BGPE Discussion Paper Series

BGPE Discussion Paper

No. 115

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February 2012

ISSN 1863-5733

Editor: Prof. Regina T. Riphahn, Ph.D.
Friedrich-Alexander-University Erlangen-Nuremberg

Why Do Platforms Charge Proportional Fees? Commitment and Seller Participation*

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This version: February 2012
First version: February 2011

Abstract

If an intermediary offers sellers a platform to reach consumers, he may face the following hold-up problem: sellers suspect the intermediary will enter their respective product market as a merchant after they have sunk fixed costs of entry. Therefore, fearing that their investments cannot be recouped, less sellers join the platform. Hence, committing to not becoming active in sellers' markets can be profitable for the intermediary.

We discuss different platform tariff systems to analyze this hold-up problem. We find that proportional fees (which are observed in many relevant real-world examples) mitigate the problem, unlike classical two-part tariffs (which most of the literature on two-sided markets examines). Thus, we offer a novel explanation for the use of proportional platform fees.

Keywords: Intermediation, Platform Tariff, Hold-Up Problem

JEL classification numbers: D40, L14, L81

*We are grateful to Norbert Schulz and Peter Welzel for insightful guidance and continuous encouragement. We also thank Anthony Creane and participants of the KUL-UMA-DICE-ZEW Ph.D. workshop, the 11th BGPE research workshop, seminars at the University of Wuerzburg and Michigan State University, the 2nd Industrial Organization Workshop (Università del Salento), Annual Conferences of the EARIE and Verein fuer Socialpolitik 2011, and the Fall 2011 Midwest Economic Theory Meeting for helpful comments.

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1 Introduction

Consumers frequently make use of marketplaces, usually provided by intermediaries who can charge different kinds of fees for using their trade platforms. Therefore, it is natural to ask about the impact of a platform's tariff choice on product market decisions. More specifically, it should be asked why platforms charge proportional fees. We address these questions for the case of an intermediary who offers sellers a marketplace (or *platform*) to reach consumers, and at the same time may be active in this marketplace, directly selling products as a *merchant*, competing with sellers.

For example, Amazon started out as an online merchant, buying books and reselling them to consumers. However, after launching Amazon Marketplace, a platform that allows third party sellers access to Amazon's consumers, a large fraction of goods traded via the Amazon web pages is now sold by external sellers and not by Amazon.[1] Participation of external sellers has lead to an increase in the variety of products offered. Similarly, the users of Apple's devices (iPhone, iPod, iPad, Mac) can access matching content (applications) supplied by third party providers via the AppStore.[2] In the same way, Google enables programmers to offer applications and reach Android users through their Android Market. Interestingly, Amazon as well as Apple and Google primarily charge sellers/software providers proportional fees.[3] Likewise, proportional fees are usually included in franchising arrangements, where the franchisor offers the franchisee a business model (platform) to reach consumers (cf. e.g. Blair & Lafontaine, 2010, p. 62ff.).

Furthermore, in all these examples, the platform operator/franchisor indeed is also a (potential) competitor to sellers, serving demand for similar products himself. This 'dual mode' can be more profitable to him than a pure 'merchant mode' or a pure 'platform mode' for several reasons. In particular, enabling third party sellers to reach consumers can be more profitable than acting as a pure merchant since more specialized sellers may be better informed about product demand than the intermediary. Moreover, when production costs differ between sellers and the intermediary, the intermediary can gain from efficiency advantages if products are offered by the most efficient provider.

In markets which feature the dual mode, the intermediary can do cherry-picking, selling profitable goods himself after observing sellers' offers. However, this potential competition makes the platform less attractive to sellers in the first place. As the platform tariff system shapes the (potential) competition between the intermediary and sellers, the intermediary trades off his gains from cherry-picking against platform attractiveness.

[1] In 2011, sales by third party sellers reached 36% of unit sales, cf. Amazon's quarterly results Q4/2011.

[2] The AppStore, conveniently integrated into the operating system of Apple devices, is a platform over which external developers can offer their applications to Apple's customers. More than 500.000 different applications are available; recently, Apple reported a sales volume (number of downloads) of 25 billions. Note that iTunes for *music* is not a platform but a retailer – our example only refers to *'apps'*.

[3] Besides a small membership fee and a fixed per-transaction fee, Amazon charges sellers a proportional fee of about 15% (depending on product category). Apple and Google charge software developers a proportional fee of 30%.

In this paper, we analyze a framework with a monopoly intermediary who can act as platform operator and merchant at the same time. We investigate the case when sellers have to sink investment costs before offering a new product on the platform. Sellers are better informed about product demand than the intermediary. Production costs can differ between sellers and the intermediary, i.e., market conditions are ex-ante unknown. In this framework, we firstly analyze "classical" two-part tariffs comprising fixed (membership) fees and per-transaction fees. Secondly, we examine tariffs that comprise proportional (per-revenue) fees.

While the extant economic literature concerned with the pricing of (two-sided) platforms has focussed on linear and classical two-part tariffs only, our analysis departs from this classical approach.[4] Thereby, we account for the fact that proportional fees are often observed in reality.

Focussing on classical two-part tariffs first, we find that the intermediary prefers per-transaction fees over membership fees. In contrast to previous findings (e.g. Armstrong, 2006), he is no longer indifferent between both kinds of fees as transaction-based fees create a competitive advantage when he becomes active as a merchant. Regarding platform attractiveness, we find that an intermediary using classical two-part tariffs always enters sellers' markets to undercut their prices whenever he is more efficient. This is to the detriment of the platform's attractiveness to sellers; in particular, if the intermediary is always more efficient than sellers, sellers will be undercut with certainty. Hence, sellers do not join the platform and the marketplace breaks down. In that case the intermediary would always profit from committing himself not to enter product markets, thereby increasing sellers' investment incentives. We find that contracts which comprise revenue sharing (proportional fees) allow an intermediary to do so. By increasing the opportunity costs of competition, the use of proportional fees makes it less attractive for an intermediary to compete with sellers as a merchant.

Introducing a dual mode of intermediation into the platform literature, our work sheds light on the different impacts of membership fees, per-transaction fees, and proportional fees on market outcomes. It provides a novel explanation why particularly proportional fees are commonly observed in reality.

Related Literature

Our paper is most closely related to the literature on platform pricing/two-sided markets and to the work on an intermediary's choice of the optimal intermediation mode.

To the best of our knowledge, the only work that directly addresses the question whether an intermediary should take an active role as a (pure) merchant, buying products himself and reselling them to buyers, or a more passive role as a (pure) platform, enabling other sellers to reach potential buyers, is Hagiu (2007). Hagiu finds that un-

[4]However, Shy and Wang (2011) and Z. Wang and Wright (2011) are two important exceptions; for more details, see our literature review.

der many circumstances a monopoly intermediary prefers the 'merchant mode' to the 'platform mode'. Furthermore, he identifies several factors that affect the intermediary's choice towards the platform mode, e.g. consumers' demand for variety or asymmetric information about product quality between the intermediary and sellers. We extend his analysis by allowing the intermediary to offer a platform and to be active as merchant at the same time. Differently from our model, Hagiu assumes that the merchant has to buy products from a seller who would otherwise sell them on the intermediary's platform (at an exogenous price).

Similar to our work, Jiang, Jerath and Srinivasan (2011) examine the case of an intermediary who offers a platform and can serve demand himself at the same time (dual mode), crowding out sellers. In their framework, the intermediary has to incur fixed costs to enter a market. Better informed sellers fear that the intermediary serves markets with high demand himself to avoid double marginalization. However, by choosing a low service level, sellers can pretend to offer a product whose demand does not suffice to cover the intermediary's fixed costs. Accordingly, the setting also includes moral hazard. Although proportional fees would tackle both the double marginalization problem and the hold-up problem that arises due to screening, Jiang et al. analyze pure per-unit fees only.

During the last decade, several seminal studies on platform pricing/two-sided markets have been published (cf. e.g.[5] Rochet & Tirole, 2006; Armstrong, 2006). They focus on intermediaries featuring the 'platform mode' and analyze tariff choices in presence of (indirect) network effects under various circumstances. Most studies on platform pricing focus on membership fees, transaction-based fees, or two-part tariffs as a combination of both. Furthermore, they usually abstract away explicit payments between the two sides of a market or price setting by sellers. Accordingly, proportional (revenue-based) fees are not discussed.

However, there are several important exceptions who examine proportional fees. Shy and Wang (2011) analyze a model of a payment card network. They find that profits of the card network are higher under proportional fees than under per-transaction fees as the network faces a double marginalization problem which is mitigated by proportional fees. In their framework, sellers earn lower profits under proportional fees, but consumers are better off and social welfare is higher than under per-transaction fees. Miao (2011) extends the model of Shy and Wang (2011). Allowing for an endogenous number of sellers, he shows that the use of proportional fees results in less seller participation. Consequently, consumer surplus and social welfare may be lower under proportional fees. Z. Wang and Wright (2011) examine the case of an intermediary who facilitates trade of products that differ in both costs and valuations. They illustrate that a combination of a per-transaction fee and a proportional fee can achieve the same profit as third-degree price discrimination, even if the intermediary is uninformed about product attributes.

