Fulfilled By Amazon: Platform Tying of Ancillary Services
Preliminary and incomplete*

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Abstract

This paper analyzes the practice of tying ancillary services (e.g., order fulfillment, payment processing, or pre-installed applications) to the core intermediation function offered by dominant digital platforms such as online marketplaces or smartphone operating systems. We study when tying is profitable for platforms, and its effects on competition. Tying induces an inefficiency by forcing the ancillary service on consumers who don't value it very much. But it also reduces sellers' market power by preventing them from using their service adoption decisions to differentiate. The second effect is so strong that the platform prefers to tie the service to increase consumers' value for the platform. Moreover, the intensification of competition benefits consumers. Thus, when we consider policies that ban tying or break-up the platform, the net effect is to harm consumers.

1 Introduction

Online platform marketplaces have revolutionized the way buyers and sellers connect, reducing transaction costs, expanding access to a global consumer base, and improving the overall efficiency of commerce. By harnessing network effects and exploiting substantial economies of scale, a handful of platforms – most notably Amazon, Apple, and Google – have emerged as dominant gatekeepers in their respective markets. This growing market power and centrality have not gone unnoticed by regulators and policymakers. The Digital Markets Act (DMA) in the European Union, for instance, explicitly targets "core

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platform services" provided by these dominant players, aiming to ensure fairness and market contestability.

A key area of regulatory focus is the set of ancillary services that platforms offer to third-party sellers. These services include order fulfillment, payment processing, customer support, insurance, product photography, and more-each designed to enhance the seller's product offering and improve the buyer's shopping experience. Yet, a practice that has drawn particular scrutiny is the frequent coupling, or "tying", of these ancillary services to the platform's core intermediation service. In other words, sellers sometimes face pressure to adopt additional services from the platform as a condition for accessing its primary marketplace.

For example, Amazon has faced allegations that it steers consumers toward sellers who use its fulfillment services, effectively making widespread adoption of these ancillary offerings a prerequisite for visibility and sales success. Similarly, Apple and Google have come under fire for requiring the use of their proprietary payment systems within their app stores. This tying of ancillary services to the core marketplace offering not only raises concerns about market foreclosure and the exclusion of independent service providers, but also highlights the delicate regulatory challenge of curbing potentially anticompetitive practices without stifling the innovation and efficiency gains these platforms have delivered.

In this paper we study a model with a monopoly platform and a set of competing sellers, and ask the following questions: when is it profitable for the platform to offer a (costly) ancillary service? What are the incentives to require sellers to adopt it (a practice we refer to as tying)? What would be the effects of a ban on tying, or of a break-up of the platform?

We consider a model where a monopoly platform can offer two services: a *core* service (such as enabling transactions between buyers and sellers) and an *ancillary* one (such as order fulfillment: storage, delivery, etc.). The platform enables consumers to compare sellers across a large number of product markets. In each market, two sellers offer a homogeneous good and compete in prices. The ancillary service increases the value of the product to consumers, but consumers are heterogeneous with respect to how much they value the service. For instance, some consumers are in urgent need of a product and are willing to pay a lot for one-day shipping, while others are more patient. The platform charges unit fees for each service, and bears a cost for providing the ancillary service. Consumers have heterogeneous outside options, so that total participation to the platform is elastic.

At a broad level, our paper provides a new efficiency argument for bundling. Because consumers have heterogeneous values for it, the ancillary service is a source of vertical differentiation for sellers. As such, if sellers were free to choose whether to offer this service (and pay for it) or not, only one of them would do so, which would relax competition and allow both sellers to charge positive mark-ups. Such weak competition implies a relatively low participation of consumers to the platform. Bundling the two services may then be a way for the platform to intensify competition among sellers and improve its attractivity to consumers. Indeed, bundling prevents vertical differentiation and forces sellers to compete fiercely. There is an inefficiency however, because bundling leads to over-provision of the (costly) ancillary service.

A ban on bundling could backfire by leading the platform to stop offering the ancillary service altogether. Indeed, in our model, not offering the service also leads to Bertrand competition, albeit among firms with a lower quality than under bundling. Consumer participation and platform profit are then higher than when the service is adopted by one seller in each market only.

