

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

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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

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1 Introduction

Amazon started out as an online dealer, buying books in the wholesale market and reselling them online 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 page is now sold by external sellers and not by Amazon.¹ Participation of external sellers has led to an increase in the variety of products offered and in turn also increased Amazon's attractiveness to consumers as a marketplace. Similarly, the attractiveness of Apple's devices (iPhone, iPod, iPad, Mac) is supported by the availability of matching content supplied by third party providers and offered via the AppStore.²

In the above examples the intermediary offers a marketplace (or *platform*) to sellers and buyers, but at the same time is active in this marketplace, directly selling to buyers as *merchant*. This 'dual mode' seems plausible for several reasons:

On the one hand, a pure platform operator can profit from becoming active as merchant since he can guarantee some variety to buyers, mitigating the well-known chicken-and-egg problem that arises as long as only few sellers or buyers have joined the platform.³ Furthermore, by acting as merchant, he can (partly) internalize negative effects from coordination problems due to scarce control over product market decisions (e.g. double marginalization problems or asymmetric information about product quality).⁴ Moreover, the intermediary can gain from efficiency advantages if he can offer products as merchant at lower costs than sellers.

On the other hand, if the intermediary only acted as pure merchant, enabling third party sellers to reach consumers would also be profitable: Firstly, also third party sellers may have lower per-unit costs. Secondly, specialized sellers may be better informed about product demand than the intermediary, resulting in lower search costs or more suitable pricing decisions. Thirdly, in particular if the merchant faces fixed costs per product, he can increase product variety within his "shop", opening up more profitable markets and attracting buyers.

Taken together, it seems natural to find intermediated markets which feature the dual mode. Typically, such markets have two specific properties: Firstly, the intermediary and sellers are potential competitors. Secondly, the platform tariff system chosen by the intermediary shapes this competition.

Building on the first property, the intermediary may want to put competitive pressure on sellers' margins, reducing double marginalization problems and making prices

¹In 2010, sales by third party sellers represented 31% of unit sales, cf. Amazon's annual report.

²The 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 300.000 different applications are available; recently, Apple reported a sales volume (number of downloads) of 10 billions. Note that iTunes for *music* is not a platform but a retailer – our example only refers to '*apps*'.

³Cf. Caillaud and Jullien (2003).

⁴Also cf. Hagiu (2007) and our literature review.

more attractive to consumers. Furthermore, he may do cherry-picking, selling profitable goods himself after observing sellers' revenues. However, potential competition makes the platform less attractive to sellers in the first place. Building on the second property, as the tariff system affects the competition between intermediary and sellers, the intermediary chooses a tariff system trading-off the benefits of increased competition against platform attractiveness.

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, but may have higher per-product costs. In this framework, we firstly analyze "classical" two-part tariffs comprising fixed fees and per-transaction fees. Secondly, we examine 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.⁵ Thereby, we account for the fact that proportional fees are often observed in reality, in particular when specific values attached to each transaction are a fundamental characteristic of the platform's business. Moreover, franchising arrangements (which exhibit important similarities with an intermediary's platform tariff system) usually comprise proportional fees.

Regarding platform attractiveness, we find that an intermediary using only fixed and per-transaction fees is committed to enter a seller's market to undercut her price whenever she is less 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. Therefore, revenue sharing among the intermediary and sellers makes the intermediary internalize sellers' profitability and hence helps the intermediary to commit himself to act in sellers' interests.

This provides a novel explanation why proportional fees are commonly observed in reality.⁶

⁵As an important exemption, Shy and Wang (2011) have recently shown that proportional tariffs (revenue-based platform fees) can mitigate coordination problems, in their case a double marginalization problem. For more details see our literature review.

⁶In particular, in both of our introductory examples (Amazon Marketplace and Apple's AppStore) the platform operators charge sellers primarily proportional (revenue-based) fees.

Related Literature

In the following, we give a brief overview of the literature that is most related to our work and that we contribute to.

We identify three main issues that are treated by both our study and previous work: the optimal intermediation mode (merchant vs. platform), the choice of an optimal platform tariff, and commitment of a platform.

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). In a context similar to ours, Hagiu finds that under many circumstances the intermediary prefers the ‘merchant mode’ to the ‘platform mode’. Furthermore, he identifies several factors, e.g. consumers’ demand for variety or asymmetric information about product quality between the intermediary and sellers, that affect the intermediary’s choice towards the platform mode. Nevertheless, he only “provides a first pass at comparing two polar strategies for market intermediation”,⁷ neglecting the important effects that arise under the opportunity of a ‘dual mode’, i.e. an intermediary who offers a platform while (potentially) competing with sellers in product markets as merchant. 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. In contrast, we assume independent production or existence of an (un-modeled) third-party wholesaler who provides products to both the intermediary and sellers. Thereby, our work offers further insights on the above-mentioned forms of market organization, in particular as we allow for a ‘dual mode’ and as we analyze endogenous price setting within product markets. In addition, we provide a further link between the literature on two-sided platforms and on “classical” intermediation (i.e. vertical structures with reselling).

Besides those strands, we also contribute to the literature on franchising, in particular by allowing a ‘dual mode’ of intermediation and analyzing a framework of asymmetric information on demand between sellers (franchisees) and intermediary (franchisor): Our work provides insights into a franchisor’s decision on dual distribution/partial vertical integration (cf. e.g. Blair & Lafontaine, 2010; Minkler, 1992; Scott, 1995) and on the frequent use of sales revenue royalties. Nevertheless, we need to stress that despite those theoretical analogies there are also important differences between franchising and intermediation (e.g. non-monetary clauses in franchising agreements or reputation concerns

During the last decade, several seminal studies on two-sided markets have been published (cf. e.g.⁸ Rochet & Tirole, 2006; Armstrong, 2006). Most of them analyze optimal platform pricing in presence of (indirect) network effects under various circumstances.

However, almost all studies focus on membership fees, transaction-based fees, or two-

⁷Cf. Hagiu (2007), p.115.

⁸Jullien (forthcoming) offers a comprehensive up-to-date survey on two-sided (B2B) platforms, including a general introduction to two-sided markets.

part tariffs as a combination of both. Furthermore, most studies abstract away explicit payments between the two sides of a market or price setting by sellers, i.e. they do not focus on the micro structure of the marketplace.

An important exception is Shy and Wang (2011): They analyze a model of a two-sided platform, namely a payment card network. They find that profits of the card network are higher under proportional (per-revenue) fees than under per-transaction fees as the network faces a double marginalization problem which is mitigated by proportional fees.⁹ However, sellers earn lower profits under proportional fees.

Our model confirms their finding that proportional fees diminish the classic double marginalization problem compared to per-transaction fees. Furthermore, by analyzing seller participation incentives, we find that platforms may prefer proportional fees even in the absence of a double marginalization problem (whose extent crucially depends on demand assumptions). Therefore, we provide another explanation of why proportional fees are frequently used not only by payment card networks but also by other platforms.

The first study discussing commitment by two-sided platforms is Hagiu (2006). In contrast to previous studies (which assume that sellers and buyers take their decisions on joining a platform simultaneously), Hagiu analyzes a sequential timing structure: All sellers arrive at the platform before the first buyer. 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.

Beyond the work that belongs to the three issues mentioned above, there are some more studies which focus on similar topics or discuss related effects.

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), 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 focusses 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.

Belleflamme and Peitz (2010) analyze how intermediation affects manufacturers' investment incentives. In their model, sellers have to invest in innovation *before* the platform sets its prices. Therefore, platforms cannot consider how their pricing affects sellers' innovation incentives. Hence, a hold-up problem for the platform is not discussed as it cannot arise within their framework.

⁹Note that the results of Shy and Wang (2011) are also in line with those drawn within the literature on different taxes, in particular ad valorem vs. unit taxes (e.g. Suits & Musgrave, 1953).

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 the subsequent section 2.1 we analyze classical two-part tariffs which consist of membership fees and per-transaction fees. In section 2.2 we discuss existence and conditions of the intermediary's hold-up problem. Within section 2.3 we analyze proportional fees. In section 2.4 we draw a comparison between the different fees, discussing the intermediary's optimal tariff choice. In section 3 we summarize our findings and discuss the results. Extensions to the model are introduced in section 4. Finally, we give a conclusion in section 5.

2 Model

We consider a market with a monopoly intermediary who acts as a middleman between sellers and 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. Those investment costs are distributed among sellers according to a distribution function $F(I)$ over the support $[\underline{I}, \bar{I}]$ with $\underline{I} \geq 0$. We assume products offered by different sellers to be completely independent, i.e. there is no seller competition. Therefore, there is a continuum of independent product markets. Sellers' constant marginal costs of supplying their respective product are given by c , incorporating all per-unit costs of retailing and wholesale/production except for retailing operation fees charged by the intermediary.

