplus. In addition, comparing

[12] Zenger (2013) makes a similar assumption.

(16) and (17), it transpires that the add-on pricing (bundling) strategy is advantageous if $\alpha > \gamma$ ($\alpha < \gamma$). If the consumer is over-optimistic, the firm can use the add-on strategy both to attract consumers via higher expected net surplus and to attain ex post additional profit.

4. Empirical validation

In this section, we perform an empirical validation of the theoretical results, by focusing on the implications of the model when the equilibrium is asymmetric (i.e. one firm offers the add-ons and the other not). As summarized in Proposition 2, we show that if only one firm offers the add-on, the presence of the add-on can increase or decrease the baseline product price, depending on the degree of market power over it. By estimating a hedonic price function on a sample of cruises offered worldwide, described in the following subsection, we can determine whether and how the ticket prices observed on the market are affected by the add-ons, controlling for other relevant cabin, ship and trip characteristics of a cruise, and for market and firm fixed-effects. Incidentally, we observe that, in the empirical analysis, it is always the case that more than one firm operates in each defined market, which justifies our focus on competitive environments. Also, the type of analysis performed here is unfeasible to test the implications of symmetric equilibria, where an add-on is offered by all firms. A character needs both to be present and not to be present at least in some observation to be able to empirically identify its effect. Consequently, we concentrate now on the asymmetric equilibrium: our dataset does not include add-ons which are offered on all cruises (such as bars), as Appendix B shows by reporting descriptive statistics. Moreover, although asymmetric equilibria require an "intermediate" fixed cost of offering the add-on, the actual range depends upon u^A. As Section 3.2.3 showed, the region of asymmetric equilibria is "large" for valuable add-ons, as is the case in the cruise market.

4.1 Data

The cruise industry is among the fastest growing categories in the entire leisure market. From 1970 to 2004, the number of passengers increased by 2200% (Klein, 2006). Even in recent years, despite the economic crisis, the number of passengers increased from 18.7 million to 22.2 million between 2010 and 2014.[13] As it has grown, the industry has also consolidated. Now, the top three cruise companies, i.e. the Carnival Corporation, Royal Caribbean Cruises Ltd. Co. and Norwegian Cruise Line Holdings Ltd., account for 81.5% of the worldwide share of carried passengers and 76.7% of the worldwide share of revenues.[14] Meanwhile, a tendency to reduce ticket prices has been observed, transforming a cruise from a luxury product into a mass product. At the same time, profitability has been preserved thanks to economies of scale guaranteed by mega ships, savings in labour costs, offshore registrations and the emergence of new extra-ticket revenue centres (Klein, 2006). Nowadays, a cruise ship can be considered a “floating resort” as it includes all the facilities and activities of a tourism destination and the data show that extra revenues associated with such add-ons are the main source of profitability for firms (Vogel, 2009, 2011).

To test the predictions of the model empirically, we use a sample of 2072 cruises offered worldwide in the period July–August 2013. All the data in our sample were collected online in April 2013 through the website Cruise.com. Table B1 in Appendix B provides descriptive statistics.

Price per night, the dependent variable of the regression model, was the cheapest offer at that time for each cabin type of the selected cruise; it is expressed as the US$ price per person excluding all taxes and port charges,[15] divided by the trip’s number of nights (cruise length). The other data can be grouped into three sets of variables: cabin, ship and trip characteristics.

The cabin characteristics comprise the following categories: inside cabin, ocean view (not obstructed) cabin, balcony cabin and suite. Within the set of cabin characteristics, the only numerical variable is the cabin square footage expressed in square feet. All the remaining variables (*private bath*, *air conditioning*, *refrigerator*, *individual safe*, *TV*, *music console*, *telephone* and *hair dryer*) are dummies for the presence of that characteristic inside the cabin.

[13] Source: Cruise Lines International Association.
[14] http://www.cruisemarketwatch.com/ accessed on May 2016.
[15] Incidentally, we notice that the website Cruise.com reports the full price of a cruise, therefore including other charges, only when the cruise is selected for purchase. By searching the same cruise on companies’ websites, it appears that “other charges” on Cruise.com are all taxes, fees, and port expenses imposed by governmental and quasi-governmental authorities.

The many characteristics pertaining to the ship are also registered through dummies (*laundry*, *swimming pool*, *beauty salon*, *casino*, *fitness*, *jogging track*, *boutiques*, *Wi-Fi*, *library* and *spa*). The age of the ship is expressed in years, the capacity in number of passengers and the speed in nodes.