[5] Jullien (forthcoming) offers a comprehensive up-to-date survey on two-sided (B2B) platforms, including a general introduction to two-sided markets.

Hagiu (2006) studies commitment of two-sided platforms to a tariff system. In contrast to previous studies (which assume that sellers and buyers take their decisions on joining a platform simultaneously), Hagiu analyzes a sequential time structure: he assumes that all sellers arrive at the platform before the first buyer does. He shows that a platform prefers to commit to the access price charged to buyers instead of setting or adapting it after sellers joined the platform under certain circumstances. Although Hagiu does not mention how commitment could be achieved, he points out that platform commitment is an important issue.

Hagiu (2009) analyzes a platform's tariff decision when sellers compete and consumers value variety. In an extension, he explains that charging variable (proportional) fees can mitigate the aforementioned commitment problem.

Within the literature on patents and licensing, there has been a debate on different tariff systems for many years, cf. e.g. Kamien and Tauman (1986), X. H. Wang (1998), Sen (2005). Nevertheless, those studies are only slightly related to our analysis as they usually do not focus on incentives to invest in innovations and as most of them focus on fixed and per-transaction fees. Furthermore, in those studies the licensor (i.e., the informed party) sets the tariff, while we assume that the platform is uninformed about specific new products but sets the tariff sellers have to pay.

Our work may also be seen as a contribution to the literature on franchising:[6] By allowing a 'dual mode' of intermediation and analyzing a framework of asymmetric information on demand between sellers (franchisees) and intermediary (franchisor), we provide additional insights into a franchisor's decision on dual distribution/partial vertical integration (cf. e.g. Minkler, 1992; Scott, 1995; Hendrikse & Jiang, 2011) and on the frequent use of sales revenue royalties.

Outline

The remainder of the paper is organized as follows: In section 2 we set up a model of a monopoly intermediary who offers a platform to connect sellers and buyers. In section 3 we solve the model for classical two-part tariffs which consist of membership fees and per-transaction fees. In section 4 we discuss existence and conditions of the intermediary's hold-up problem, starting with the decisions a social planer would take. Within section 5 we analyze proportional fees as part of multi-part tariffs. In section 6 we summarize our findings and discuss the results. Finally, we give a conclusion.

[6] Blair and Lafontaine (2010) provide a well-founded introduction into the economics of franchising.

2 Framework

We consider a market with a monopoly intermediary who offers sellers a platform to reach potential buyers.

There is a unit mass of sellers. For being able to list a new product on the marketplace, a seller has to incur fixed investment costs I which are sunk after investment. These costs may be interpreted as costs of developing the respective product, or as general costs of sales preparation (e.g. market research, designing an attractive product illustration, or establishing capacities to ensure immediate supply). They are distributed among sellers according to a distribution function $F(I)$ over the support $[\underline{I}, \overline{I}]$ with $\underline{I} \geq 0$. We assume products offered by different sellers to be completely independent. Hence, there is no competition between sellers. Taken together, there is a continuum of independent product markets which are characterized by their respective investment costs.[7] For each unit sold, sellers incur constant costs $c \in (0, r)$, incorporating all per-unit costs except for platform fees charged by the intermediary. In the following, we simply refer to c as (marginal) production costs, although c could also represent costs of purchasing the product from some wholesaler, retailing or transaction costs like payment charges, or the expected costs of product failure.

Buyers' gross utilities from consuming a good are assumed to be homogeneous among buyers and also constant over products for each buyer. We assume that each buyer purchases at most one unit of each product.[8] The common gross utility for consuming a product is denoted by r and there is a mass of M buyers.[9] Buyers' (as well as sellers') outside option is normalized to zero, i.e., not joining the platform yields a zero pay-off to either side. As we will assume that buyers do not have to pay a membership fee, it is a dominant strategy for buyers to join the platform.[10] Hence, for each product the demand function is given as[11]

$$D(p) = \begin{cases} M, & p \leq r \\ 0, & p > r \end{cases}$$

The intermediary chooses a platform tariff system which can comprise different forms of payments by sellers: a fixed membership fee A, a per-unit fee a, or a proportional fee.

[7] Note that our framework also covers the situation of one single seller with unknown investment costs if $F(I)$ is interpreted as a probability instead of the mass of sellers having investment costs below I.

[8] Accordingly, a double marginalization problem cannot arise and the profitability of proportional fees is *not* driven by the effect of mitigating double marginalization.

[9] Our results would also generalize to cases of heterogenous product categories with varying market sizes or different gross utilities across markets.

[10] We implicitly rule out trivial equilibria in which no buyer and no seller joins.

[11] We assume that the demand structure for new products is common knowledge. This seems reasonable at least within smaller product categories since the intermediary is supposed to be informed about typical market characteristics, though not being informed about existence of specific products. Note that this might be a rationale for Amazon's discriminating practice of charging different fees across well-defined product categories.

For the latter a fixed share α of seller revenues accrues to the platform. All platform costs are normalized to zero.

Additionally, the intermediary can decide to compete with sellers who joined his platform, becoming active as a *merchant* in the respective product markets. In doing so, he either imitates the product that is offered by a seller, or he starts selling the same product, purchasing it from some supplier. We assume that the intermediary cannot offer a product if the respective seller did not join the platform.[12] This assumption captures the following situation: the intermediary is ex ante uninformed about existence of new products or corresponding demand. In contrast, more specialized sellers are (perfectly) informed about existence of demand for products which they may offer. By joining the intermediary's platform, they disclose information. Thereby, the intermediary can easily learn existence of demand for each specific product as platform operator. He may pick specific products and enter the respective markets after observing his constant marginal production costs.[13] We assume that these marginal costs ζ are drawn from an atomless distribution $H(\zeta)$ with support $[\underline{\zeta}, \overline{\zeta}]$. A draw of ζ captures the intermediary's relative bargaining position towards suppliers or his ability in imitating sellers' products; he may have higher or lower production costs than sellers, i.e., $c \in (\underline{\zeta}, \overline{\zeta})$. We assume that the merchant's marginal costs are determined by one single draw, and, hence, are the same for all products. For entering a market that was disclosed by a seller, the intermediary faces infinitesimal small (but positive) costs $\varepsilon > 0$.[14] However, we assume that he can base his entry decision on the realization of his production costs which he learns without bearing any costs, cf. the timing introduced in the next paragraph.

As the intermediary attains an (exclusive) information advantage about profitable product markets compared to sellers who are active in other markets, his imitation incentives are much stronger than those ones faced by other sellers. Therefore, we do not allow for sellers imitating each other but focus on potential competition between the merchant and each individual seller. Specifically, we assume that the products offered by the merchant are not differentiated from the respective sellers' products that he imitated. If the intermediary and a seller are active in the same product market, they compete in Bertrand fashion, setting prices.

We abstract from modeling the product segment for which the intermediary is informed about demand, and, hence, does not require sellers to open up markets.

[12] This assumption could be interpreted as a search cost advantages of sellers, cf. e.g. Minkler (1992).

[13] Again, we use the term "production costs" as representative for any kind of per-transaction costs.

[14] This assumption is made for two reasons: (i) The asymmetry between the intermediary's and each seller's investment costs accounts for the fact that the intermediary becomes informed about important product characteristics without bearing any costs. Once the seller disclosed demand and established her product on the platform, it is much less costly to simply imitate the product. (ii) Positive investment costs solve the tie situation the intermediary would face if he was indifferent regarding market entry, i.e., in cases he faces higher production costs than the respective seller, and, hence, is not willing to serve any demand.

Timing

The timing of the game is given as follows:[15]

1. The intermediary sets the platform tariff.[16]

2. Decision on platform membership:

   i) Sellers' investment costs are realized;

   ii) Sellers & buyers decide on joining the platform.

3. Intermediary's decision on becoming merchant/imitating sellers:

   i) The intermediary's production costs are realized;

   ii) The intermediary decides whether to enter product markets.

4. In each product market that the intermediary entered he competes with the respective seller by setting prices; otherwise, sellers take their monopoly pricing decisions.

We assume that the structure of demand as well as all costs, once realized, are common knowledge to sellers and the intermediary. Both sellers and the intermediary are assumed to maximize their expected profits, i.e., they are risk neutral.

In the following, we firstly analyze tariffs that consist of a fixed membership fee and a per-transaction fee charged to sellers. Secondly, we elaborate on the hold-up problem which emerges under those classical two-part tariffs. Thirdly, we discuss the case of a proportional fee, i.e., revenue sharing between the intermediary and each seller, as a special case of three-part tariffs.

3 Classical two-part tariffs charged to sellers

In this section, we consider classical two-part tariffs charged to sellers only. These tariffs combine a membership fee A as fixed transfer and a transaction-based per-unit fee a which increases each seller's perceived marginal costs.[17] We restrict our analysis to non-negative fees charged to sellers only. We rule out negative membership fees since they induce a moral hazard problem.[18] Similarly, negative per-unit fees are not feasible as they would create incentives for fictitious transactions.

[15] It may be natural to include another period of sales between the second and third stage. In this period, sellers who joined the platform could be active as monopolists. However, this would not affect any of our results.