Buyers' gross utilities from consuming a good are assumed to be homogeneous among buyers and also constant over products for each buyer.¹⁰ We assume that each buyer purchases at most one unit of each product. The common gross utility for consuming a product is denoted by r and there is a mass of M buyers. 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. Therefore, for each product the following demand function results:

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

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. For the latter a fixed share α of seller revenues accrues to the platform.

Additionally, the intermediary can decide to imitate products offered by sellers on his platform to become active as a *merchant* in the respective product markets. We assume that the intermediary is ex ante uninformed about existence of new products or corresponding demand. In contrast, more specialized sellers are perfectly informed

¹⁰In an extension we show that our results also hold under less restrictive demand assumptions.

about demand for the products which they may offer. By joining the intermediary's platform, they disclose information, i.e. the intermediary can easily learn existence of demand for each specific product as platform operator.¹¹ The intermediary may pick specific products and enter the respective markets after observing his constant marginal costs which are drawn from an atomless distribution $H(\zeta)$ with support $[\underline{\zeta}, \bar{\zeta}]$.¹² We assume that those marginal costs are identically distributed for all products and that $r > \bar{\zeta}$ holds. Furthermore, we assume that the intermediary has infinitesimal small (but positive) costs $\varepsilon > 0$ for entering a market.

We assume that the products offered by the merchant are not differentiated from the respective sellers' products that he imitated. Hence, if the intermediary and a seller are active in the same product market, they compete in Bertrand fashion.

Timing

The timing of the game is given as follows:

1. The intermediary announces a platform tariff.
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 imitate sellers/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.

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. Fourthly, we consider multi-part tariffs as combinations of the three fees discussed before.

¹¹In our examples, 'imitating products' either means offering the same product after purchasing it from some supplier (disclosed demand information in case of Amazon), or it means reproducing a product/application (based on a small but promising idea a seller/developer disclosed in case of the AppStore). The assumption of asymmetric information may be motivated by search cost advantages of sellers, cf. e.g. Minkler (1992).

¹²The random draw may capture the intermediary's relative bargaining position towards suppliers; he may have higher or lower per-unit costs than sellers, though the latter case seems more likely.

2.1 Classical two-part tariffs charged to sellers

In this subsection, 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.¹³ We restrict our analysis to positive membership fees charged to sellers only. We rule out negative membership fees since they induce a moral hazard problem: 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. Within the last stage, we firstly discuss fixed fees and per-unit fees in parallel and secondly combine our findings to examine two-part tariffs in the preceding stages. Afterwards, we explain why a hold-up problem arises if sellers pay only fixed membership fees and per-unit fees.

2.1.1 Stage 4: Product pricing decisions

Stage 4 is only reached if a seller decided to join the platform in stage 2. We now look at one representative product market, at first under a membership fee, afterwards under a per-unit fee, and finally under a two-part tariff.

Membership fee only

The seller has paid a fixed amount A up front to the intermediary. Hence, at this point, the transfers to the intermediary are independent of the market outcome.

There are two cases to be considered:

- a) The intermediary entered the market in stage 3, competing with the seller.

Merchant and seller compete in standard Bertrand fashion, with asymmetric costs. Thus, if the merchant turns out to be more efficient than the seller, i.e. $\zeta < c$, the merchant will undercut the seller and serve all demand himself. The price in that case equals the seller's marginal costs:

$$p_{merchant}^{comp} = c.$$

When the seller is more efficient, i.e. $c < \zeta$, she serves the market and the price equals the realization of the merchant's marginal costs:

$$p_{seller}^{comp} = \zeta.$$

The case that both are equally efficient happens with zero probability as ζ is distributed atomless.

¹³We assume that 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, i.e. each buyer asks for one unit of each product if the individual reservation value is above the respective price.

- b) The intermediary did not enter the market.

As the seller is a monopolist for her product in the marketplace, her price equals

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

Per-unit fee only

There are again two situations to be considered, but in contrast to the case of a pure membership fee tariff, under a per-unit fee the transfers to the intermediary are directly dependent on the market outcome:

- a) The intermediary entered the market as merchant, competing with the seller.

The lowest profitable price the seller can offer are her perceived marginal costs $a+c$. Therefore, the merchant has a competitive advantage (the per-unit fee increases seller's costs).

If the merchant is more efficient ($\zeta < c$), he serves the market at a price of

$$p_{merchant}^{comp}(a) = a + c$$

for the following reason: If the merchant did *not* undercut the seller, the intermediary's (platform) profit would be Ma . Otherwise, he has to sell the product himself at a price of $a + c$, earning a (merchant) profit of $M\{a + c - \zeta\} > Ma$.

If the merchant is less efficient ($\zeta \geq c$), the seller serves the market and her price fulfills

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

This becomes clear as follows (assuming that $a + \zeta \leq r$): If the seller sets a price of $a + \zeta$, the intermediary's platform profit without selling the product a equals his profit from selling at a price of $a + \zeta$ as merchant, while at lower prices his profit is higher if he does *not* serve any demand. Therefore, the merchant has no incentives to undercut prices $p \leq a + \zeta$, but would prefer selling the product himself at prices above $a + \zeta$.

- b) The intermediary did not enter the market, i.e. the seller behaves like a monopolist facing constant marginal costs of $a + c$. By setting the optimal price

$$p^{mon} = r$$

the seller earns a profit of $\pi^{mon}(a + c) = M\{r - (a + c)\}$.

Two-part tariff

Neither of both fees examined above affects the seller's monopoly pricing decision – due to our simplifying assumption of inelastic demand.¹⁴ However, competitive prices are

¹⁴With elastic demand, the monopoly price would be higher under a per-unit fee than under a membership fee.

always higher under a per-unit fee (independent of demand assumptions) as the increase in seller's perceived marginal costs relaxes competition:

Lemma 1 (Pricing decisions under classical two-part tariffs).

If the intermediary entered a market as merchant under a classical two-part tariff (A, a) , he undercuts sellers by setting a price equal to their perceived marginal costs $a + c$ whenever he has lower marginal costs than sellers ($\zeta < c$). If he did not enter a market, sellers are monopolists in their respective markets and set a price equal to r .

2.1.2 Stage 3: Intermediary's entry decision

In stage 3, the intermediary decides on imitating sellers who joined the platform, anticipating the pricing decisions just discussed.

As mentioned above, the fixed transfers to the intermediary have already been determined in stage 2. Therefore, they are also independent of the intermediary's entry decision. The intermediary decides on entry contingent upon his costs: As demand is assumed to be perfectly inelastic (no consumer heterogeneity, i.e. all consumers have the same willingness to pay), he only enters if he is more efficient, serving demand himself as merchant. If he is less efficient and entered, he would never serve a positive share of the market in the last stage. Hence, the only effect of entry would be lower prices, but (i) in case of inelastic demand there is no double marginalization problem, and (ii) buyers always join the platform, irrespective the price level, as they do not have to pay any fees. Therefore, he does not enter markets if he has higher marginal costs than the seller.

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 he turns out to be more efficient than sellers ($\zeta < c$).

In order to compare product market decisions (i.e. pricing and entry behavior) under a membership fee with those under a per-unit fee, we may again consider degenerate two-part tariffs $(A, 0)$ and $(0, a)$: Entry behavior is exactly the same both under a pure fixed fee tariff and a pure per-unit fee tariff, but pricing decisions are affected only by the per-unit fee because it is charged contingent upon selling the product and relaxes competition by increasing seller's perceived marginal costs. Therefore, if the intermediary turns out to be more efficient ($\zeta < c$), the price $a + c$ consumers have to pay under a pure per-unit fee tariff is higher than the price c which they would have to pay under a pure fixed fee tariff.

2.1.3 Stage 2: Sellers' and buyers' decision on joining the platform

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

Since we assume that (potential) buyers do not have to pay any fee to join the platform, they always join, given the assumption $r > \bar{\zeta}$.