The last set of variables groups the trip characteristics. In addition to the number of nights of the trip, the variable *excursions per night* was obtained by dividing the number of intermediate ports on the itinerary by the number of nights (cruise length). The two categorical variables *destination* and *cruise line* produce a large set of dummies to control for market and firm fixed-effects on the price per night.

4.2 Model specification and hypotheses

In the next section, a hedonic price model is estimated (Rosen, 1974; Carlton and Waldman, 2010), in which we measure the relative impact on prices of all the cruise's characteristics. A preliminary step has been to classify characteristics as add-ons, for which consumers pay a separate price, and controls, if this is not the case, also distinguishing the former in terms of firms' marker power over them. For this purpose, we used the existing literature on cruise economics (Klein, 2006) and other sources like online guides for first-time travellers[16] and companies' website.[17] At the end, we classified cruise characteristics into three groups:[18]

i) Casino gaming, boutiques, spa treatments, beauty salons, Wi-Fi, telephone and laundry services are add-ons (consumers pay a separate price for them), for which the firms' market power is expected to be high as they are offered on board, with no alternatives. Therefore, being add-ons associated to "high" values of α, in line with Proposition 2, we expect a negative effect of their presence on the cruise ticket price.

ii) Shore excursions are also add-ons, since they are not included in the ticket price. In this case, however, we argue that the degree of firm market power is limited by the possibility

[16] See, for instance, websites such as http://www.cruises.com/promotion/cruising-101.do or http://www.cruise.com/cruise-information/cruise-tips.asp

[17] https://help.carnival.com/app/answers/detail/a_id/3861/~/what-does-the-price-of-my-cruise-include%3F

[18] A few characteristics could be associated to "bundle of services" which are only partially included in the baseline products. This may be the case of TVs (firms can charge for pay-per-view movies) and refrigerators (guests can be charged for drinks from the minibar). Thus, allocating these characteristics to the add-ons or control group can in fact look arbitrary. In that respect, we adopted a "restrictive" approach in the definition of add-ons, excluding from the group the" ambiguous" characteristics, such as TV and refrigerator.

of self-organised trips and existence of alternatives offered by specialized companies. Being add-ons associated to "low" values of α, in line with Proposition 2, we expect a positive coefficient for the variable *number of excursions* in our regression.

iii) All other ship characteristics and the cabin characteristics do not correspond to additional products and services for which consumers pay a separate price. We use them as controls, expecting a positive sign for those services (such as air conditioning in the cabin or the use of the library) which are bundled with the baseline product (see Section 3.3.1).

An important remark is in order. It is well known that hedonic regressions do not usually separate the effects of demand and supply on equilibrium prices (Pakes, 2003); in particular, regression coefficients may reflect the variation in cost associated with the inclusion of a characteristic, rather than the consumers' valuation of it. However, for those add-ons for which we expect a negative coefficient, a "cost effect" would work against our prediction, so we should not be concerned as long as the predictions are confirmed. For the variable *number of excursions*, for which a positive coefficient is expected, we observe that by construction we excluded from the ticket price the main source of additional costs, i.e. port taxes, so that we are confident that the coefficient mainly reflects the variation in consumers' value.

4.3 Estimates

Before estimating the model, we transform numerical variables into natural logarithms.[19] Table 2 reports the results of two OLS estimations: the first model is complete and the second model is more parsimonious, excluding the insignificant variables.[20] At the end of the table, diagnostic tests are reported. The high significance of the regression tests and the high adjusted R^2 allow us to conclude

[19] The estimated coefficients of these variables are therefore price elasticities. Given that the variable excursions per night assumes the value 0 for some observations and that the logarithm is not defined at 0, we add 0.001 to this variable before taking logs.

[20] Among the diverse models we tested, we also considered interactions between cabin type and other variables to see if different quality levels in the cabins would have an effect on the evaluations of other characteristics. However, the interactions were not significant. The results presented in Table 2 are robust to these specifications (the significant variables we find continue to be significant and with the same sign). A previous specification also included the variable tonnage of the ship. As tonnage (log of) resulted in high collinearity with capacity (log of) in the VIF test, we decided to include only capacity as the measure of size in the final analysis. The results of these various model specifications are available from the authors upon request.

that these models explain cruise pricing fairly well. Moreover, the last three tests show that neither model suffers from problems of collinearity, a misspecified functional form or heteroskedasticity. Finally, the jointly significant destination and cruise line dummies correct for possible omitted variables that are constant over destinations and lines.