[16] We implicitly assume that the tariff is contractible, or, at least, that commitment to a tariff system is feasible. Commitment seems plausible: As the tariff system is publicly observable, a reputation for not changing can be obtained.

[17] In our setting there is no difference between a per-unit fee and a per-transaction fee; formally, each seller's payment is proportional to the *quantity* he sells over the platform. As each buyer asks for one unit of each product, the number of transactions equals the number of units sold.

[18] With a negative A, sellers would list products they do not want to sell. In our setting the platform cannot distinguish good products from worthless ones before they are listed; hence, the platform would have to pay $|A|$ to the seller indiscriminate of the listing value.

We solve the game described before by backward induction.

3.1 Product pricing decisions

Stage 4 is only reached if sellers joined the platform in stage 2. We now look at the pricing decisions in one representative product market that a seller disclosed before.

The seller paid a fixed amount A up front to the intermediary. Hence, A are sunk costs to the seller. However, the seller has to pay a for each unit sold which increases his marginal costs to $a + c$.

If the intermediary did not enter the market, the seller is a monopolist, charging the price

$$p^{mon} = r.$$[19]

In this case, the seller's profit (before investment costs and membership fee) equals $\pi^{mon} = M \cdot \{r - (c + a)\}$.[20]

If the intermediary entered the market in stage 3, he and the seller compete à la Bertrand, with asymmetric costs. However, contrary to standard price competition, the intermediary receives a transfer of a for each unit sold by the seller. Thus, if the intermediary undercuts the seller's (perceived) marginal costs $c + a$, he in addition loses the per-unit transfer a. Hence, the intermediary undercuts a seller if and only if his respective merchant profit exceeds the (variable) per-product platform revenue:[21]

$$M \cdot ((c + a) - \zeta) > M \cdot a \;\Leftrightarrow\; \zeta < c. \tag{1}$$

Hence, if production costs turn out to be below the seller's costs ($\zeta < c$), the merchant serves all demand himself. The price in that case equals the seller's production costs increased by the per unit fee, i.e.,

$$p_m^{comp}(a) = c + a.$$

If the merchant's production costs are higher ($\zeta > c$), the seller serves the market and her price fulfills

$$p_s^{comp}(a) = \min\{\zeta + a, r\}.$$

The intermediary does not undercut $p_s^{comp}(a)$ by any amount $k > 0$ as he would lose $M \cdot a$ in platform fees while only gaining merchant profits of $M \cdot ((\zeta + a - k) - \zeta) < M \cdot a$ (assuming that $\zeta + a \leq r$). Charging prices above r is dominated as it results in zero demand. Finally, the case that both are equally efficient ($\zeta = c$) happens with zero probability as the distribution of ζ is atomless.

[19]Note that the monopoly price is affected neither by c nor by a. This is due to our assumption on demand being inelastic. With elastic demand, per-unit fees would increase the monopoly price, contrary to membership fees.

[20]We can exclude cases where $a > r - c$ as then stage 4 was never reached (zero seller participation).

[21]As is standard in the literature, we rule out prices below marginal costs because they are not limits of undominated strategies in discrete approximations of the strategy space.

Lemma 1 (Product pricing under classical two-part tariffs).
Under classical two part tariffs (A, a)*, if the intermediary did not enter a market, the respective seller is a monopolist, setting a price of* r*. If the intermediary entered a market and has lower production costs than the seller* ($\zeta < c$)*, he undercuts the seller by setting a price of* $c + a$*. If he faces higher production costs* ($\zeta > c$)*, the seller serves demand at a price of* $\min\{\zeta + a, r\}$*.*

Note that competitive prices increase in the per-unit fee as the increase in seller's perceived marginal costs (and the intermediary's outside option) relaxes competition.

3.2 Intermediary's entry decision

In stage 3, the intermediary decides on entering markets that sellers disclosed by joining the platform, anticipating the pricing decisions just discussed.

The intermediary decides on entry contingent upon his production costs. He enters markets only if he serves demand, which is the case when he has lower production costs ($\zeta < c$), as then his merchant profit exceeds his foregone platform revenues, cf. condition (1).

If he entered without serving demand, he would lose exactly his entry costs $\varepsilon > 0$, without any gains.

Lemma 2 (Intermediary's entry decision under classical two-part tariffs).
Under a classical two-part tariff (A, a)*, the intermediary enters product markets if and only if his production costs are lower than sellers' costs* ($\zeta < c$)*.*

Note that neither the fixed membership fee nor the per-unit fee affects the intermediary's entry decision. This is intuitive for the membership fee, but more surprising for the per-unit fee. The latter increases the platform revenue by a per unit. However, it also increases the competitive price and thus the merchant profit by a per unit. Hence, a does not affect the trade-off between platform revenue and merchant profit.

3.3 Decisions on joining the platform

In stage 2, sellers and buyers simultaneously decide whether to join the platform.

Recall that for buyers joining is a dominant strategy. Hence, all buyers join the platform.[22] Sellers join the platform if they expect to be able to at least recoup their investment costs I. As argued before, each seller will be a monopolist in her respective product market if $c < \zeta$, but will be undercut if $c > \zeta$. Hence, each seller's expected profit from joining the platform under a two-part tariff (A, a) is given by

$$\pi_s^e(A, a, I) = Pr(\zeta > c) \cdot M \cdot \{r - (c + a)\} - I - A,$$

[22] Note that this would be the case even if buyers had to pay fees. As there is no buyer heterogeneity, all buyers take a uniform joining decision. Hence, there is either zero or full buyer participation, where the former can never be optimal.

where $Pr(\zeta > c) = 1 - H(c)$ represents the probability that the intermediary does not enter as he is less efficient. Defining the critical level of investment costs

$$\widetilde{I}(A,a) \equiv \{1 - H(c)\} \cdot M \cdot \{r - (c+a)\} - A, \tag{2}$$

we achieve the following result:

Lemma 3 (Decisions on joining the platform under classical two-part tariffs)**.** *Under a classical two-part tariff (A, a), all buyers join the platform. Sellers join if their investment costs are below $\widetilde{I}(A, a)$ as defined in equation (2). The mass of sellers joining the platform, $F(\widetilde{I}(A, a))$, decreases in both A and a.*

Since the intermediary cannot charge negative fees to sellers,

$$\underline{I} < \{1 - H(c)\} \cdot M \cdot (r - c) \;\Leftrightarrow\; \underline{I} < \widetilde{I}(0,0)$$

is a necessary condition for seller participation under any classical two-part tariff; otherwise, the whole marketplace breaks down as no seller would have an incentive to join the platform, even if the intermediary charged no fees at all.

The basic intuition behind this condition is simple: If the probability of the intermediary facing lower production costs than the seller, i.e., $H(c)$, is high, each seller rarely makes product market profits as he will often be undercut by the intermediary. Hence, expected earnings from selling her product would not suffice to compensate even for the lowest investment costs $\underline{I}$. Therefore, no products would be introduced to the marketplace, and no markets would be disclosed to the intermediary.

We elaborate on the hold-up problem that evolves from the threat of entry (captured by the probability $1 - H(c)$) in more detail within the next section. However, we first solve the model under two-part tariffs by discussing the intermediary's tariff decision in the first stage. Throughout the remaining analysis, we make the following assumption to ensure that positive seller participation can be achieved with classical two-part tariffs:

Assumption 4 (Positive seller participation)**.** *If the platform does not charge any fees, seller's expected monopoly profit suffices to cover the lowest level of investment costs: $\underline{I} < \{1 - H(c)\} \cdot M \cdot (r - c)$.*

3.4 Optimal classical two-part tariff

In the first stage, the intermediary sets the membership fee A and the per-unit fee a.

Recall that under any two-part tariff (A, a) the intermediary will enter product markets as merchant if and only if he has lower production costs than sellers. The respective probability for ζ being below c is given by $H(c)$. Therefore, for each product listed on the marketplace, the intermediary's expected platform profit equals

$$\pi_p^e(A,a) = A + (1 - H(c)) \cdot M \cdot a, \tag{3}$$

and his expected per-product merchant profit (which is independent of the membership fee A) is given by

$$\pi_m^e(a) = H(c) \cdot M \cdot \{c + a - E[\zeta|\zeta < c]\}. \tag{4}$$

His expected overall profit is given by the sum of his platform profit $\pi_p^e(A, a)$ and his merchant profit $\pi_m^e(a)$, times the mass of sellers who joined the platform:

$$\Pi^e(A, a) = F(\widetilde{I}(A, a)) \cdot \{\pi_p^e(A, a) + \pi_m^e(a)\}. \tag{5}$$

We observe that if we define the merchant's expected cost advantage as

$$\Delta^e(c) \equiv H(c) \cdot \left(c - \frac{1}{H(c)} \int_{\underline{\zeta}}^{c} x dH(x) \right), \tag{6}$$

we can rewrite the intermediary's expected overall profit (5), inserting (3) and (4), as

$$\Pi^e(A, a) = F(\widetilde{I}(A, a)) \cdot \{A + M \cdot (a + \Delta^e(c))\}. \tag{7}$$

Proposition 5 (Optimal classical two-part tariff).
The optimal two-part tariff consists of a zero membership fee and a positive per-unit fee a^*. Given that $F(\cdot)$ is (weakly) concave, interior a^* are defined by the first order condition

$$f(\widetilde{I}(0, a^*)) \cdot (1 - H(c)) \cdot M \cdot (a^* + \Delta^e(c)) = F(\widetilde{I}(0, a^*)). \tag{8}$$

Proof. See appendix, p. 24. □

The intuition why the intermediary prefers the transaction fee to the membership fee is the following: while every combination of a membership fee and a per-unit fee that generates the same level of expected platform profit induces the same rate of seller participation, only the per-unit fee increases the merchant profit by creating an additional competitive advantage for the merchant, raising the competitive price.