Sellers' decisions depend on their individual investment costs and the fees charged by the platform. As argued before, each seller will act as a monopolist in her respective product market if her marginal costs c are lower than the intermediary's marginal costs ζ . Hence, each seller's expected profit from joining the platform under a two-part tariff (A, a) is given by

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

where $Pr(\zeta > c) = 1 - H(c)$ represents the probability that the intermediary does not enter as he is less efficient. As a seller joins the platform if and only if her expected profit is positive, we achieve the following result:

Lemma 3 (Sellers' decision to join the platform under classical two-part tariffs). *Under a classical two-part tariff (A, a) , sellers join the platform if and only if their investment costs are below $\tilde{I}(A, a) \equiv \{1 - H(c)\}M\{r - (a + c)\} - A$.*

As we assume homogeneous consumers, yielding perfectly inelastic demand, the main difference between a membership fee and a per-unit fee evolves from the sales-dependence of the latter: Within $\tilde{I}(A, a)$, the per-unit fee a is multiplied by the coefficient $Pr(\zeta > c) = 1 - H(c)$, contrary to the membership fee A .

2.1.4 Stage 1: Intermediary's tariff decision

In the first stage, the intermediary sets the membership fee A and the per-unit fee a (as platform operator).

Recall that under any two-part tariff (A, a) the intermediary enters product markets as merchant if and only if he is more efficient, i.e. if he has lower marginal costs than sellers. His entry decision directly depends on his marginal costs ζ , but it is independent of the amount of the membership fee or transaction fee charged. Hence, his expected merchant profit equals

$$\Pi_M^e(A, a) = F(\tilde{I}(A, a))H(c)M\{c + a - E[\zeta|\zeta < c]\},$$

and his expected platform profit is given by

$$\Pi_P^e(A, a) = F(\tilde{I}(A, a))\{A + aM(1 - H(c))\}.$$

Actually, a membership fee only redistributes rents from the seller to the intermediary by decreasing seller profits and increasing platform profits, whereas a per-unit fee in addition increases the equilibrium price in case merchant and seller compete.

If the intermediary was acting as platform operator only, he would be indifferent between charging a membership fee or a corresponding per-unit fee. However, per-unit fees in addition increase the intermediary's merchant profit and hence are superior from the intermediary's point of view:

Lemma 4 (Optimal classical two-part tariff).

The optimal classical two-part tariff for an intermediary consists only of a per-unit fee a and a zero membership fee.

Formally, the derivation of this result from the above-mentioned formulas is straightforward:¹⁵ Each critical investment level \hat{I} defines a unique platform profit level but can be obtained by infinitely many combinations of A and a , allowing (A, a) being any convex combination

$$\lambda(A^{max}(\hat{I}), 0) + (1 - \lambda)(0, a^{max}(\hat{I}))$$

of degenerate two-part tariffs with

$$A^{max}(\hat{I}) = \{1 - H(c)\}M(r - c) - \hat{I}$$

and $a^{max}(\hat{I}) = \frac{A^{max}(\hat{I})}{\{1 - H(c)\}M}$. As the merchant's competitive price $a + c$ is strictly increasing in a , the expected merchant profit $\Pi_M(A, a)$ is maximized by setting $A = 0$ and $a = a^{max}(\hat{I})$ for any level of \hat{I} (and, therefore, for any level of platform profit).

For completeness, we also derive the first order condition for the optimal per-unit fee. The intermediary maximizes his expected profit $\Pi_P^e(0, a) + \Pi_M^e(0, a)$ which equals

$$\left(aM\{1 - H(c)\} + H(c)M \left\{ a + c - \frac{1}{H(c)} \int_{\underline{c}}^c x dH(x) \right\} \right) F(\tilde{I}(0, a)).$$

If we define the merchant's expected per-transaction profit as

$$\Delta^e(c) \equiv H(c)c - \int_{\underline{c}}^c x dH(x),$$

the bracket term (which represents the intermediary's expected per-product profit) can be boiled down to $M\{a + \Delta^e(c)\}$. Hence, we achieve the following result:¹⁶

Proposition 5 (Optimal classical two-part tariff¹⁷ and seller participation).

If $\underline{c} < \{1 - H(c)\}M\{r - c\}$ holds, the optimal classical two-part tariff consist of a zero membership fee and a per-unit fee a^* defined by $\{1 - H(c)\}Mf(\tilde{I}(0, a^*)) = \frac{F(\tilde{I}(0, a^*))}{a^* + \Delta^e(c)}$.

The intuition behind the first order condition can be understood as follows: The intermediary profits through his platform part and his merchant part. On the one hand, he is interested in a high rate of seller participation.¹⁸ On the other hand, he is interested in a high expected per-transaction profit $M\{a + \Delta^e(c)\}$ which is proportional to his per-unit fee a .

Therefore, the intermediary sets the per-unit fee a to balance the change in the rate of seller participation $\frac{\partial F(\tilde{I}(0, a))}{\partial a} = \{1 - H(c)\}Mf(\tilde{I}(0, a))$ with the ratio between the rate of seller participation and his expected per-transaction profit.

¹⁵Another proof can be found in the appendix.

¹⁶Note that $\underline{c} < \{1 - H(c)\}M\{r - c\} \Leftrightarrow F(\tilde{I}(0, 0)) > 0$.

¹⁷Discussion of second order conditions to be included; nevertheless, a sufficient condition is F being weakly concave.

¹⁸ $F(\tilde{I}(0, a))$ can be interpreted as the (expected) mass of sellers who decide to join the platform.

2.1.5 Seller participation

Since the intermediary cannot charge a negative membership fee to sellers,

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

is a necessary condition for seller participation under any classical two-part tariff; otherwise, the whole marketplace breaks down as no seller has an incentive to join the platform.

The basic intuition behind this condition is rather simple: If the probability of the intermediary being more efficient than the seller is rather high, the likelihood that the intermediary does *not* become active as merchant, undercutting the seller, is rather low. Consequently, each seller's expected earnings from selling her respective product cannot compensate her individual investment costs. Therefore, no products are introduced to the marketplace, and no markets are disclosed to the intermediary.

2.2 Hold-up problem

If the necessary condition for seller participation stated above fails to hold, the intermediary faces excessive entry incentives which discourage sellers from joining his platform. In those cases, the intermediary would be better off if he could commit not to enter even if he is more efficient, in particular when his costs are only slightly smaller than c , thereby increasing $1 - H(c)$ and the critical level of investment costs which determines seller participation.

In this subsection, we show that the intermediary always faces excessive entry incentives under classical two-part tariffs. For this purpose, we focus on cases where the above condition for seller participation is fulfilled. We assume that the intermediary can commit not to enter product markets if his marginal costs exceed a critical level $\hat{\zeta}$ which he may set in the first stage. We find that the optimal level of $\hat{\zeta}$ is always smaller than c , meaning that the intermediary faces a hold-up problem under any tariff that comprises only membership and per-unit fees: Excessive entry incentives discourage sellers and impede the intermediary to exploit the full trade potential of all profitable markets.¹⁹

Given any two-part tariff (A, a) , the intermediary's expected merchant profit under commitment on entering product markets only if $\zeta < \hat{\zeta}$ is given by

$$\hat{\Pi}_M^e(A, a, \hat{\zeta}) = F(\hat{I}(A, a, \hat{\zeta}))H(\hat{\zeta})M\{c + a - E[\zeta | \zeta < \hat{\zeta}]\},$$

with $\hat{I}(A, a, \hat{\zeta}) \equiv \{1 - H(\hat{\zeta})\}M\{r - a - c\} - A$ as critical level of sellers' investment costs. The intermediary's expected platform profit under that kind of commitment equals

$$\hat{\Pi}_P^e(A, a, \hat{\zeta}) = F(\hat{I}(A, a, \hat{\zeta}))\{A + aM(1 - H(\hat{\zeta}))\}.$$

¹⁹In the appendix, we illustrate the hold-up problem in another way: Under certain circumstances, the intermediary prefers to commit not to enter product markets at all, only acting as platform operator.

After defining the merchant’s expected per-transaction profit under commitment as

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

the intermediary’s expected profit $\hat{\Pi}_M^e(A, a, \hat{\zeta}) + \hat{\Pi}_P^e(A, a, \hat{\zeta})$ under commitment can be written as

$$\hat{\Pi}^e(A, a, \hat{\zeta}) = F(\hat{I}(A, a, \hat{\zeta}))\{A + M\{a + \Delta^e(c, \hat{\zeta})\}\}.$$

Lemma 6 (Introduction 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 $\hat{\zeta} < c$.

It can be shown [to be included in the appendix] that $\frac{\partial \hat{\Pi}^e(A, a, \hat{\zeta})}{\partial \hat{\zeta}}|_{\hat{\zeta}=c} < 0$ holds.

Proposition 7 (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.