INSERT TABLE 2 ABOUT HERE

The results for the add-on variables are broadly consistent with the prediction of the model. For on-board activities, we find the expected negative effect for casino, boutiques, Wi-Fi and beauty salon (statistically significant only in the parsimonious model), while the telephone and laundry service dummy variables are negative but not significant.[21] The effect for the casino variable is particularly strong: the presence of a casino on the ship leads to a reduction of 28.5% in the ticket price. For shore excursions, we observe a positive coefficient, in line with the supposed low market power of cruise firms in this case. The only result which is in contrast with our expectation is the one concerning spa treatments, for which we find a positive coefficient. One possible explanation is that spa may act (also) as a signal of overall cruise quality, thus capturing an otherwise unobservable dimension of vertical heterogeneity across cruises. Consistently with this hypothesis, cruises without spa use are significantly (at 1%) smaller, older and slower ships and less likely to off all the other add-ons. Being presumably perceived as a luxury service, the signaling effect may be purely psychological, due to the halo effect discussed in Bertini et al. (2009).

We now briefly comment on the results for control variables. As with the cabin characteristics, the estimation results confirm that cabin type is a significant determinant of cruise pricing. The F test on the battery of dummies for this categorical variable shows that they are jointly significant. If we look at the estimated coefficients, we can see that suite and then balcony cabin are the most expensive types of cabin. Another interesting result is that a 10% increase in the cabin square footage translates into a 0.8% increase in the price per night. Moreover, of the cabin characteristics, a private bath, air conditioning and refrigerator are the characteristics that have a significant positive effect on the price

[21] Insignificance can be accounted for by considering that these two variables are associated to services with presumably low value for consumers and relatively low probability to be used.

per night of a cruise. As for ship characteristics, presence of a library and fitness center exhibit a positive coefficient, while the swimming pool variable is not significant. Older and bigger ships are characterised by lower prices, probably because of the perception of a lower overall quality and economies of scale. Among the trip characteristics, the significant negative coefficient of the number of nights points both to a scale effect and a quantity discount.

4.4 Further analysis

The aim of this section is to provide further evidence on market power role in determining the effect of add-ons on baseline prices. For that purpose, we focus on shore excursions, and we introduce two proxies of firms' market power over this add-on.

Theoretically (Section 3.2), we defined market power as $\alpha = \frac{u^A - \underline{u}}{u^A}$, where u^A is the gross surplus the consumer obtains from the add-on product A, and $\underline{u}$ the utility provided by the firms offering the outside option to the add-on. In the case of shore excursions, we looked for proxies of $\underline{u}$ and u^A , which we identified as follows:

- As proxy for $\underline{u}$, we introduced the variable *market size*, measured as the mean of the variable *excursions per night* (log of), at destination level for the given cruise. The higher the value of this variable, the more the cruise is operating in a destination with a high concentration of viable ports. This creates a larger market for firms offering alternatives to the shore excursions organized by the cruise companies; in turn, this may lead to more entry, lower prices and possibly higher quality in a such a market. Within our model, the described mechanism boils down in conjecturing a positive relationship between *market size* and $\underline{u}$, which implies a negative relationship between *market size* and market power α. Therefore, in light of our theory, we expect the marginal impact of *excursions per night* (log of) to be bigger the larger is *market size*: that is, we expect a positive coefficient for the interaction between *excursions per night* and *market size*.
- As proxy for u^A, we introduced the variable *market share* measured as the cruise's company revenue percentage of all the revenues in the market. The data refer to the year before prices

were observed, i.e. to 2012, and their source is Cruise Market Watch (www.cruisemarketwatch.com). In the cruise industry, small market-share firms usually offer luxury products, while large market-share firms offer mass products, and we assume that this may be the case both for baseline products and add-ons.[22] As a consequence, we expect a negative correlation between *market share* and u^A, and therefore between *market share* and α. From the model, it follows that the marginal impact of *excursions per night* should be bigger the larger is *market share:* that is, we expect a positive coefficient for the interaction between *excursions per night* and *market share*.

Table 3 reports the results of the two regressions in which we add the interaction between *market size* and *market share* and *excursions per night* (log of) to the parsimonious model in Table 2. Note that, to avoid multicollinearity, we had to exclude the destination fixed effects in the market size regression (in which we controlled for heterogeneity in market size per destination) and we had to exclude the cruise line fixed effects in the market share regression (in which we controlled for heterogeneity in market share per company). To save on space, we report the results for add-on variables only (the results for the other variables, qualitatively unaffected, are available upon request).