4 Efficiency benchmarks and hold-up problem

In this section we firstly analyze the first-best outcome a social planner would establish. Secondly, we examine the welfare-maximizing outcome with non-negative fees (second-best). Finally, we show that the intermediary always faces a hold-up problem under classical two-part tariffs.

4.1 Efficiency benchmarks

We consider a social planner maximizing expected welfare. He can obtain the first-best outcome by choosing the consumer price, a critical level of investment costs I^* that determines which markets will be opened up, and an allocation rule that specifies who provides the product, given the realization of the intermediary's production costs ζ.

Lemma 6 (First-best outcome)**.**
In the first-best outcome the intermediary enters and serves demand if and only if $\zeta < c$*. The critical level of investment costs* I^* *equals* $M \cdot \{r - c + \Delta^e(c)\}$*, and price is below* r*.*

Proof. See appendix, p. 24. □

Firstly, first-best requires that all disclosed markets are served as buyers' gross utility r exceeds production costs. Secondly, demand is served by the most efficient supplier. Finally, markets are opened up whenever the expected surplus created by a market,

$$M \cdot \{r - (1 - H(c)) \cdot c - H(c) \cdot E[\zeta|\zeta < c]\} = M \cdot \{r - c + \Delta^e(c)\},$$

covers the investment costs.

Clearly, if there was no information asymmetry between sellers and the intermediary, the first-best outcome could be obtained as the intermediary could then extract the full surplus. In particular, a simple (customized) two-part tariff offered to each seller would implement the first-best outcome: a negative membership fee covers the seller's individual investment costs if they are below I^*, and a per-unit fee of $r - c$ extracts the market surplus that is generated when the seller serves demand.

However, in case of asymmetric information, the intermediary will charge non-negative fees only. Therefore, the first-best outcome cannot be obtained since the critical level of investment costs $\widetilde{I}(A, a)$ will then be strictly smaller than I^*. Hence, efficient markets remain unexplored and will not be opened up. Moreover, if the social planner faces the same constraint, i.e., can only set non-negative two-part tariffs, he cannot implement first-best:

Lemma 7 (Second-best outcome)**.**
Under the constraint that $(A, a) \geq 0$*, the welfare-maximizing tariff is* $(0, 0)$*. The intermediary serves demand if and only if his production costs do not exceed a threshold that is strictly below* c*. The critical level of investment costs is strictly below* I^**.*

Proof. See appendix, p. 25. □

The intuition for the proof is that marginally decreasing the entry threshold does not cause a reduction in productive efficiency but increases seller investment incentives. However, the second-best outcome features underinvestment and usually requires a distortion in productive efficiency: the intermediary does not serve demand although he is more efficient. Thereby, expected seller rents, and, thus, seller participation, are increased.

4.2 Hold-up problem

A reasoning similar to the second-best outcome also holds if the intermediary could commit not to enter markets even in cases he faces (marginally) lower costs than sellers. He would always utilize this option to increase seller participation:

Lemma 8 (Profitability of commitment to restricted entry).
Under any classical two-part tariff (A, a)*, the intermediary benefits from committing not to enter with costs above a threshold* $\hat{\zeta} < c$*.*

Proof. See appendix, p. 26. □

With classical two-part tariffs, the intermediary therefore faces a hold-up problem: he would like to commit to enter markets in less cases. However, as he decides on entry when sellers have already joined the platform, he will enter markets whenever he is more efficient (see Lemma 2). Hence, we arrive at the following result:

Proposition 9 (Intermediary's hold-up problem under classical two-part tariffs).
Under any two-part tariff consisting of a membership fee and a per-unit fee, the intermediary faces a hold-up problem: his excessive entry behavior leads to insufficient seller investment incentives as well as poor seller participation and impedes him to open up all profitable product markets.

In some cases the intermediary would even profit from a commitment never to enter. This is the case when the expected foregone profit of not entering is small, which is the case if $\Delta^e(c)$ is small. However, the intermediary would often prefer to enter markets if he is much more efficient, while committing not to enter only when his cost advantage is small. We discuss the profitability of (full) commitment never to compete with sellers and the (partial) commitment created by proportional fees in the following section.

5 Proportional fees mitigate the hold-up problem

We have shown that for any classical two-part tariff the intermediary always enters a seller's market when he has lower marginal costs than the seller.

Nevertheless, we have argued that an intermediary using only classical two-part tariffs would profit if he committed not to compete with sellers in cases he is more efficient. However, we have not explained *how* an intermediary could achieve such commitment – in fact committing not to compete seems to be hard to achieve (i) in a credible way and (ii) by legal means.[23]

We now consider an intermediary using proportional fees, i.e., tariffs that comprise revenue sharing where the intermediary earns a fraction α of the revenues that sellers realize on his platform. We find that proportional fees allow the intermediary to credibly commit not to compete with sellers even in cases he has lower marginal costs. Therefore, proportional fees help the intermediary to attract more sellers, mitigating the hold-up problem. Furthermore, we show that even if full commitment not to compete with sellers

[23]Note that platforms like Amazon often already have a reputation for acting under the dual mode, i.e., competing with sellers in a variety of existing product markets. Therefore, credible commitment on *not* competing might not be feasible. Furthermore, an announcement not to compete with other sellers may be interpreted as a horizontal collusive agreement.

could be achieved without using proportional fees, the intermediary would prefer not to use this option under certain circumstances, while the introduction of a proportional fee is profitable to him.

In the following, we analyze three-part tariffs as combinations of classical two-part tariffs and proportional fees. We again proceed by backward induction. The key insight regarding the intermediary's entry behavior (which is decisive for the hold-up problem) will be given in the second subsection (analysis of third stage). However, we also show that the inclusion of an additional proportional fee improves the optimal classical two-part tariff under certain conditions. This gives an explanation for the frequent observation of platforms and similar businesses using proportional fees.

5.1 Product pricing decisions under a three-part tariff

Along the lines of the analysis under classical two-part tariffs, we have to consider two cases to determine price setting within a (representative) product market that a seller disclosed under a three-part tariff (A, a, α).

If the intermediary did not enter the market, the seller is a monopolist and earns a profit (before investment costs and membership fee) of $M \cdot \{(1-\alpha) \cdot r - (c+a)\}$ by setting a price of

$$p^{mon} = r.$$

If the intermediary entered the market as merchant, he competes with the seller in Bertrand fashion. Nevertheless, he might prefer not to serve any demand, even if he earned a positive margin by undercutting the seller, as he would lose the transfer $a + \alpha p$ that he earns for each transaction conducted by the seller at a price of p.

We find that the intermediary prefers to serve demand whenever he has lower costs than the seller. This can be seen as follows: At any price p chosen by the seller, the intermediary is tempted to undercut the seller if his merchant profit $M \cdot (p - \zeta)$ exceeds his variable platform profit $M \cdot (a + \alpha \cdot p)$. Accordingly, serving demand himself at a given price p is more profitable than acting as platform operator if

$$p - \zeta > a + \alpha p \;\Leftrightarrow\; p > \frac{\zeta + a}{1 - \alpha}.$$

As the lowest price the seller can offer without obtaining a negative margin equals $\frac{c+a}{1-\alpha}$, the intermediary indeed prefers to undercut the seller by charging a price of

$$p_m^{comp}(a, \alpha) = \frac{c + a}{1 - \alpha}$$

if $\zeta < c$. Then, the intermediary achieves a profit of $M \cdot \left(\frac{c+a}{1-\alpha} - \zeta\right)$.[24]

If the merchant faces higher production costs than the seller ($\zeta \geq c$), the seller serves demand at a price of

$$p_s^{comp}(a, \alpha) = \min\left\{\frac{\zeta + a}{1 - \alpha}, r\right\},$$

[24] Again, our notation excludes cases where $\frac{c+a}{1-\alpha} > r$ as these cannot occur (no seller participation).

obtaining a non-negative contribution margin (profit before investment costs).

We summarize our findings in the following result:

Lemma 10 (Pricing decisions under a three-part tariff).
Under a three-part tariff (A, a, α)*, if the intermediary did not enter, the seller serves demand at a price equal to* r*. If the intermediary entered the product market as merchant, he serves demand at a price of* $\frac{c+a}{1-\alpha}$ *if and only if he has lower costs than sellers* ($\zeta < c$)*; otherwise* ($\zeta \geq c$)*, the seller serves demand at a price of* $\min\left\{\frac{\zeta+a}{1-\alpha}, r\right\}$.