2.3 Proportional fees and three-part tariffs

We have shown that for any classical two-part tariff the intermediary is *committed to enter* a seller’s market when he has lower marginal costs than the seller. However, sellers fearing the intermediary to compete in their product markets generally have insufficient investment incentives, also from the intermediary’s point of view.

We have argued that an intermediary using only classical two-part tariffs can profit from committing not to compete with sellers in cases he is more efficient. However, we have not explained *how* an intermediary can 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.

In the following, we consider an intermediary using proportional fees, i.e. revenue sharing contracts where the intermediary earns a fraction α of the revenues that sellers realize on his platform.

As several prominent platforms make use of this tariff form, and, moreover, the majority of franchising agreements comprises proportional fees, it seems important to examine the differences between ‘classical’ two-part tariffs (that only comprise membership and per-unit fees) and proportional fees.

In particular, we find one major difference: The use of proportional fees allows the intermediary to credibly commit not to compete with sellers also in cases he has lower marginal costs. Therefore, proportional fees help the intermediary to attract more sellers, mitigating the hold-up problem.²⁰

²⁰Besides this difference, proportional fees can alleviate double marginalization problems, cf. Shy and

We again proceed by backward induction. We examine decisions under a pure proportional fee tariff, and, in addition, state all results for three-part tariffs comprising a membership fee A , a per-unit fee a , and a proportional fee α . 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).

2.3.1 Stage 4: Product pricing decisions

Given that a seller joined the intermediary's platform in stage 2, two cases have to be considered to determine price setting within a (representative) product market under a pure proportional fee tariff:

If the intermediary has not entered the market, the seller is a monopolist and earns a profit of $M\{(1 - \alpha)r - c\}$ by setting a price of $p^{mon} = r$.

If the intermediary has entered the product market as merchant, he competes with the seller in Bertrand fashion. Nevertheless, he need not serve any demand, even if he earned a positive margin by undercutting the seller. Therefore, we compare his merchant profit from selling at a given price p with his platform profit if the seller chooses a price p , not being undercut by the merchant.

The intermediary's merchant profit, given price p , equals $M\{p - \zeta\}$, while his platform profit would be $M\{\alpha p\}$. Accordingly, selling as a merchant is more profitable than charging a share of α of the seller's revenue as platform operator if

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

The lowest price the seller can offer without obtaining a negative margin equals $\frac{c}{1 - \alpha}$. Hence, the intermediary undercuts the seller and serves demand himself whenever he is more efficient (i.e. $\zeta < c$), charging a price of

$$p_{merchant}^{comp}(\alpha) = \frac{c}{1 - \alpha}$$

and achieving a profit of $M\left(\frac{c}{1 - \alpha} - \zeta\right)$.

If the merchant is less efficient ($\zeta \geq c$), the seller serves demand at a price of

$$p_{seller}^{comp}(\alpha) = \frac{\zeta}{1 - \alpha},$$

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

We generalize our findings to achieve the following result:

Lemma 8 (Pricing decisions under a three-part tariff).

If the intermediary entered a market as merchant under a three-part tariff (A, a, α) , he undercuts sellers by setting a price equal to their perceived marginal costs $\frac{c+a}{1-\alpha}$ if and only if he has lower marginal costs than sellers ($\zeta < c$). If he did not enter a market, sellers are monopolists in their respective markets and set a price equal to r .

Wang (2011) and our extension.

2.3.2 Stage 3: Intermediary's entry decision

After the intermediary's marginal costs have been realized, he decides on entering product markets. If he has higher marginal costs than a (representative) seller ($\zeta \geq c$), he does not enter the market, anticipating the decisions in stage 4.

If he turns out to be more efficient, he enters if his merchant profit from competing with the seller exceeds his platform profit that consists of a share of the seller's monopoly revenue, i.e. if the following condition is satisfied:

$$p_{merchant}^{comp}(\alpha) - \zeta > \alpha p^{mon}.$$

Accordingly, his entry decision now depends on the difference of marginal costs, the level of marginal costs, and the per-revenue fee α .²¹ Since this condition for entry being profitable can be rewritten as

$$\zeta < \frac{c}{1-\alpha} - \alpha r \equiv \tilde{\zeta}(\alpha),$$

the critical threshold $\tilde{\zeta}(\alpha)$ of merchant's marginal costs now generally differs from the seller's marginal costs c .

Lemma 9 (Intermediary's entry decision under a pure proportional fee tariff).

Under a proportional (per-revenue) fee α , the intermediary enters product markets if and only if $\zeta < \tilde{\zeta}(\alpha)$ holds.

In order to discuss the given condition, we start with the border case of $\zeta = c$: In this case, the condition for entry being more profitable is equivalent to $\alpha > \frac{r-c}{r}$. As no seller would join in stage 2 if the intermediary set a per-revenue fee above her profit margin $\frac{r-c}{r}$ (monopoly profits would be negative), the optimal fee set in the first stage must be below this critical value. Therefore, the intermediary strictly decides not to enter in all relevant cases if he faces the same marginal costs as sellers.

As a first illustration of the case $\zeta < c$, we include figure 1 which shows the intermediary's scaled per-product profit, either acting as platform or merchant (i.e. both sides of the inequality given above) for a given level of ζ .

– Insert figure 1 about here (see appendix) –

For certain parameter constellations (in particular if the merchant's cost advantage $c - \zeta$ is only marginal), the two graphs intersect twice. If α is contained in the range between the two points of intersection, the intermediary decides not to enter as his merchant profit would be smaller than his profit earned as platform operator, not being active in the market himself.

In order to obtain a more intuitive illustration of the intermediary's tradeoff, we define the intermediary's cost advantage as $\Delta c = c - \zeta$. Then, his merchant profit equals

²¹Note that α is determined endogenously in the first stage of the game, basically depending on the distribution of sellers' investment costs.

$\Delta c + \alpha \frac{c}{1-\alpha}$ and we can rewrite his entry condition again: He decides to enter the market as merchant if

$$\Delta c + \alpha p_{merchant}^{comp}(\alpha) > \alpha p^{mon} \Leftrightarrow \Delta c > \alpha \left(r - \frac{c}{1-\alpha} \right),$$

i.e. if his cost advantage (LHS) overcompensates the loss incurred by the price reduction which is caused by competition (RHS).

Firstly, if the intermediary's share α is rather large compared to his cost advantage Δc , the difference between monopoly and competitive price becomes small (relaxed competition), the inequality is fulfilled, and the intermediary prefers to enter the product market.

Secondly, if his share α is relatively small, there is fierce price competition. Nevertheless, the significant price reduction caused by market entry is not decisive as the loss incurred due to it does not exceed the intermediary's cost advantage. Hence, the intermediary enters the market also for very small levels of α .

Taken together, the loss from competition $\alpha \left(r - \frac{c}{1-\alpha} \right)$ is rather small for extreme values of α . However, for intermediate levels of α , this loss exceeds reasonable levels of Δc , and the intermediary refuses to enter the product market despite his cost advantage.

Formally, the intermediary prefers *not* to enter if both $\Delta c < \frac{(r-\zeta)^2}{4r}$ and

$$\alpha \in \left(\frac{r-\zeta}{2r} - \sqrt{\left(\frac{r-\zeta}{2r}\right)^2 - \frac{\Delta c}{r}}, \frac{r-\zeta}{2r} + \sqrt{\left(\frac{r-\zeta}{2r}\right)^2 - \frac{\Delta c}{r}} \right).$$

We define

$$\tilde{\zeta}(a, \alpha) = \frac{c+a}{1-\alpha} - \alpha r - a$$

to state our result for a three-part tariff:

Proposition 10 (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 $\zeta < \tilde{\zeta}(a, \alpha)$ holds.

Corollary 11.

Under any three-part tariff (A, a, α) that yields positive seller participation and comprises a positive proportional fee $\alpha < \frac{r-c}{r}$ and non-negative fees A and a , the range $(\tilde{\zeta}(a, \alpha), \bar{\zeta})$ of marginal costs at which the intermediary prefers not entering product markets contains sellers' marginal costs c , i.e. $\tilde{\zeta}(a, \alpha) < c$. Accordingly, the intermediary does not compete with sellers even if he is (a little) more efficient/enjoys a (small) cost advantage.

2.3.3 Stage 2: Sellers' decision on joining the platform

Along the lines of the analysis under classical two-part tariffs, we now examine sellers' joining decisions under a three-part tariff. Using the critical level of merchant's marginal

costs $\tilde{\zeta}(a, \alpha)$, a seller's expected profit from joining the intermediary's platform can be written as

$$Pr(\zeta \geq \tilde{\zeta}(a, \alpha)) M\{(1 - \alpha)r - c - a\} - I - A,$$

where $Pr(\zeta \geq \tilde{\zeta}(a, \alpha))$ denotes the probability of the intermediary not entering the respective product market, which equals $1 - H(\tilde{\zeta}(a, \alpha))$.