INSERT TABLE 3 ABOUT HERE

The coefficients of the two interaction variables are both positive and statistically significant, in line with our hypotheses. All the explanatory variables associated to add-ons keep their sign and significance, with the exception of beauty salon in the market size regression (it was significant at 10% in the original parsimonious model). As an additional interesting feature of the market share model, we observe that when the market share is at its minimum the average marginal effect of *excursions per night* (log of) is negative (significant point estimate -0.032 with standard error 0.013 when market share is 0.0004). The opposite happens on the other extreme (significant point estimate 0.061 with standard error 0.023 when market share is 0.156).

[22] In our data, this is shown by the negative correlations between the estimated cruise line dummies and the market share in terms of passengers and revenue, -0.32 and -0.36 respectively. This suggests a price premium for small market-share firms.

5. Discussion

Our theoretical results, with the support of the empirical evidence, provide new insights into add-on pricing by looking at the combination of degree of market power and firms' asymmetries. In this section, we further elaborate on the implications of our results.

A first point refers to the evolution of pricing strategies in the presence of innovation and imitation in add-ons. When firms innovate by introducing a new add-on, they can obtain a competitive advantage irrespective of the degree of market power over the add-on. However, the pricing strategy of the innovator is affected by the degree of market power over the add-on: when it is sufficiently low, the price for the baseline product increases. When the innovation is diffused, it is the baseline product price that declines, with firms obtaining their profits from the add-on. In a fascinating account of the razor industry, Picker (2011) shows that Gillette was in fact fixing a high price for razors (and a relatively low price for blades) during the monopoly period following the patented introduction of safety razors. Picker argues that Gillette's ability to fix a high price for blades was limited by the consumers' alternative to re-sharpen blades as they were used with straight razors. Instead, the add-on pricing strategy (also known as the "razor and blades" strategy) emerged only with competition.

A second point concerns firms' incentive to increase the degree of market power over add-ons. In the basic version of the model with full rationality, we found that profits are unaffected by the degree of market power. However, in the presence of consumers with biased beliefs, for a given perception of add-on surplus, the increase in market power has a positive effect on profits (and makes the add-on strategy strictly preferred to bundling). In fact, firms seem to invest in increasing α. In the cruise industry, for instance, the Norwegian Cruise Line introduced on-shore excursions to privately owned islands, from which the company appropriates all the revenues (Klein, 2006). It should be noted, however, that if consumers can learn the real value of α over time, the gain of the add-on pricing strategy decreases. Therefore, we can expect cycles in the introduction of add-ons, with firms continuously introducing new (high margin) add-ons, profiting from them until consumers assess the real surplus they can obtain from them. A similar argument has already been put forth by Gabaix and Laibson (2006). In presence of customers switching costs, incentives to innovate through new add-ons will depend also on the size of the installed base, similarly to the analysis by Schmidt (2013) on cost-reducing innovations.

6. Conclusion

According to the "razor and blades" strategy for add-on pricing, firms offering add-ons should lower the price of the baseline product and obtain most of their profit from the add-ons. In this paper, we have shown that this conclusion is not warranted in asymmetric configurations, in which a single firm offers the add-on. In this case, the add-on is both a source of competitive advantage (because it increases product quality) and of additional revenues. When market power in the supply of the add-on is limited, the first effect prevails and baseline product prices are higher for firms offering the add-on. Our theoretical results find support in the empirical analysis. By estimating a hedonic price function on a dataset of cruises, we found that those additional activities that are characterised by high market power (i.e. on-board sales) reduce ticket prices, while the opposite occurs for low market power activities (e.g. shore excursions).

We see opportunities to build on our work in three directions. First, the implications for antitrust and consumer policy should be assessed. The current framework with discrete demand is not well suited to this, so an extension is needed. Second, one might consider building a model able to rationalise heterogeneity in pricing strategies even when all firms offer the add-on. For instance, in the game console market, Microsoft Xbox and Sony PlayStation are consoles usually priced below their cost, thus Microsoft and Sony have to recoup their investments with high prices for add-ons such as joypads (hardware) and games (software). Nintendo Wii, with a different strategy, produces consoles technologically less cutting edge that allow a positive profit (as the price for the base product is high in comparison to the cost). At the same time, prices for Nintendo Wii add-ons are usually lower (online gaming is free with Wii, whereas you have to pay a subscription with Xbox and PlayStation).[23] Such a model would probably require more dimensions of consumers' heterogeneity (including their degree of sophistication) and appears to be an intriguing avenue for future research. Finally, more sophisticated types of price competition for the baseline products could be investigated, giving a role for forms of

[23] http://www.vgchartz.com/

price discrimination such as behaviour-based price discrimination (Carroni, 2018) and couponing (Kosmopoulou et al., 2016).