5.2 Intermediary's entry decision under a three-part tariff

After the intermediary's production costs have been realized, he decides on entering product markets. If he faces higher production costs than a (representative) seller ($\zeta \geq c$), he does not enter the market, anticipating the decisions in stage 4: if he entered, he would not serve any demand, but incur entry costs $\varepsilon > 0$. Furthermore, entry would drive down the seller's price by $r - \frac{\zeta+a}{1-\alpha}$. Hence, if the intermediary's tariff includes a positive proportional fee α, the intermediary in addition loses parts of his platform profit by entering the market, even though he does not serve any demand.

The latter logic also applies to the case when the intermediary's production costs turn out to be below the seller's costs: if the intermediary charges a proportional fee, he incurs a direct loss from the reduction in prices which is induced by his market entry. Therefore, the intermediary prefers not to enter even if he has a (small) cost advantage. This can be formalized as follows: the intermediary prefers entry if his merchant profit from undercutting the seller exceeds his variable platform profit that consists of a share of the seller's monopoly revenue and the per-unit fee, i.e., if

$$p_m^{comp}(a, \alpha) - \zeta > a + \alpha \cdot p^{mon}. \tag{9}$$

Rewriting condition (9) for entry being profitable as

$$\zeta < \frac{c+a}{1-\alpha} - \alpha \cdot r - a \equiv \widetilde{\zeta}(a, \alpha), \tag{10}$$

we observe that the critical threshold $\widetilde{\zeta}(a, \alpha)$ of merchant's production costs generally differs from the seller's marginal costs c. Differently from the analysis under classical two-part tariffs, his entry decision now depends on the difference of production costs, the level of production costs, and the transaction-based tariff components a and α.

Lemma 11 (Intermediary's entry decision under a three-part tariff).
Under a three-part tariff (A, a, α)*, the intermediary enters product markets if and only if* $\zeta < \widetilde{\zeta}(a, \alpha)$.

For a more intuitive illustration of the intermediary's tradeoff, we define $\Delta c \equiv c - \zeta$ as the merchant's cost advantage. Then, we can rewrite his merchant profit $p_m^{comp}(a, \alpha) - \zeta$

as $\Delta c + a + \alpha \cdot \left(\frac{c+a}{1-\alpha}\right)$. Hence, condition (9) for entry being profitable becomes

$$\Delta c > \alpha \cdot \left(r - \frac{c+a}{1-\alpha}\right). \tag{11}$$

This inequality exactly corresponds to the reasoning that we made above: if the intermediary enters the market, he incurs a loss from the price reduction caused by competition which is captured by the (RHS). He only enters if this loss is overcompensated by his cost advantage Δc.

Taking a closer look at the (RHS) of inequality (11), we can state the following result:

Proposition 12 (Intermediary's entry decision under a three-part tariff)**.** *Under any three-part tariff that yields positive seller participation and comprises a proportional fee $\alpha > 0$, the intermediary only enters product markets if his cost advantage exceeds a strictly positive threshold, i.e., $c - \widetilde{\zeta}(a, \alpha) > 0$.*

Proof. See appendix, p. 26. □

Accordingly, under three-part tariffs that include a positive proportional fee, the intermediary always enters in fewer cases than under any classical two-part tariff. The use of proportional fees creates a credible commitment not to enter product markets for cost advantages $\Delta c < c - \widetilde{\zeta}(a, \alpha)$, and, therefore, mitigates the hold-up problem by reducing the threat of competition.

5.3 Sellers' joining decisions under a three-part tariff

Given the critical level of merchant's production costs $\widetilde{\zeta}(a, \alpha)$, a seller's expected profit from joining the intermediary's platform can be written as

$$\pi_s^e(A, a, \alpha, I) = Pr(\zeta \geq \widetilde{\zeta}(a, \alpha)) \cdot M \cdot \{(1-\alpha) \cdot r - c - a\} - A - I,$$

where $Pr(\zeta \geq \widetilde{\zeta}(a, \alpha))$ denotes the probability of the intermediary not entering the respective product market, which equals $1 - H(\widetilde{\zeta}(a, \alpha))$. A seller joins the platform if her expected profit $\pi_s^e(A, a, \alpha, I)$ is positive, i.e., if her investment costs are below the critical level

$$\widetilde{I}(A, a, \alpha) \equiv \{1 - H(\widetilde{\zeta}(a, \alpha))\} \cdot M \cdot \{(1-\alpha) \cdot r - c - a\} - A. \tag{12}$$

Interestingly, while $\widetilde{I}(A, a, \alpha)$ is strictly decreasing in both A and a, it is increasing in the proportional fee α under certain conditions. For $\alpha = 0$, i.e., classical two-part tariffs, seller participation increases in α if and only if

$$\frac{(1 - H(c)) \cdot r}{r - c - a} < h(c) \cdot (r - c - a).\text{[25]} \tag{13}$$

[25] The condition for $\frac{\partial \widetilde{I}}{\partial \alpha}$ being positive in case of $\alpha \neq 0$ can be found in the proof of lemma 13.

While all tariff components, i.e., A, a, and α, strictly reduce sellers' margins from selling their products, the proportional fee α in addition reduces the intermediary's entry incentives, and, in turn, makes sellers more likely to sell their products themselves. The (LHS) of condition (13) captures the relative reduction of sellers' margins that is caused by a change in α (increasing α decreases sellers' expected profits at a rate of $(1 - H(c)) \cdot r$). The (RHS) comprises the effect of lowering the entry threshold (increasing α decreases the entry threshold, which, in turn, increases sellers' expected profits by $h(c) \cdot (r - c - a)$). If the latter effect of a lower entry threshold overcompensates the margin effect, a higher α implies more sellers joining the platform.

The results are summarized in the following lemma:

Lemma 13 (Sellers' decision to join the platform under a three-part tariff)**.** *Under a three-part tariff (A, a, α), the mass of sellers that join the platform equals $F(\widetilde{I}(A, a, \alpha))$. It decreases in A and a, but the effect of a change in α is ambiguous.*

Proof. See appendix, p. 27. □

5.4 Intermediary's decision on the use of proportional fees

Given the results derived before, the intermediary's expected per-product platform profit under a three-part tariff (A, a, α) equals

$$\pi_p^e(A, a, \alpha) = A + M \cdot \{1 - H(\widetilde{\zeta}(a, \alpha))\} \cdot (a + \alpha \cdot r), \tag{14}$$

and his expected per-product merchant profit is given by

$$\pi_m^e(a, \alpha) = M \cdot H(\widetilde{\zeta}(a, \alpha)) \cdot \left\{ \frac{c + a}{1 - \alpha} - E[\zeta | \zeta < \widetilde{\zeta}(a, \alpha)] \right\}. \tag{15}$$

His expected overall profit equals the sum of his platform profit $\pi_p^e(A, a, \alpha)$ and his merchant profit $\pi_m^e(a, \alpha)$, multiplied by the mass of sellers who joined the platform:

$$\Pi^e(A, a, \alpha) = F(\widetilde{I}(A, a, \alpha)) \cdot \{\pi_p^e(A, a, \alpha) + \pi_m^e(a, \alpha)\}. \tag{16}$$

Substituting (14) and (15) into (16) leads to

$$\Pi^e(A, a, \alpha) = F(\widetilde{I}(A, a, \alpha)) \cdot \left\{ A + M \cdot \left[a + \alpha \cdot r + \Delta^e \left(\widetilde{\zeta}(a, \alpha) \right) \right] \right\}, \tag{17}$$

where

$$\Delta^e \left(\widetilde{\zeta}(a, \alpha) \right) = H(\widetilde{\zeta}(a, \alpha)) \cdot \widetilde{\zeta}(a, \alpha) - \int_{\underline{\zeta}}^{\widetilde{\zeta}(a, \alpha)} x dH(x)$$

as defined in (6).[26] Evaluating the partial derivative of the intermediary's profit $\Pi^e(A, a, \alpha)$ with respect to α at the optimal two-part tariff leads to the following result:

[26] Note that $\Delta^e(x)$ can only be interpreted as the merchant's expected cost advantage if $x = c$.

Proposition 14 (Proportional fees improve optimal classical two-part tariff).
The inclusion of an additional proportional fee improves the optimal classical two-part tariff $(0, a^*)$ *if*

$$\frac{h(c)}{1 - H(c)} \cdot (r - c - a^*) > H(c). \tag{18}$$

Proof. See appendix, p. 27. □

Note that the proposition only gives a sufficient condition for proportional fees to increase the intermediary's profit. If condition (18) holds, a marginal substitution from a to α is profitable, starting at $\alpha = 0$. The condition is implied by condition (13): if seller participation increases in α, the intermediary's profit also increases in α as the additional platform revenue per market $(\alpha \cdot r)$ overcompensates the loss from not being active as merchant with costs ζ marginally below c (captured by $\Delta^e(\widetilde{\zeta}(\cdot))$).

In the following, we show that even if direct commitment never to enter sellers' markets was feasible, (i) the intermediary might prefer not to use this commitment, while at the same time (ii) introducing a proportional fee (which endogenously yields a commitment not to enter for small cost advantages) is profitable to him.

For the remaining analysis, we make the following simplifying assumption:

Assumption 15 (Uniformly distributed investment costs).
Sellers' investment costs follow a uniform distribution with support $[0, \overline{I}]$.