Lemma 12 (Sellers' decision to join the platform under a three-part tariff).

Under a three-part tariff (A, a, α) , sellers join the platform if and only if their investment costs are below $\tilde{I}(A, a, \alpha) \equiv \{1 - H(\tilde{\zeta}(a, \alpha))\}M\{(1 - \alpha)r - c - a\} - A$.

2.3.4 Stage 1: Intermediary's tariff decision – optimal three-part tariffs

[to be written: optimal three part-tariffs, also cf. appendix]

some preliminary results:

- Additional proportional fee improves optimal classical two-part tariff if hazard rate of cost distribution at value c is large (sufficient condition: $\frac{h(c)}{1-H(c)} > \frac{r}{(r-c-a)^2}$)
- Proportional fee may affect choice between membership fee and per-unit fee: Per-unit fee again increases entry incentives if $\alpha > 0$
- Proportional fee always reduces entry incentives

2.3.5 Hold-up Problem

The use of proportional fees mitigates the hold-up problem by incentivizing the intermediary not to enter sellers' markets even when he is more efficient, whereas, under classical two-part tariffs, he would always enter in this situation, discouraging sellers to join his platform.

[to be continued]

3 Discussion [preliminary]

The analysis of classical two-part tariffs has shown that a hold-up problem always exists if a platform operator can enter product markets as a merchant.

In the case of a pure membership fee tariff the intermediary's entry decision and the degree of competition between seller and intermediary is not affected by the level of the fee. Hence, when the intermediary is more efficient than a seller, he enters the seller's market as merchant. Thus, when there is a high likelihood that the intermediary is more efficient, sellers anticipate that they cannot recover their investment costs. Indeed, if the intermediary (as merchant) is always more efficient than sellers, no seller joins the marketplace. An intermediary is always better off if he commits not to compete with sellers in cases he is a little more efficient, as the threat of entry disincentivizes sellers to participate.

Per-unit fees cause a similar hold-up problem. However, when demand is elastic, per-unit fees in addition lead to a double marginalization problem, as retailers charge a mark-up on top of the fee. In order to reduce the double marginalization problem, the intermediary enters sellers' markets independently of being more or less efficient. When he is less efficient, he enters to reduce sellers' mark-ups, increasing quantities.²²

For proportional (per-revenue) fees, we found that the double marginalization problem is reduced compared to per-unit fees, this is in line with the result of Shy and Wang (2011). However, more importantly, proportional fees allow the intermediary to commit not to enter sellers' markets even in case he is more efficient, contrary to classical two-part tariffs.

The hold-up problem for classical two-part tariffs is particularly strong under the following two properties: (i) The merchant is very likely to have lower marginal costs than sellers. (ii) The merchant's cost advantage, i.e. the difference between marginal costs, is small. However, proportional fees make entry for the intermediary unprofitable just for the cases in which the merchant's cost advantage is small. With revenue sharing, the intermediary thus can commit himself not to enter in those cases for which the hold-up problem under classical two-part tariffs is especially harmful.

Consider two-part tariffs with membership fee and either per-unit or proportional per-revenue fee. What is the optimal platform tariff among them? Ideally, those products for which demand suffices to compensate for the seller's investment should be listed on the platform. Finally, these products should be supplied by the merchant or seller dependent on who is more efficient. However, if the merchant is more efficient, sellers have to be compensated for their investments in order to participate. The most efficient form of compensation, a fixed listing premium to sellers (i.e. a negative membership fee A), is ruled out by a moral hazard problem. Sellers cannot verifiably inform the intermediary about the demand before the product is listed on the platform. Hence, with a listing premium even products for which there is no demand would be listed, to the detriment of the platform's profits. To circumvent the moral hazard problem, sellers have to be compensated dependent on actual sales. If the intermediary enters the market when he is more efficient, sellers' investments are only rewarded when they are more efficient.

However, with per-revenue fees the intermediary will not enter in those cases when he is only a little more efficient. Thus, as sellers' investment incentives are insufficient, the commitment of an intermediary not to compete with sellers through revenue sharing contracts improves the situation. Nevertheless, under elastic demand, per-revenue fees yield a double marginalization problem, too, although to a lesser extent harmful than per-unit fees. Thus, if the intermediary wants to extract rents from sellers, the membership fee is the efficient instrument and the per-revenue fee should only be used to increase seller profitability by reducing the intermediary's entry incentives.

Note that the platform has to be able to commit to its tariff system to mitigate

²²Cf. our extension.

the hold-up problem with proportional fees: The commitment effect of proportional fees only contains a commitment not to enter sellers' markets if the tariff system cannot be changed after entry. Nevertheless, it is reasonable to assume that even if the tariff system is not part of a long term contract, a reputation for not changing the tariff system can be obtained.

[to be completed: commitment socially desirable]

4 Extensions [preliminary]

4.1 Buyer heterogeneity: Elastic demand

During the preceding theoretical analysis, we have assumed that the willingness to pay is equal among buyers and across products. We now discuss the effects that arise with buyer heterogeneity, i.e. under elastic demand. Therefore, we modify the game structure introduced above as follows: At the beginning of the second stage, in addition to sellers' investment costs, each buyer's gross utility from consuming a product is realized. Accordingly, we now assume that the willingness to pay is heterogeneous among buyers but constant over products for each buyer. We leave buyers' outside option unchanged and represent the distribution of gross utilities by its distribution function $G(r)$. We denote the support by $[\underline{r}, \bar{r}]$ and assume $\underline{r} > \underline{c}$ to rule out situations where trade should not occur. Consequently, for each product, demand $D(p)$ is now given by $M\{1 - G(p)\}$.

Firstly, the introduction of buyer heterogeneity implies that sellers' monopoly pricing decisions are changed: Given a specific tariff system, marginal revenues (which now do depend on charged prices) have to equal marginal costs. Secondly, the intermediary's entry incentives are changed due to the demand effect that arises from the difference between seller's monopoly price and the respective competitive price. As both a per-unit fee and a proportional fee increase sellers' perceived marginal costs, the well-known double marginalization problem emerges. Consequently, thirdly, sellers' joining decisions and the intermediary's tariff choice are affected.

We now take a closer look at the changes that arise under the different tariff components compared to our results under inelastic demand.

4.1.1 Membership fee

Under a pure membership fee, there is no double marginalization problem and seller's monopoly price fulfills

$$p^{mon} = \arg \max_p \{(p - c)D(p)\}.$$

All other product market decisions, including intermediary's entry, remain unchanged. The critical level of investment costs decreases as the seller's monopoly profit shrinks: $\pi_{mon} \leq M(r - c)$. Accordingly, the optimal membership fee is smaller. The hold-up problem is still present, but the effect on its extent is ambiguous (depending on the distribution function $F(I)$).

4.1.2 Per-unit fee

Under a per-unit fee a and elastic demand, both the monopoly price and the competitive price increase in a . The intermediary is interested not only in seller participation (as under a pure membership fee), but also in high demand, which now decreases in charged product prices. Therefore, the intermediary always enters product markets once sellers joined his platform, either to serve demand himself when he is more efficient than sellers, or to increase demand by driving down sellers' prices. Consequently, sellers' expected profits are rather low and the hold-up problem is even more severe without the simplifying assumption of homogenous buyers, as now there are two forces that impair a seller's expected profits: On the one hand, the seller has to be more efficient than the merchant (i.e. $c < \zeta$) not to be undercut by him and to serve any demand. On the other hand, with decreasing demand and a per-unit fee, the intermediary would always enter all product markets to mitigate the double marginalization problem. Therefore, even if the seller turns out to be more efficient, she is not a monopolist in her market and her price is driven down to $a + \zeta$.

4.1.3 Proportional fee

[to be done]

4.2 Other extensions

4.2.1 Network externalities and membership fees charged to consumers

The intermediary in our model offers a “two-sided” platform in the sense that his payoff depends on the attractiveness of the marketplace to two groups, sellers and buyers. However, there are no direct nor indirect network effects. Demand for a seller's product is independent of the presence of other sellers, there is neither a negative nor a positive externality.

The literature on two-sided markets has shown that if the buyer-side is relatively elastic, buyers are optimally not charged by the platform. In reality, this property of tariff systems is often observed; for example, Amazon does not charge consumers. Therefore, our simplifying assumption seems reasonable: Indirect network effects over the consumer side are excluded by assuming that buyers have no cost of joining the platform and cannot be charged by the platform.