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Appendix A

Proof of Proposition 1

We now show how equilibrium prices are computed in each case.

Case *a)*

If no firm offers A, consumers' utility functions are given by:

$$u_i(0) = u^B - p_0^B - \tau x_i \tag{A1}$$

$$u_i(1) = u^B - p_1^B - \tau(1 - x_i) \tag{A2}$$

The location of the indifferent consumer (for a given price) is obtained by solving:

$$u^B - p_0^B - \tau\hat{x} = u^B - p_1^B - \tau(1 - \hat{x}) \tag{A3}$$

which yields:

$$\hat{x} = \frac{1}{2} + \frac{p_1^B - p_0^B}{2\tau} \tag{A4}$$

Demand for firm 0 is then equal to $\hat{x}$, while demand for 1 is equal to $1 - \hat{x}$. Profit functions are thus as follows:

$$\Pi_0 = \left(\frac{1}{2} + \frac{p_1^B - p_0^B}{2\tau}\right) p_0^B \tag{A5}$$

$$\Pi_1 = \left(\frac{1}{2} + \frac{p_0^B - p_1^B}{2\tau}\right) p_1^B \tag{A6}$$

As the two firms are symmetric, we need to consider the first-order condition of one firm only, say firm 0:

$$\left(\frac{1}{2} + \frac{p_1^B - p_0^B}{2\tau}\right) - \frac{1}{2t} p_0^B = 0 \tag{A7}$$

Imposing symmetry ($p_1^B = p_0^B$) and solving equation (A7), we obtain equilibrium prices $p_1^B = p_0^B = \tau$. Putting equilibrium prices into (A5) and (A6) yields the equilibrium profits.

Case *b)*

If only firm 0 offers A, the utility functions are:

$$u_i(0) = (1-\alpha)u^A + u^B - p_0^B - \tau x_i \tag{A8}$$

$$u_i(1) = u^B - p_1^B - \tau(1 - x_i) \tag{A9}$$

The location of the indifferent consumer (for a given price) is obtained, in this case, by solving:

$$(1-\alpha)u^A + u^B - p_0^B - \tau x_i = u^B - p_1^B - \tau(1 - x_i) \tag{A10}$$

which yields:

$$\hat{x} = \left(\frac{1-\alpha}{2\tau}\right)u^A + \frac{1}{2} + \frac{p_1^B - p_0^B}{2\tau} \tag{A11}$$

Profits are given by:

$$\Pi_0 = \left(\frac{1-\alpha}{2\tau}u^A + \frac{1}{2} + \frac{p_1^B - p_0^B}{2t}\right)(p_0^B + \alpha u^A) \tag{A12}$$

$$\Pi_1 = \left(\frac{\alpha-1}{2\tau}u^A + \frac{1}{2} + \frac{p_0^B - p_1^B}{2\tau}\right)p_1^B \tag{A13}$$

From the first-order conditions, we obtain firms' best response functions:

$$p_0^B = \frac{\tau + p_1^B + (1-2\alpha)u^A}{2} \tag{A14}$$

$$p_1^B = \frac{\tau + p_0^B - (1-\alpha)u^A}{2} \tag{A15}$$

Solving (A14–A15) yields equilibrium prices. Substituting equilibrium prices into (A12) and (A13) yields equilibrium profits.

Case *c)*

The solution of case *c)* is symmetric to case *b)*.