Given this assumption, we can explicitly write down the optimal two-part tariff:

Corollary 16 (Optimal classical two-part tariff).
With uniformly distributed investment costs, the optimal classical two-part tariff consists of a zero membership fee and a per-unit fee

$$a^* = \max\left\{0, \frac{r - c - \Delta^e(c)}{2}\right\}. \tag{19}$$

Proof. See appendix, p. 28. □

In order to focus on cases in which the intermediary earns positive platform revenues, we make another assumption which ensures that the optimal per-unit fee (19) is strictly positive:

Assumption 17 (Positive platform revenues).
The intermediary's expected cost advantage does not exceed sellers' profit margin: $\Delta^e(c) < r - c$.

Then, the intermediary's expected profit under a classical two-part tariff equals

$$\Pi^e(0, a^*) = \frac{1 - H(c)}{\overline{I}} \cdot M^2 \cdot \left(\frac{r - c + \Delta^e(c)}{2}\right)^2. \tag{20}$$

If the intermediary could fully commit not to enter sellers' markets, he would achieve a maximal expected profit of

$$\frac{1}{\bar{I}} \cdot M^2 \cdot \left(\frac{r-c}{2}\right)^2 \tag{21}$$

by setting a per-unit fee of $a^*_{f.c.} = \frac{r-c}{2}$.[27]

Defining

$$\gamma \equiv \frac{c - E[\zeta|\zeta < c]}{r-c} \tag{22}$$

as the ratio of the intermediary's average cost advantage to sellers' gross margin (which determines the extractable rent),[28] we can state the following result:

Lemma 18 (Non-profitability of full commitment)**.**
If full commitment not to enter sellers' markets was feasible with a classical two-part tariff, the intermediary would prefer not to commit if

$$\gamma > \frac{1-\sqrt{1-H(c)}}{H(c)\sqrt{1-H(c)}}. \tag{23}$$

Proof. See appendix, p. 28. □

The intuition behind condition (23) can be understood as follows: the intermediary's decision on commitment is affected by the probability of facing lower costs than sellers, $H(c)$, and the ratio γ which is given by definition (22).[29] The hold-up problem is most severe if the probability for entering a market under a classical two-part tariff, $H(c)$, is large. Accordingly, commitment not to compete with sellers, creating additional investment incentives, becomes more attractive if $H(c)$ increases, what explains why the (RHS) of inequality (23) is strictly increasing in $H(c)$.[30] However, full commitment (if feasible) also means forgoing the additional profit option of selling as a merchant at lower costs than sellers. Therefore, it is more profitable to attract only some sellers and retain this option instead of completely eliminating the threat of entry if the average cost advantage is relatively large.

By inserting the optimal per-unit fee (19), we can rewrite condition (18) for an introduction of a proportional fee being profitable as

$$\frac{h(c)}{1-H(c)} \cdot \frac{r-c}{2} \cdot (1 + H(c) \cdot \gamma) > H(c). \tag{24}$$

Finally, we arrive at the following result:

[27]As argued within the analysis of classical two-part tariffs, a pure platform operator is indifferent between any combination of fees that yield the same rate of seller participation.

[28]Note that assumption 17 implies $\gamma < \frac{1}{H(c)}$.

[29]Note that the shape of the cost distribution $H(\zeta)$ above c does not affect any decision as long as the corresponding probability mass $1 - H(c)$ remains constant. This is because the intermediary never enters with costs $\zeta > c$.

[30]For $H(c) \to 0$, $\frac{1-\sqrt{1-H(c)}}{H(c)\sqrt{1-H(c)}}$ approaches 0.5.

Proposition 19 (Commitment and profitability of proportional fees).
If conditions (23) and (24) hold, the introduction of a proportional fee improves the optimal classical two-part tariff, whereas the intermediary would reject the opportunity of full commitment.

Differently from full commitment, the introduction of a proportional fee creates additional investment incentives for sellers without completely abandoning the merchant option. Accordingly, the sufficient condition for a proportional fee being profitable can be fulfilled while full commitment is not attractive to the intermediary.[31] In particular, this shows that (partial) commitment using a proportional fee is not only more profitable than setting a classical two-part tariff, but also more profitable than full commitment (if feasible at all) under certain circumstances.

6 Discussion

In many cases intermediaries who operate marketplaces can become active in these marketplaces themselves. While it makes no difference if a pure platform operator levies tariffs on a membership or a per-transaction basis (in line with Armstrong, 2006), the opportunity of competing with sellers changes the trade-off between different forms of fees charged to sellers. Allowing for (potential) competition between sellers and the platform operator, i.e., a dual mode of intermediation, we show that the intermediary strictly prefers per-unit fees to membership fees: per-unit fees increase sellers' perceived marginal costs and thereby relax competition. However, per-unit fees do not affect the intermediary's incentives to compete with sellers as they increase the competitive price and platform revenues by the same amount.

Under classical two-part tariffs, the intermediary enters product markets, competing with sellers and serving demand, if and only if he faces lower production costs than sellers. If sellers incur investment costs when joining the platform, the threat of competition leads to a hold-up problem: profitable product markets remain unexplored as sellers' investment incentives are insufficient, both from the intermediary's and a social point of view. Consequently, and as charging negative fees would cause a moral hazard problem, the intermediary would like to diminish the threat of entry, forgoing parts of his merchant profits to increase investment incentives.

We argue that announcing not to compete with sellers might not be credible or feasible at all. However, even if credible commitment never to enter sellers' markets was feasible, it would not always be profitable to the intermediary. If the intermediary's average cost advantage is sufficiently large, he prefers gaining from cost advantages

[31] The combination of conditions (23) and (24) can be written as

$$h(c) \cdot \frac{r-c}{2} \cdot (1 + H(c) \cdot \gamma) > H(c) \cdot (1 - H(c)) > \frac{\sqrt{1 - H(c)} - (1 - H(c))}{\gamma}.$$

Both inequalities hold if $r - c$ and γ are sufficiently large.

instead of solving the hold-up problem.

Taken together, the intermediary prefers to commit not to enter if his cost advantage is small, but wants to exercise his merchant option in case of a large cost advantage.[32] We show that using proportional (revenue-based) fees allow this form of partial commitment as the intermediary internalizes the loss due to the price reduction that his entry decision may cause.

However, proportional fees are not always in the interest of the intermediary since the commitment comes with the cost of a relative reduction in the competitive price: a per-unit fee that yields the same level of platform profit as a certain proportional fee results in a higher competitive price. Therefore, proportional fees mitigate the hold-up problem by yielding partial commitment, increasing investment incentives by reducing the threat of entry, but their profitability depends on the distribution of the intermediary's costs. If the probability of the intermediary facing costs slightly below sellers' costs c is large, the introduction of a proportional fee is always profitable as it significantly reduces the hold-up problem.[33]

Focussing on the hold-up problem, we show that proportional fees may be used to create investment incentives by increasing sellers' expected profits, contrary to the effects discussed in the extant literature (Shy & Wang, 2011; Miao, 2011; Z. Wang & Wright, 2011), where proportional fees are used by the platform operator to appropriate a larger share of sellers' profits.

We assume that buyers are inelastic in their participation and buying decisions. Thereby, we abstract from the double marginalization effect that is the core of Shy and Wang (2011) and Miao (2011). Although the intermediary would face additional incentives to enter product markets if we introduced elastic demand into our model (entry decreases price, and, hence, mitigates the double marginalization problem), the commitment effect of proportional fees would still be present.

In contrast to Z. Wang and Wright (2011), we assume symmetry of product markets (apart from investment costs) and full observability of the characteristics of disclosed markets. Even if we introduced seller heterogeneity, the latter assumption would allow direct discrimination based on observable characteristics.[34] Therefore, proportional fees do not have a price discrimination effect in our framework.

[32]As the intermediary's costs are rarely verifiable, such behavior seems not to be contractible directly.

[33]Furthermore, if the intermediary's maximal cost advantage is relatively small, the intermediary can achieve credible commitment *never* to enter sellers' markets by charging a proportional fee that implies that the entry threshold $\widetilde{\zeta}(\cdot)$ equals $\underline{\zeta}$.

[34]Also cf. footnote 11.

7 Concluding Remarks

While real world platforms use a mixture of tariff forms, including proportional (per-revenue) fees, the great majority of the economic literature on platform markets has focussed on membership fees and per-unit fees. The extant studies on proportional platform fees highlight the reduction of the double marginalization problem and price discrimination effects caused by proportional fees.

Analyzing a dual mode of intermediation, i.e., potential competition between the platform operator and sellers active in the marketplace, we find that proportional fees can be used to align sellers' and intermediary's conflicting interests. In our model, the use of proportional fees increases the attractiveness of the platform to sellers by reducing the threat of competition, creating additional investment incentives. Our model predicts the use of revenue-based fees which are observed for several platforms, e.g. Amazon Marketplace, Apple's AppStore, and Google's Android Marketplace.

Our analysis sheds light on the economics of intermediated markets, in particular markets in which the intermediary does not only organize a marketplace, but can become active in it himself. In addition, our reasoning might be also applicable more generally in the context of franchising, licensing, and imitable (non-patented) innovations.