Nevertheless, we briefly consider the case when buyers have to pay a positive membership fee: The mass of buyers who join the platform then depends on the expected mass of products offered that attracts them. We conjecture that our findings would generalize to markets with those network effects: When consumers need to recover membership fees through their surplus from buying products, the hold-up problem becomes even more severe, but proportional fees still incentivize the intermediary to act in sellers interests, not undercutting them in cases he is a little more efficient.

4.2.2 Competition between sellers

We exclude a second form of network effect: Competition between sellers. Shy and Wang (2011) show that seller competition can dampen the double marginalization problem as mark-ups vanish when competition increases. If sellers, additionally to fearing competition from the intermediary, fear competition from other sellers, the problem of insufficient investment incentives is exacerbated. While the analysis of the optimal tariff structure would be more complicated, we conjecture that the property of proportional fees, marking entry for the intermediary less profitable, extends to scenarios with seller competition as well. Nevertheless, the effect of the platform operator's tariff choice on competition between sellers still needs to be examined.

4.2.3 Competition between platforms

We analyze the optimal tariff choice for a monopoly platform, thus a natural area for future research would be to consider competition between platforms. However, in the markets the model can most reasonably be applied to, i.e. electronic sales platforms, it is reasonable to treat the intermediary as monopolist. Regarding our first example, we argue that Amazon can be treated as a monopoly gatekeeper to consumers due to consumer loyalty. For our second example this is even more straight forward: After consumers purchased an Apple device, they are locked in Apple's AppStore to find matching applications.

5 Concluding Remarks [preliminary]

While real world platforms use a mixture of tariff forms, including proportional (per-revenue) fees, the extant economic literature has focused on linear (transaction-based) tariffs and membership fees. We found that proportional fees do not only reduce double marginalization problems but can also 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 on the platform. Our analysis sheds light on the economics of intermediated markets in which the intermediary does not only organize a marketplace but can become active in it himself. Our model predicts the use of revenue-based fees which are observed for both Amazon Marketplace and Apple's AppStore.

In addition, our reasoning might be applicable more generally in the context of both franchising and imitable, i.e. not patented, innovations.

A Figures

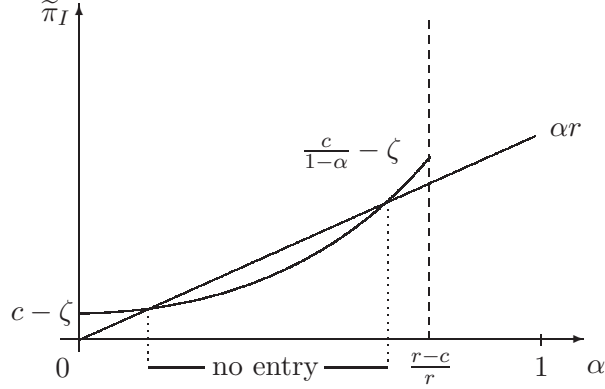


Figure 1: No-entry range for proportional fee

B Optimal tariffs

B.1 Optimal three-part tariffs

B.1.1 Intermediary's profit

We first observe that the critical level of investment costs that determines seller participation under a three-part tariff with a membership fee A , a per-unit fee a and a proportional fee α can be written as

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

where the critical level of ζ (the intermediary's entry threshold) is given by

$$\tilde{\zeta}(a, \alpha) \equiv \frac{c + a}{1 - \alpha} - \alpha r - a.$$

Therefore, the mass of sellers who join the platform is $F(\tilde{I}(A, a, \alpha))$. Hence, the intermediary's expected platform profit under the three-part tariff equals

$$\Pi_{IM}^e(A, a, \alpha) = F(\tilde{I}(A, a, \alpha)) \{ \pi_p(A, a, \alpha) + \pi_m(a, \alpha) \},$$

where his expected per-product platform profit equals

$$\pi_p(A, a, \alpha) = A + M \{1 - H(\tilde{\zeta}(a, \alpha))\} (a + \alpha r),$$

and his expected per-product merchant profit is defined by

$$\begin{aligned} \pi_m(a, \alpha) &= M Pr \left(\zeta < \tilde{\zeta}(a, \alpha) \right) \left\{ p^{comp}(a, \alpha) - E[\zeta | \zeta < \tilde{\zeta}(a, \alpha)] \right\} \\ &= M H(\tilde{\zeta}(a, \alpha)) \left\{ \frac{c + a}{1 - \alpha} - E[\zeta | \zeta < \tilde{\zeta}(a, \alpha)] \right\}. \end{aligned}$$

With $\pi(A, a, \alpha) \equiv \pi_p(A, a, \alpha) + \pi_m(a, \alpha)$, the partial derivatives are given as follows:

$$\frac{\partial \Pi_{IM}^e}{\partial A} = F(\tilde{I}(A, a, \alpha)) - f(\tilde{I}(A, a, \alpha))\pi(A, a, \alpha) \quad (\text{B.1})$$

$$\begin{aligned} \frac{\partial \Pi_{IM}^e}{\partial a} = & F(\tilde{I}(A, a, \alpha)) \frac{\partial \pi(A, a, \alpha)}{\partial a} - f(\tilde{I}(A, a, \alpha))M\pi(A, a, \alpha) \\ & \left\{ (1 - H(\tilde{\zeta}(a, \alpha))) + h(\tilde{\zeta}(a, \alpha)) \frac{\alpha}{1-\alpha} \{(1-\alpha)r - c - a\} \right\} \end{aligned} \quad (\text{B.2})$$

$$\begin{aligned} \frac{\partial \Pi_{IM}^e}{\partial \alpha} = & F(\tilde{I}(A, a, \alpha)) \frac{\partial \pi(A, a, \alpha)}{\partial \alpha} - f(\tilde{I}(A, a, \alpha))M\pi(A, a, \alpha) \\ & \left\{ (1 - H(\tilde{\zeta}(a, \alpha)))r + h(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \{(1-\alpha)r - c - a\} \right\} \end{aligned} \quad (\text{B.3})$$

B.1.2 First order conditions (optimization without restraints)

As

$$\begin{aligned} \pi(A, a, \alpha) &= A + M(a + \alpha r) + MH(\tilde{\zeta}(a, \alpha))\{\tilde{\zeta}(a, \alpha) - E[\zeta | \zeta < \tilde{\zeta}(a, \alpha)]\} \\ &= A + M \left\{ (a + \alpha r) + H(\tilde{\zeta}(a, \alpha))\tilde{\zeta}(a, \alpha) - \int_{\underline{\zeta}}^{\tilde{\zeta}(a, \alpha)} x dH(x) \right\}, \end{aligned}$$

the partial derivatives of $\pi(A, a, \alpha)$ are:

$$\begin{aligned} \frac{\partial \pi(A, a, \alpha)}{\partial a} &= M \left\{ 1 + \frac{\alpha}{1-\alpha} \left(h(\tilde{\zeta}(a, \alpha))\tilde{\zeta}(a, \alpha) + H(\tilde{\zeta}(a, \alpha)) - \tilde{\zeta}(a, \alpha)h(\tilde{\zeta}(a, \alpha)) \right) \right\} \\ &= M \left\{ 1 + H(\tilde{\zeta}(a, \alpha)) \left(\frac{\alpha}{1-\alpha} \right) \right\}, \end{aligned}$$

$$\frac{\partial \pi(A, a, \alpha)}{\partial \alpha} = M \left\{ r + H(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \right\}.$$

Hence, using the partial derivatives, the first order conditions read

$$\frac{F(\tilde{I}(A, a, \alpha))}{f(\tilde{I}(A, a, \alpha))} = \pi(A, a, \alpha) \quad (\text{B.4})$$

$$\frac{F(\tilde{I}(A, a, \alpha)) \left\{ 1 + H(\tilde{\zeta}(a, \alpha)) \left(\frac{\alpha}{1-\alpha} \right) \right\}}{f(\tilde{I}(A, a, \alpha)) \left\{ (1 - H(\tilde{\zeta}(a, \alpha))) + h(\tilde{\zeta}(a, \alpha)) \frac{\alpha}{1-\alpha} \{(1-\alpha)r - c - a\} \right\}} = \pi(A, a, \alpha) \quad (\text{B.5})$$

$$\frac{F(\tilde{I}(A, a, \alpha)) \left\{ r + H(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \right\}}{f(\tilde{I}(A, a, \alpha)) \left\{ (1 - H(\tilde{\zeta}(a, \alpha)))r + h(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \{(1-\alpha)r - c - a\} \right\}} = \pi(A, a, \alpha) \quad (\text{B.6})$$