Case *d)*

If both firms offer A, consumers' utility functions are given by:

$$u_i(0) = (1-\alpha)u^A + u^B - p_0^B - \tau x_i \tag{A16}$$

$$u_i(1) = (1-\alpha)u^A + u^B - p_1^B - \tau(1-x_i) \tag{A17}$$

The location of the indifferent consumer (for a given price) is obtained by solving:

$$(1-\alpha)u^A + u^B - p_0^B - \tau\hat{x} = (1-\alpha)u^A + u^B - p_1^B - \tau(1-\hat{x}) \tag{A18}$$

which yields:

$$\hat{x} = \tfrac{1}{2} + \tfrac{p_1^B - p_0^B}{2\tau} \tag{A19}$$

Demand for firm 0 is then equal to $\hat{x}$, while demand for 1 is equal to $1-\hat{x}$. Profit functions are thus as follows:

$$\Pi_0 = \left(\tfrac{1}{2} + \tfrac{p_1^B - p_0^B}{2\tau}\right)(p_0^B + \alpha u^A) \tag{A20}$$

$$\Pi_1 = \left(\tfrac{1}{2} + \tfrac{p_0^B - p_1^B}{2\tau}\right)(p_1^B + \alpha u^A) \tag{A21}$$

As the two firms are symmetric, we need to consider the first-order condition of one firm only, say firm 0:

$$\left(\tfrac{1}{2} + \tfrac{p_1^B - p_0^B}{2\tau}\right) - \tfrac{1}{2\tau}(p_0^B + \alpha u^A) = 0 \tag{A22}$$

Imposing symmetry ($p_1^B = p_0^B$) and solving equation (A22), we obtain equilibrium prices $p_1^B = p_0^B = \tau - \alpha u^A$. Putting equilibrium prices into (A20) and (A21) yields the equilibrium profits.

Proof of Proposition 3

The proof is almost immediate. If $k < \frac{1}{2}\tau - \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right) \equiv \frac{u^A}{3} - \frac{(u^A)^2}{18\tau}$, *OffA* is the best response to *OffA*. If $k > \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right) - \frac{\tau}{2} \equiv \frac{u^A}{3} - \frac{(u^A)^2}{18\tau}$, *NotOffA* is the best response to *NotOffA*. If $\frac{1}{2}\tau - \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right) < k < \left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - \frac{1}{2}\tau$, *OffA* is the best response to *NotOffA* and vice versa, which leads to asymmetric equilibria. In asymmetric equilibrium, offering the add-on entails higher profit if $k < \left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right)$. This inequality is always satisfied in the asymmetric equilibria region since $\left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - \frac{1}{2}\tau \equiv \frac{u^A}{3} - \frac{\left(u^A\right)^2}{18\tau} < \left(\tau + \frac{u^A}{3}\right)\left(\frac{1}{2} + \frac{u^A}{6\tau}\right) - \left(\tau - \frac{u^A}{3}\right)\left(\frac{1}{2} - \frac{u^A}{6\tau}\right) \equiv \frac{2u^A}{3}$.

Appendix B

INSERT TABLE B1 ABOUT HERE

Tables

Table 1 – Game at t=0

Firm 0\Firm 1	*NotOffA*	*OffA*
NotOffA	$\Pi_0(i);\ \Pi_1(i)$	$\Pi_0(iii);\ \Pi_1(iii) - k$
OffA	$\Pi_0(ii) - k; \Pi_1(ii)$	$\Pi_0(iv) - k; \Pi_1(iv) - k$

Table 2 – Hedonic price model estimations

Dependent Variable: Price per night (log of)	**Complete model**		**Parsimonious model**	
Explanatory Variables:	*Coefficient*	*Standard Error*	*Coefficient*	*Standard Error*
Add-ons				
Casino	-0.285***	(0.043)	-0.283***	(0.042)
Boutiques	-0.040**	(0.018)	-0.044**	(0.018)
Spa	0.136***	(0.041)	0.127***	(0.041)
Beauty salon	-0.037	(0.025)	-0.042*	(0.024)
Wi-Fi	-0.105***	(0.015)	-0.106***	(0.015)
Telephone	-0.000	(0.026)		
Laundry	-0.009	(0.024)		
Excursions per night (log of)	0.026***	(0.006)	0.028***	(0.006)
Controls				
Cabin characteristics				
Cabin type (Inside cabin reference category)	*F*(3,1993) = 529.00***		*F*(3,2011) = 547.54***	
Ocean view cabin	0.196***	(0.018)	0.195***	(0.018)
Balcony cabin	0.444***	(0.019)	0.444***	(0.019)
Suite	0.846***	(0.022)	0.848***	(0.022)
Cabin square footage (log of)	0.081***	(0.015)	0.079***	(0.015)
Private bath	0.111***	(0.030)	0.108***	(0.029)
Air conditioning	0.048**	(0.019)	0.049***	(0.018)
Refrigerator	0.028	(0.017)	0.033**	(0.017)
Individual safe	-0.006	(0.021)		
TV	-0.015	(0.038)		
Music console	0.022	(0.019)		
Hair dryer	-0.046*	(0.024)	-0.047**	(0.022)
Ship characteristics				
Swimming pool	-0.059	(0.075)		
Jogging track	-0.040**	(0.017)	-0.033**	(0.017)
Library	0.045**	(0.021)	0.051**	(0.021)
Fitness	0.035*	(0.019)	0.033*	(0.019)
Age (log of)	-0.085***	(0.015)	-0.082***	(0.014)
Capacity (log of)	-0.199***	(0.020)	-0.200***	(0.020)
Speed (log of)	-0.293***	(0.092)	-0.293***	(0.090)