A Proofs

Proof of Proposition 5

Recall that the intermediary's expected overall profit under a two-part tariff (A, a) can be written as

$$\Pi^e(A,a) = F(\widetilde{I}(A,a))\{A + M \cdot (a + \Delta^e(c))\}, \tag{25}$$

with $\Delta^e(c)$ being independent of both A and a.

We show that it is always more profitable to charge a higher per-unit fee instead of a membership fee: a 'compensated' increase in the per-unit fee a which does not affect seller participation leads to an increase in the intermediary's per-product profit. Starting from an arbitrary tariff scheme (A, a) with $A > 0$, we firstly determine how to adapt the membership fee A such that the critical level of investment costs $\widetilde{I}(A, a)$ remains constant while changing a. Secondly, given this compensation, we show that the effect of a change in the per-unit fee a overcompensates the effect of the corresponding adaption of the membership fee A.

(i) Given the definition

$$\widetilde{I}(A,a) \equiv \{1 - H(c)\}M\{r - (a + c)\} - A$$

from Lemma 3, we have $\frac{\partial \widetilde{I}(A,a)}{\partial A} = -1$. By implicit function theorem it follows that the compensation $A(a)$ has to fulfill $\frac{\partial A(a)}{\partial a} = -\frac{\partial \widetilde{I}/\partial a}{\partial \widetilde{I}/\partial A} = \frac{\partial \widetilde{I}(A,a)}{\partial a}$. Substituting $\frac{\partial \widetilde{I}}{\partial a}$ yields $\frac{\partial A(a)}{\partial a} = -M \cdot (1 - H(c))$.

(ii) Define $\pi(A, a) \equiv A + M \cdot (a + \Delta^e(c))$. Then, we obtain $\frac{\partial \pi}{\partial A} = 1$ and $\frac{\partial \pi}{\partial a} = M$. Substituting these derivatives and $\frac{\partial A(a)}{\partial a}$ into the definition of the total differential

$$d\pi = \frac{\partial \pi}{\partial A} dA + \frac{\partial \pi}{\partial a} da$$

leads to $\frac{d\pi}{da} = M \cdot H(c) > 0$, and the loss from a decrease in A is overcompensated by the corresponding increase in a as the latter creates an additional advantage for the merchant in case of competition (that occurs with probability $H(c)$).

Now, we can focus on pure per-unit fee tariffs as the optimal membership fee is zero. Differentiating equation (7) with respect to a and plugging in $A = 0$ yields

$$\frac{\partial \Pi^e(0,a)}{\partial a} = M \cdot \left\{ F(\widetilde{I}(0,a)) - f(\widetilde{I}(0,a^*)) \cdot \{1 - H(c)\} \cdot M \cdot (a^* + \Delta^e(c)) \right\}.$$

Setting this equation to zero yields the first order condition (8).

If $F(\cdot)$ is weakly concave, $\Pi^e(0, a)$ is strictly concave in a. Hence, the first order condition is sufficient for a maximum.

Proof of Lemma 6

We already explained that the expected surplus created by a market equals $M \cdot \{r - c + \Delta^e(c)\}$. Intuitively, a market should be opened up if this expected surplus covers investment costs. More formally, it is easy to show that $I^* = M \cdot \{r - c + \Delta^e(c)\}$ maximizes expected welfare

$$W^e = F(\hat{I}) \cdot M \cdot \{r - c + \Delta^e(c)\} - \int_{\underline{I}}^{\hat{I}} I \, dF(I).$$

We can focus on the first order condition with respect to $\hat{I}$. Using the Leibniz integral rule, the condition indeed turns out to be $I^* = M \cdot \{r - c + \Delta^e(c)\}$.

Proof of Lemma 7

In the second-best case, the social planner faces the constraint $(A, a) \geq 0$ when maximizing the expected welfare, which is given by

$$W^e(A, a, \hat{\zeta}) = F(\hat{I}(A, a, \hat{\zeta})) \cdot M \cdot \{H(\hat{\zeta})(r - E[\zeta | \zeta < \hat{\zeta}]) + (1 - H(\hat{\zeta}))(r - c)\} - \int_{\underline{I}}^{\hat{I}(A,a,\hat{\zeta})} I \, dF(I),$$

with $\hat{I}(A, a, \hat{\zeta}) \equiv M \cdot \{1 - H(\hat{\zeta})\} \cdot (r - (c + a)) - A$.

Firstly, for $(A, a) \geq 0$, less sellers invest than in the first-best case:

$$\hat{I}(A, a, \hat{\zeta}) < I^* \;\Leftrightarrow\; \{1 - H(\hat{\zeta})\} \cdot \{r - (c + a)\} - A < r - c + \underbrace{\Delta^e(c)}_{\geq 0}.$$

Intuitively, since investment incentives are too low, charging positive fees only reduces welfare. Formally, both $\frac{\partial W^e}{\partial A}$ and $\frac{\partial W^e}{\partial a}$ are strictly negative within the support of $F(\cdot)$, i.e., if $f(\cdot) > 0$ (which necessarily holds in the optimum):

$$\frac{\partial W^e}{\partial A} = -f(\hat{I}(A, a, \hat{\zeta})) \cdot M \cdot \underbrace{\left\{ H(\hat{\zeta}) \cdot r - \int_{\underline{\zeta}}^{\hat{\zeta}} x dH(x) + \frac{A}{M} + (1 - H(\hat{\zeta})) \cdot a \right\}}_{>0},$$

$$\frac{\partial W^e}{\partial a} = \{1 - H(\hat{\zeta})\} \cdot \frac{\partial W^e}{\partial A}.$$

Hence, for any value of $\hat{\zeta} \in (\underline{\zeta}, \overline{\zeta})$, $(A, a) = (0, 0)$ maximizes welfare, given the constraint $(A, a) \geq 0$.

It is left to show that the social planer chooses $\hat{\zeta} < c$. We can rule out that $\hat{\zeta} \geq c$ since in that case expected welfare could be improved by lowering $\hat{\zeta}$:

$$\begin{aligned}
\frac{\partial W^e}{\partial \hat{\zeta}} &= -h(\hat{\zeta}) \cdot M^2 \cdot (r - (c + a)) \cdot f(\hat{I}(A, a, \hat{\zeta})) \cdot \left\{ r - (1 - H(\hat{\zeta}))c - \int_{\underline{\zeta}}^{\hat{\zeta}} x dH(x) \right\} \\
&\quad + F(\hat{I}(A, a, \hat{\zeta})) \cdot M \cdot h(\hat{\zeta}) \cdot (c - \hat{\zeta}) + M \cdot h(\hat{\zeta}) \cdot (r - (c + a)) \cdot f(\hat{I}(A, a, \hat{\zeta})) \cdot \hat{I}(A, a, \hat{\zeta}) \\
&= h(\hat{\zeta}) \cdot M \cdot (r - (c + a)) \cdot f(\hat{I}(A, a, \hat{\zeta})) \cdot \left[\hat{I}(A, a, \hat{\zeta}) - M \cdot \left\{ r - (1 - H(\hat{\zeta}))c - \int_{\underline{\zeta}}^{\hat{\zeta}} x dH(x) \right\} \right] \\
&\quad + F(\hat{I}(A, a, \hat{\zeta})) \cdot M \cdot h(\hat{\zeta}) \cdot (c - \hat{\zeta}) \\
&= M \cdot h(\hat{\zeta}) \cdot \left\{ \left(\frac{\partial W^e}{\partial A} \right) \cdot (r - (c + a)) + F(\hat{I}(A, \hat{\zeta})) \cdot (c - \hat{\zeta}) \right\}
\end{aligned}$$

The second summand in curly brackets, $F(\hat{I}(A,\hat{\zeta}))\cdot(c-\hat{\zeta})$, is negative for $\hat{\zeta}>c$ (and 0 for $\hat{\zeta}=c$). As the first summand is negative, we have

$$\left.\frac{\partial W^e}{\partial\hat{\zeta}}\right|_{\hat{\zeta}\geq c}<0,$$

and the optimal threshold is below c.

Proof of Lemma 8

The intermediary's expected overall profit under commitment not to enter with production costs above $\hat{\zeta}$ is given as follows:

$$\widehat{\Pi}^e(A,a,\hat{\zeta})=\begin{cases}F(\hat{I}(A,a,\hat{\zeta}))\cdot\{A+M\cdot(a+\Delta^e(c,\hat{\zeta}))\}, & \hat{\zeta}\leq c\\ F(\hat{I}(A,a,\hat{\zeta}))\cdot\{A+M\cdot(a+\Delta^e(c,c))\}, & \hat{\zeta}>c\end{cases}, \tag{26}$$

where

$$\hat{I}(A,a,\hat{\zeta})=M\cdot\{1-H(\hat{\zeta})\}\cdot(r-(c+a))-A,$$

and

$$\Delta^e(c,\hat{\zeta})\equiv H(\hat{\zeta})\cdot c-\int_{\underline{\zeta}}^{\hat{\zeta}}xdH(x).$$

Firstly, note that $\hat{\zeta}>c$ are dominated by $\hat{\zeta}=c$. This can be seen as follows: if $\hat{\zeta}>c$, $\hat{\zeta}$ affects the intermediary's profit only through the change in seller participation captured by $F(\cdot)$ because it is never profitable for the intermediary to enter with costs $\zeta\in(c,\hat{\zeta})$ (i.e., $\Delta^e(c,c)$ does not depend on $\hat{\zeta}$). For any $\hat{\zeta}>c$, $F(\hat{I}(A,a,c))>F(\hat{I}(A,a,\hat{\zeta})$ holds.