From conditions (B.4) and (B.5) it follows that

$$H(\tilde{\zeta}(a, \alpha)) \left(\frac{\alpha}{1-\alpha} \right) = -H(\tilde{\zeta}(a, \alpha)) + h(\tilde{\zeta}(a, \alpha)) \frac{\alpha}{1-\alpha} \{(1-\alpha)r - c - a\}$$

has to hold. This condition can be boiled down to

$$\frac{H(\tilde{\zeta}(a, \alpha))}{h(\tilde{\zeta}(a, \alpha))} = \alpha \{(1-\alpha)r - c - a\}. \quad (\text{B.7})$$

Furthermore, conditions (B.4) and (B.6) yield

$$H(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) = -H(\tilde{\zeta}(a, \alpha))r + h(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \{(1-\alpha)r - c - a\},$$

which is equivalent to

$$\frac{H(\tilde{\zeta}(a, \alpha))}{h(\tilde{\zeta}(a, \alpha))} \frac{\left(\frac{c+a}{(1-\alpha)^2} \right)}{\left(\frac{c+a}{(1-\alpha)^2} - r \right)} = (1-\alpha)r - c - a. \quad (\text{B.8})$$

Conditions (B.7) and (B.8) imply

$$\alpha = 1 - \frac{r(1-\alpha)^2}{c+a} \Leftrightarrow \alpha = \frac{r-c-a}{r}.$$

Hence, the optimal three-part tariff consists of a combination of a and α which drive each seller's monopoly profit to zero. Consequently, from (B.4) it follows that the optimal membership fee must be negative, but due to the moral hazard problem (a negative membership fee incentivizes sellers to list worthless products) we have to include the constraint $A \geq 0$. [to be continued]

B.1.3 When it pays to 'shift' from A to a (while $\alpha \geq 0$)

We now analyze under which circumstances a 'compensated' increase in the per-unit fee a leads to an increase in the intermediary's per-product profit (starting from an arbitrary tariff scheme (A, a, α)): While changing a , we adapt the membership fee A such that the mass of sellers $F(\tilde{I}(A, a, \alpha))$ remains unchanged. Given this compensation, we examine the effect of an increase of a on per-product profit $\pi(A, a, \alpha)$, i.e. the non-constant part of the intermediary's expected profit.

Since $\frac{\partial \tilde{I}(A, a, \alpha)}{\partial A} = -1$, it follows that the compensation $A(a)$ has to fulfill

$$\frac{\partial A(a)}{\partial a} = -\frac{\partial \tilde{I}/\partial a}{\partial \tilde{I}/\partial A} = \frac{\partial \tilde{I}(A, a, \alpha)}{\partial a}.$$

Substituting

$$\begin{aligned} \frac{\partial \pi}{\partial A} &= 1, \\ \frac{\partial \pi}{\partial a} &= M \left\{ 1 + H(\tilde{\zeta}(a, \alpha)) \left(\frac{\alpha}{1-\alpha} \right) \right\}, \end{aligned}$$

and

$$\frac{\partial A(a)}{\partial a} = \frac{\partial \tilde{I}}{\partial a} = -M \left(1 - H(\tilde{\zeta}(a, \alpha)) + h(\tilde{\zeta}(a, \alpha))\alpha \left(r - \frac{c+a}{1-\alpha} \right) \right)$$

into the definition of the total differential

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

leads to

$$\frac{d\pi}{da} = M \left\{ \frac{H(\tilde{\zeta}(a, \alpha))}{1-\alpha} - h(\tilde{\zeta}(a, \alpha))\alpha \left(r - \frac{c+a}{1-\alpha} \right) \right\}.$$

Hence,

$$\frac{d\pi}{da} > 0 \Leftrightarrow \frac{H(\tilde{\zeta}(a, \alpha))}{h(\tilde{\zeta}(a, \alpha))} > \alpha \{ (1-\alpha)r - c - a \}.$$

If α is zero, this condition is always fulfilled as $\tilde{\zeta}(a, 0) = c$.

B.2 Improving a classical two-part tariff

B.2.1 A sufficient condition for $\partial \Pi / \partial \alpha$ being positive

Using a reduced form of the intermediary's profit, its derivative can be rewritten as

$$\frac{\partial \Pi_{IM}^e}{\partial \alpha} = f(\tilde{I}(A, a, \alpha)) \frac{\partial \tilde{I}(A, a, \alpha)}{\partial \alpha} \pi(A, a, \alpha) + F(\tilde{I}(A, a, \alpha)) \frac{\partial \pi(A, a, \alpha)}{\partial \alpha}.$$

As $\frac{\partial \pi(A, a, \alpha)}{\partial \alpha}$ is positive for 'interior solutions', a sufficient condition for this derivative being positive is $\frac{\partial \tilde{I}(A, a, \alpha)}{\partial \alpha}$ being positive, which is equivalent to

$$-M \left\{ h(\tilde{\zeta}(a, \alpha)) \left(\frac{c+a}{(1-\alpha)^2} - r \right) \{ (1-\alpha)r - (c+a) \} + \left(1 - H(\tilde{\zeta}(a, \alpha)) \right) r \right\} > 0.$$

This can be boiled down to

$$\frac{h(\tilde{\zeta}(a, \alpha))}{1 - H(\tilde{\zeta}(a, \alpha))} \left((1-\alpha)r - \frac{c+a}{(1-\alpha)} \right) > \frac{(1-\alpha)r}{(1-\alpha)r - (c+a)},$$

or

$$\frac{h(\tilde{\zeta}(a, \alpha))}{1 - H(\tilde{\zeta}(a, \alpha))} ((1-\alpha)r - (c+a)) > \frac{(1-\alpha)r}{(1-\alpha)r - \frac{c+a}{(1-\alpha)}}.$$

Note that the LHS of the latter condition denotes the hazard rate multiplied by seller's monopoly margin. On the RHS, the numerator equals the seller's monopoly revenue, and the denominator depicts the decrease of seller's revenue due to merchant entry.

For $\alpha = 0$, our condition becomes

$$\frac{h(c)}{1 - H(c)} (r - c - a) > \frac{r}{(r - c - a)},$$

i.e. the hazard rate of the intermediary's cost distribution at c has to be sufficiently large.

For a more intuitive explanation, recall that we just look at $\tilde{I}(a, \alpha)$, deriving a sufficient condition. It may be useful to rewrite $\frac{\partial \tilde{I}(A, a, \alpha)}{\partial \alpha}$ as

$$\frac{\partial Pr(\zeta > \tilde{\zeta}(a, \alpha))}{\partial \alpha} M \rho_{seller}(a, \alpha) - Pr(\zeta > \tilde{\zeta}(a, \alpha)) Mr,$$

where $\rho_{seller}(a, \alpha) = (1-\alpha)r - (c+a)$ denotes the seller's monopoly margin.

B.2.2 When it pays to ‘shift’ from a to α (at $\alpha = 0$)

(to be completed)

A compensated shift to α increases intermediary’s per-product profit π if

$$\frac{H(c)}{r - c - a} < \frac{h(c)}{1 - H(c)}.$$

B.2.3 When it pays to ‘shift’ from A to α

(to be completed)

A compensated shift to α increases intermediary’s per-product profit π if

$$\frac{H(\tilde{\zeta}(a, \alpha))}{(1 - \alpha)r - c - a} > h(\tilde{\zeta}(a, \alpha)) \left(1 - \frac{(1 - \alpha)^2 r}{c + a}\right).$$

B.3 Optimal pure membership fee tariff (old)

The intermediary’s expected platform profit equals $\pi_P(A) = AF(\tilde{I}_m(A))$, and his expected merchant profit is given by

$$\pi_M(A) = H(c)M\{c - E[\zeta|\zeta < c]\}F(\tilde{I}_m(A)).$$

The maximization of $\pi_P(A) + \pi_M(A)$ is equivalent to the following problem:

$$\max_A \left(\left(A + M \left\{ H(c)c - \int_{\underline{\zeta}}^c x dH(x) \right\} \right) F(\underbrace{\{1 - H(c)\}M\{r - c\} - A}_{=\tilde{I}_m(A)}) \right)$$

We define the merchant’s expected per-transaction profit as

$$\Delta^e(c) \equiv H(c)c - \int_{\underline{\zeta}}^c x dH(x)$$

to achieve the following result:²³

Lemma 13 (Intermediary’s optimal membership fee and seller participation).