	Trip characteristics			
Nights (log of)	-0.064***	(0.018)	-0.072***	(0.018)
Destination	*F*(14,1993) = 8.73***		*F*(14,2011) = 9.27***	
Cruise line	*F*(25,1993) = 38.86***		*F*(25,2011) = 41.22***	
Constant	6.978***	(0.261)	6.922***	(0.244)
Number of obs	2060		2072	
Regression test	*F*(66,1993) = 93.70***		*F*(60,2011) = 103.27***	
Adjusted R^2	0.7482		0.7477	
Mean VIF	2.01		1.96	
Ramsey RESET test	*F*(3,1990) = 0.79		*F*(3,2008) = 0.61	
Heteroskedasticity Breusch–Pagan/Cook–Weisberg test	$\chi^2(1) = 1.88$		$\chi^2(1) = 1.47$	

Significance levels: * 0.10, ** 0.05, *** 0.01. Destination and cruise line fixed effects are included (see Table B1 in Appendix B for the full list of destinations and cruise lines); their *F* statistic tests their joint significance.

Table 3 – Hedonic price model estimations: market size and companies' market share

Dependent Variable: Price per night (log of)	**market size**		**market share**	
Explanatory Variables:	*Coefficient*	*Standard Error*	*Coefficient*	*Standard Error*
	Add-ons			
Casino	-0.338***	(0.040)	-0.346***	(0.037)
Boutiques	-0.051***	(0.018)	-0.038*	(0.023)
Spa	0.146***	(0.041)	0.238***	(0.051)
Beauty salon	-0.038	(0.023)	-0.062**	(0.029)
Wi-Fi	-0.103***	(0.015)	-0.083***	(0.018)
Excursions per night (log of)	0.044***	(0.010)	-0.032**	(0.013)
Excursions per night (log of) X market size (log of)	0.013**	(0.006)		
Excursions per night (log of) X market share			0.596***	(0.206)
market size (log of)	-0.066***	(0.016)		
market share			-1.634***	(0.306)
Number of obs	2072		1882	
Regression test	*F*(48,2023) = 123.85***		*F*(37,1844) = 85.36***	
Adjusted R^2	0.7401		0.6240	
Mean VIF	1.93		1.75	
Ramsey RESET test	*F*(3,2020) = 0.81		*F*(3,1841) = 1.45	
Heteroskedasticity Breusch–Pagan/Cook–Weisberg test	$\chi^2(1) = 1.86$		$\chi^2(1) = 2.06$	

Significance levels: * 0.10, ** 0.05, *** 0.01

Table B1 – Descriptive statistics

Variable	*Mean*	*Std Dev*	*Min*	*Max*
Price per night	263.087	179.439	33	1490.833
Cabin characteristics				
Cabin type				
Inside cabin	0.250	0.433	0	1
Ocean view cabin	0.251	0.434	0	1
Balcony cabin	0.249	0.432	0	1
Suite	0.250	0.433	0	1
Cabin square footage	222.483	132.608	12	2000
Private bath	0.930	0.256	0	1
Air conditioning	0.591	0.492	0	1
Refrigerator	0.711	0.453	0	1
Individual safe	0.758	0.428	0	1
TV	0.941	0.236	0	1
Music console	0.204	0.403	0	1
Telephone	0.824	0.381	0	1
Hair dryer	0.843	0.364	0	1
Ship characteristics				
Laundry	0.855	0.352	0	1