Differentiating $\widehat{\Pi}^e(A,a,\hat{\zeta})$ from below c yields

$$\begin{aligned}\left.\frac{\partial\widehat{\Pi}^e(A,a,\hat{\zeta})}{\partial\hat{\zeta}}\right|_{\hat{\zeta}\leq c}&=f(\hat{I}(A,a,c))\cdot\{-h(\hat{\zeta})\cdot M\cdot(r-(c+a)\}\cdot\{A+M\cdot(a+\Delta^e(c,\hat{\zeta}))\}\\&\quad+F(\hat{I}(A,a,\hat{\zeta}))\cdot\{M\cdot h(\hat{\zeta})\cdot(c-\hat{\zeta})\}.\end{aligned}$$

For $\hat{\zeta}=c$, the first term is negative, while the second term equals zero. Hence,

$$\left.\frac{\partial\widehat{\Pi}^e(A,a,\hat{\zeta})}{\partial\hat{\zeta}}\right|_{\hat{\zeta}=c}<0,$$

and $c>\arg\max_{\hat{\zeta}}\widehat{\Pi}^e(A,a,\hat{\zeta})$.

Proof of Proposition 12

The condition $\widetilde{\zeta}(a,\alpha)<c$ is equivalent to $\frac{c+a}{1-\alpha}-\alpha r-a<c$, which can also be written as $c-(1-\alpha)\cdot\alpha\cdot r+\alpha\cdot a<(1-\alpha)\cdot c$, or $\alpha\cdot(c+a)<(1-\alpha)\cdot\alpha\cdot r$. Division by $\alpha>0$ yields $c+a<(1-\alpha)\cdot r$, a necessary condition for positive seller participation.

Proof of Lemma 13

Equation (12) defines the critical level of investment costs under a three-part tariff as

$$\widetilde{I}(A,a,\alpha) \equiv \{1 - H(\widetilde{\zeta}(a,\alpha))\} \cdot M \cdot \{(1-\alpha)\cdot r - c - a\} - A.$$

Since $\widetilde{\zeta}(a,\alpha) \equiv \frac{c+a}{1-\alpha} - \alpha r - a = \frac{c}{1-\alpha} - \alpha r + \frac{\alpha}{1-\alpha}\cdot a$, $\widetilde{I}$ clearly decreases in A and a. Furthermore, we have

$$\frac{\partial \widetilde{I}(A,a,\alpha)}{\partial \alpha} = -M \cdot \left\{ \underbrace{(1 - H(\widetilde{\zeta}(a,\alpha)))r}_{\text{change of revenue share}} \underbrace{- h(\widetilde{\zeta}(a,\alpha)) \left(r - \frac{c+a}{(1-\alpha)^2} \right) \{(1-\alpha)r - (c+a)\}}_{\text{change of entry incentives}} \right\}.$$

This expression is positive if and only if

$$(1 - H(\widetilde{\zeta}))\cdot r < h(\widetilde{\zeta}) \cdot \left(r - \frac{c+a}{(1-\alpha)^2} \right) \cdot \{(1-\alpha)\cdot r - (c+a)\}.$$

Proof of Proposition 14

Firstly, we consider the merchant's expected cost advantage. We observe

$$\begin{aligned} \frac{\partial \Delta^e(\widetilde{\zeta}(a,\alpha))}{\partial \alpha} &= h(\widetilde{\zeta}(a,\alpha)) \cdot \frac{\partial \widetilde{\zeta}(a,\alpha)}{\partial \alpha} \cdot \widetilde{\zeta}(a,\alpha) + H(\widetilde{\zeta}(a,\alpha)) \cdot \frac{\partial \widetilde{\zeta}(a,\alpha)}{\partial \alpha} \\ &\quad - \left[\widetilde{\zeta}(a,\alpha) \cdot h(\widetilde{\zeta}(a,\alpha)) \cdot \frac{\partial \widetilde{\zeta}(a,\alpha)}{\partial \alpha} \right], \end{aligned}$$

where the last term in brackets follows from the Leibniz integral rule. As the first and the last term cancel out, this simplifies to

$$\frac{\partial \Delta^e(\widetilde{\zeta}(a,\alpha))}{\partial \alpha} = H(\widetilde{\zeta}(a,\alpha)) \cdot \frac{\partial \widetilde{\zeta}(a,\alpha)}{\partial \alpha} = H(\widetilde{\zeta}(a,\alpha)) \cdot \left(\frac{c+a}{(1-\alpha)^2} - r \right).$$

Hence, the derivative of the intermediary's expected profit (17) is given by

$$\begin{aligned} \frac{\partial \Pi^e(A,a,\alpha)}{\partial \alpha} &= F(\widetilde{I}(A,a,\alpha)) \cdot M \cdot \left[r + H(\widetilde{\zeta}(a,\alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \right] \\ &\quad + f(\widetilde{I}(A,a,\alpha)) \cdot \left(\frac{\partial \widetilde{I}(A,a,\alpha)}{\partial \alpha} \right) \cdot \left\{ A + M \cdot \left[a + \alpha r + \Delta^e \left(\widetilde{\zeta}(a,\alpha) \right) \right] \right\}, \end{aligned}$$

with $\frac{\partial \widetilde{I}(A,a,\alpha)}{\partial \alpha}$ as given in the proof of lemma 13. Defining

$$\pi(A,a,\alpha) \equiv \left\{ A + M \cdot \left[a + \alpha r + \Delta^e \left(\widetilde{\zeta}(a,\alpha) \right) \right] \right\},$$

we find that $\frac{\partial \Pi^e(A,a,\alpha)}{\partial \alpha}$ is positive if and only if

$$\frac{F(\widetilde{I}(A,a,\alpha))}{f(\widetilde{I}(A,a,\alpha))} > \pi(A,a,\alpha) \frac{(1 - H(\widetilde{\zeta}(a,\alpha)))r + h(\widetilde{\zeta}(a,\alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \{(1-\alpha)r - c - a\}}{r + H(\widetilde{\zeta}(a,\alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right)}.$$

From proposition 5, we know that the optimal per-unit fee in case of $\alpha = 0$ is defined by

$$\{1 - H(c)\} \cdot \{\underbrace{M \cdot (a^* + \Delta^e(c))}_{=\pi(0,a^*,0)}\} = \frac{F(\widetilde{I}(0, a^*, 0))}{f(\widetilde{I}(0, a^*, 0))}.$$

Hence, by envelope theorem, $\frac{\partial \Pi^e(0,a^*,0)}{\partial \alpha} > 0$ holds at the optimal two-part tariff if

$$\begin{aligned} 1 - H(c) &> \frac{(1 - H(c))r - h(c)\{r - c - a^*\}^2}{r - H(c)\{r - c - a^*\}} \\ \Leftrightarrow -H(c)\{r - c - a^*\} &> \frac{-h(c)\{r - c - a^*\}^2}{1 - H(c)} \\ \Leftrightarrow \qquad \frac{h(c)}{1 - H(c)} &> \frac{H(c)}{r - c - a^*}. \end{aligned}$$

Proof of Corollary 16

Again, from proposition 5, we know that the optimal per-unit fee (in case of an interior solution, i.e., $a^* > 0$) is defined by

$$\{1 - H(c)\} \cdot \{M \cdot (a^* + \Delta^e(c))\} = \frac{F(\widetilde{I}(0, a^*))}{f(\widetilde{I}(0, a^*))},$$

with $\widetilde{I}(0, a) = \{1 - H(c)\} \cdot M \cdot \{r - c - a\}$. As $F(I) = \frac{I}{\overline{I}}$ for $I \in [0, \overline{I}]$, the condition becomes

$$\{1 - H(c)\} \cdot \{M \cdot (a^* + \Delta^e(c))\} = \frac{\{1 - H(c)\} \cdot M \cdot \{r - c - a^*\}}{\overline{I}} \cdot \overline{I},$$

which is equivalent to

$$a^* = \frac{r - c - \Delta^e(c)}{2}.$$

Inserting this fee into the intermediary's profit (7) yields the expected profit (20).

Proof of Lemma 18

Comparing the intermediary's expected profit under a classical two-part tariff (with entry if costs are below c) given in (20) with his expected profit (21) under full commitment never to enter sellers' markets, full commitment is *not* profitable if

$$(1 - H(c)) \cdot \left(\frac{r - c + \Delta^e(c)}{2}\right)^2 > \left(\frac{r - c}{2}\right)^2.$$

By definition (22), we have $\Delta^e(c) = (r - c) \cdot H(c) \cdot \gamma$. Therefore, the latter condition is equivalent to

$$\sqrt{1 - H(c)} \cdot (1 + H(c) \cdot \gamma) > 1.$$

Solving this condition for γ yields condition (23).

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