If $\underline{I} < \{1 - H(c)\}M\{r - c\}$ holds, the intermediary maximizes his expected payoff by setting a membership fee A^* that fulfills the first order condition $A^* + M\Delta^e(c) = \frac{F(\tilde{I}_m(A^*))}{f(\tilde{I}_m(A^*))}$.

Given the membership fee A^* , a seller joins the platform in the second stage if her investment costs turn out to be below $\tilde{I}_m(A^*) = \{1 - H(c)\}M\{r - c\} - A^*$.

B.4 Optimal pure per-unit fee tariff (old)

The intermediary sets the per-unit fee a to maximize his expected profit which is defined as sum of his expected platform and merchant profits:

$$\left(aM\{1 - H(c)\} + H(c)M \left\{ a + c - \frac{1}{H(c)} \int_{\underline{\zeta}}^c x dH(x) \right\} \right) F(\tilde{I}_u(a)).$$

²³Note that $\underline{I} < \{1 - H(c)\}M\{r - c\} \Leftrightarrow F(\tilde{I}_m(A)) > 0$.

Along the lines of the maximization with a membership fee, the first order condition reads

$$(1 - H(c))M \{a^* + \Delta^e(c)\} = \frac{F(\tilde{I}_u(a^*))}{f(\tilde{I}_u(a^*))}.$$

C Hold-up problem: Alternative illustration

Hold-up problem under a pure membership fee

Leaving the game structure unchanged (expect for the credible restriction of the intermediary's set of actions in the third stage), we first observe that sellers always earn monopoly profits after they have joined the platform. Therefore, the critical level of investment costs now becomes $\tilde{I}_m^{commit}(A) = M(r - c) - A$.

Under a pure membership fee tariff, the intermediary chooses A^{**} to maximize his expected platform profit $AF(\tilde{I}_m^{commit}(A))$. Hence, the first order condition now becomes

$$A^{**} = \frac{F(\tilde{I}_m^{commit}(A^{**}))}{f(\tilde{I}_m^{commit}(A^{**}))}.$$

For a comparison of the optimal membership fee without commitment (A^*) and the optimal membership fee with commitment (A^{**}), note that

$$\tilde{I}_m^{commit}(A) = \tilde{I}_m(A) + H(c)M(r - c).$$

As argued above, if $\underline{I} \geq \{1 - H(c)\}M\{r - c\}$, and in particular if the intermediary has lower marginal costs for sure ($H(c) = 1$), without commitment, the marketplace breaks down and the intermediary makes zero profits. However, if he somehow commits not to enter product markets, sellers join his platform unless trade would be inefficient ($\underline{I} > M\{r - c\}$).

In case of $\underline{I} < \{1 - H(c)\}M(r - c)$ (and, therefore, $H(c) < 1$), without commitment, the intermediary's platform part earns some profit by extracting rents from participating sellers. However, if the intermediary commits not to become active as merchant while leaving the membership fee unchanged, more sellers decide to join his platform (since $\tilde{I}_m^{commit}(A) > \tilde{I}_m(A)$). Therefore, he would prefer not to enter if the additional rent extracted under commitment exceeds the loss to his merchant part.

Taking into account that the intermediary's optimal membership fee A^{**} under commitment may differ from his optimal membership fee A^* without commitment, the following effects on the intermediary's profit result from commitment: Firstly, he loses his merchant profit $M\Delta^e(c)F(\tilde{I}_m(A^*))$; secondly, he gains from increased seller participation incentives increasing his platform profits. This is driven by either or both a higher critical level of investment costs that a seller is willing to incur (as she does not fear competition from the intermediary) and a higher membership A^{**} that can be extracted.

Accordingly, the intermediary's profits are higher under commitment if and only if

$$A^{**}F(\tilde{I}_m^{commit}(A^{**})) - A^*F(\tilde{I}_m(A^*)) > M\Delta^e(c)F(\tilde{I}_m(A^*)).$$

Using the first order conditions given above, this condition can be rewritten as

$$\frac{\{F(\tilde{I}_m^{commit}(A^{**}))\}^2}{f(\tilde{I}_m^{commit}(A^{**}))} > \frac{\{F(\tilde{I}_m(A^*))\}^2}{f(\tilde{I}_m(A^*))}.$$

If the ratio $\frac{F(x)}{f(x)}$ (sometimes called the ‘inverse Mills’ ratio’) is non-decreasing in x , this condition is equivalent to $\tilde{I}_m(A^*) < \tilde{I}_m^{commit}(A^{**})$.²⁴ This is the same as saying the commitment problem exists if with commitment more sellers participate after the membership fee has been adjusted optimally. This is the case when the reduction of seller’s membership fee from A^{**} to A^* does not compensate for the loss of monopoly profits in case of being underbid by the intermediary. More formally, if the ratio $\frac{F(x)}{f(x)}$ is non-decreasing in x , commitment is profitable for the intermediary if

$$\tilde{I}_m(A^*) < \tilde{I}_m^{commit}(A^{**}) \Leftrightarrow H(c)M(r - c) > A^{**} - A^*.$$

Assumption 14 (Non-decreasing inverse Mills’ ratio).

The inverse Mills’ ratio of the investment cost distribution $\frac{F(x)}{f(x)}$ is non-decreasing in x .

Proposition 15 (Hold-up problem: Membership fee).

When the intermediary charges a membership fee to sellers, commitment not to enter any product market is profitable

- i) if $\underline{I} \geq \{1 - H(c)\}M(r - c)$, as in that case no seller would join the platform without commitment (breakdown of marketplace);*
- ii) if $\underline{I} < \{1 - H(c)\}M(r - c)$ and $H(c)M(r - c) > A^{**} - A^*$.*

Hold-up problem under a pure per-unit fee

As argued before, the intermediary faces a hold-up problem if his expected profit in the original game is lower than in a modified game in which he commits himself not to enter any product markets, making his platform more attractive to sellers.

Under a per-unit fee, the intermediary’s expected profit in the modified game equals $F(\tilde{I}_u^{commit}(a))Ma$, where the critical level of investment costs is given by

$$\tilde{I}_u^{commit}(a) = \pi^{mon}(a + c) = M\{r - (a + c)\}.$$

Consequently, for a given level of a , the intermediary would prefer commitment if

$$F(\tilde{I}_u(a))\{a + \Delta^e(c)\} < F(\tilde{I}_u^{commit}(a))a.$$

Accounting for the fact that the optimal level a^{**} under commitment differs from a^* , and using the first order conditions, commitment turns out to be profitable if

$$(1 - H(c))\frac{\{F(\tilde{I}_u^{commit}(a^{**}))\}^2}{f(\tilde{I}_u^{commit}(a^{**}))} > \frac{\{F(\tilde{I}_u(a^*))\}^2}{f(\tilde{I}_u(a^*))}.$$

²⁴A sufficient condition for $\frac{F(x)}{f(x)}$ to be non-decreasing is $F(x)$ being weakly concave, or the stronger requirement of a monotone (decreasing) hazard rate. Examples for $\frac{F(x)}{f(x)}$ non-decreasing: uniform distribution and exponential distribution.

Extent of the hold-up problem (using alternative illustration)

We have shown that the intermediary could profit from committing not to enter product markets under any classical two-part tariff. Without any further commitment, under both regimes entry incentives crucially depend on the merchant's potential cost advantage. More precisely, the intermediary's decision to become active as merchant depends only on the existence of a cost advantage, but not on its extent. Therefore, the hold-up problem is most harmful to the intermediary if the probability of being more efficient, $H(c)$, is rather high, while his expected conditional cost advantage $c - E[\zeta | \zeta < c]$ is only marginal, as under those conditions $\Delta^e(c)$ tends to be small.

However, though entry incentives do not differ between pure membership fee and per-unit fee tariffs, profitability of commitment is different. Under commitment not to enter at all, membership fees and per-unit fees are strategically equivalent and the intermediary (who only acts as platform operator) is indifferent between charging a per-unit fee A^{**} or a membership fee $A^{**} = Ma^{**}$.²⁵ Nevertheless, without commitment, both fees are not equivalent any longer as the per-unit fee creates an additional competitive advantage (besides a potential cost advantage) for the intermediary and shifts (expected) rents from buyers to him. Therefore, comparing both kind of fees, the hold-up problem is less severe under a pure per-unit fee tariff than under a pure membership fee tariff.

²⁵Strategic equivalence between both fees only holds under our assumption of no consumer heterogeneity, i.e. inelastic demand. With elastic demand, the intermediary faces a double marginalization problem under per-unit fee tariffs, cf. the respective extension.

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