Swimming pool	0.990	0.098	0	1
Beauty salon	0.885	0.320	0	1
Casino	0.925	0.263	0	1
Fitness	0.815	0.388	0	1
Jogging track	0.531	0.499	0	1
Boutiques	0.792	0.406	0	1
Wi-Fi	0.531	0.499	0	1
Library	0.800	0.400	0	1
Spa	0.958	0.201	0	1
Age	11.676	5.956	1	42
Capacity	2455.823	1071.267	30	8994
Speed	22.221	2.887	9	30
Trip characteristics				
Nights	7.894	4.058	1	33
Excursions per night	0.617	0.267	0	2
Destination				
Caribbean/Bahamas	0.121	0.326	0	1
Alaska	0.164	0.370	0	1
Australia/New Zealand	0.006	0.076	0	1
Bermuda	0.033	0.178	0	1
Europe-Northern	0.192	0.394	0	1
Europe-Southern	0.189	0.391	0	1
Europe-Rivers	0.011	0.105	0	1
Hawaii/Tahiti/S. Pacific	0.035	0.183	0	1
Mexico-Pacific Coast	0.014	0.119	0	1
Asia/Africa/M.E.	0.053	0.223	0	1
Panama Canal & C. America	0.016	0.125	0	1
South America	0.006	0.076	0	1
US & Canada Eastern	0.049	0.216	0	1
US & Canada Pacific	0.017	0.131	0	1
Other	0.095	0.293	0	1
Cruise line				
Carnival Cruise	0.090	0.286	0	1
Costa Cruise	0.068	0.252	0	1
Disney Cruise Line	0.034	0.181	0	1
MSC Cruises	0.077	0.267	0	1
Norwegian Cruise Line	0.085	0.279	0	1
Princess Cruises	0.083	0.276	0	1
Royal Caribbean International	0.123	0.328	0	1
Azamara Club Cruises	0.048	0.214	0	1
Celebrity Cruises	0.091	0.287	0	1
Cunard Line	0.078	0.268	0	1
Holland America Line	0.046	0.210	0	1
Oceania Cruises	0.052	0.222	0	1
Crystal Cruises	0.009	0.093	0	1
Regent Seven Seas Cruises	0.002	0.044	0	1
Seabourn	0.002	0.044	0	1
SeaDream Yacht Club	0.002	0.044	0	1
Silversea	0.004	0.062	0	1
Star Clippers	0.012	0.107	0	1
Windstar Cruises	0.004	0.062	0	1
AmaWaterways	0.004	0.062	0	1
American Cruise Lines	0.007	0.085	0	1
American Safari Cruises	0.003	0.058	0	1
Avalon Waterways	0.006	0.076	0	1
Uniworld River Cruises	0.006	0.076	0	1
Viking River Cruises	0.006	0.076	0	1
Other	0.060	0.237	0	1

Source: Cruise.com

Figures

Figure 1 - Offering the add-on: the impact on prices

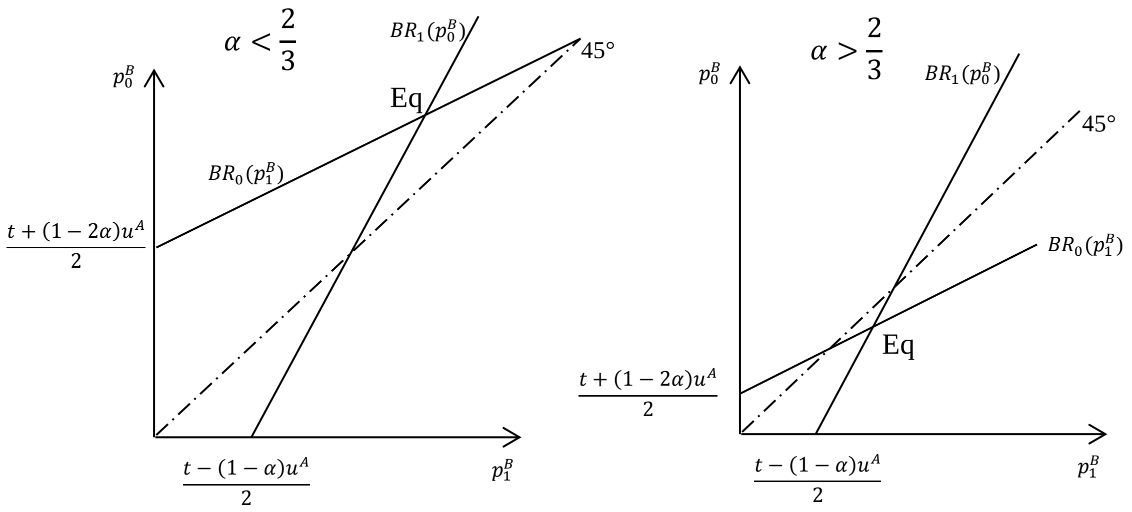

Figure 2: Choice at stage *t*=0