We then consider another policy intervention, namely the structural separation of the platform, forcing it to divest its ancillary service activity. Because the two services are complementary, separation would lead to double marginalization if the new provider of ancillary service was a monopolist. In order to shut down this well-understood mechanism, we assume that the assets are sold to a competitive fringe of firms, who then offer the ancillary service at cost. Such a policy reduces welfare and consumer surplus, by allowing sellers to restore their market power through vertical differentiation: in equilibrium, one seller in each market adopts the ancillary service and firms charge positive mark-ups.

Because one of the concerns of policy makers is the potential exclusionary effects of the practice on the market for the provision of ancillary services, we next enrich the model by adding a fringe of superior competing suppliers on that market. Under a ban on tying, the platform may want to subsidize its own version of the service with a below-cost fee in order to deter sellers from adopting a fringe version and thereby achieving even higher levels of differentiation. Despite this subsidy, we continue to find that a ban on tying would be harmful for consumers.

We conclude the analysis by discussing a number of further extensions. We allow for ad valorem platform fees, two-part tariff contracts, more than two sellers per market, and a monopoly seller.

Related literature The economic literature has put forward three main explanations for tying practices: transaction or distribution cost savings, price discrimination, and leverage of market power. In the context of digital goods, new efficiency arguments have been put forward by Bakos and Brynjolfsson (1999) (bundling zero-cost goods is profitable and efficient), Choi (2010) (bundling can foster multihoming and expand output) and Amelio and Jullien (2012) (bundling as a way to circumvent a non-negative price constraint and boost participation). Network effects and the non-negative price constraint may also offer an opportunity for anticompetitive bundling (Choi et al., 2024; Choi and Jeon, 2021).

In all these papers, tying is on the consumer side, forcing consumers who want to use a product (say, A) to also use another product (B). Our setup differs in that tying happens on the seller side: sellers who want to use service A (the core service) have to also use service B (the ancillary one), while consumers simply choose which seller to buy from. Li (2024) also features tying (or rather, self-preferencing) on the seller side, and shows that self-preferencing benefits sellers by inducing the platform to attract more of them. Unlike here, that paper shuts down competition among sellers, so that the mechanisms are different.

In this paper, tying affects competition between sellers by preventing vertical differentiation. Our work is therefore related to two other strands of research: the literature on tying by an upstream firm in vertical supply chains (de Cornière and Taylor, 2021 and 2024), and the one on platforms' strategies to affect competition among sellers (Hagiu, 2009, de Cornière, 2016, Belleflamme and Peitz, 2019). In particular, Teh (2022) discusses how a platform should balance the interests of buyers and sellers depending on the available pricing tools (e.g., unit versus ad valorem fees). With respect to this, while we assume unit fees in the baseline model, we show that the insights carry over to the case of ad valorem fees provided that sellers' marginal costs are not too small.

Our research is also related to the literature on platforms' business models. While commission on goods sold is an important source of revenue for platforms and an important determinant of the relationship between the platform and independent sellers (Jiang et al., 2011; Hagiu and Wright, 2015; Lai et al., 2016), more recently platforms have been relying heavily on revenue from advertising (Long et al., 2022; Belleflamme and Johnen, 2023; Abshishek et al., 2024; Long and Amaldoss, 2024; Long and Liu, 2024) and ancillary services such as delivery services (Abhishek et al., 2016; Iyengar et al., 2023). Our paper investigates the impact of tying the use of these ancillary services to the use of the main service on the platform as well as the sellers, which is also an important policy question, as discussed earlier.

2 Model

There are a large number of product markets, each served by two ex ante homogeneous *sellers*. The sellers produce output at marginal cost $c \geq 0$ and sell them at price p_i.

In order to reach *consumers*, the sellers must list their products on a monopoly *platform*. The platform provides two services. The first, denoted A, is the platform's core transaction-enabling function and is essential for trade between sellers and consumers to take place. Service B is a non-essential *ancillary service* offered to sellers. The platform can serve transactions at zero marginal cost, but incurs a marginal cost of $k \geq 0$ for each consumer served with the ancillary service. We begin by assuming that the platform charges sellers unit fee f_A for each transaction served, plus and additional f_B if the transaction included the ancillary service.

Consumers have unit demand and value the base good at $v \geq c$. Each consumer has an idiosyncratic type, $\theta \sim U[0,1]$, measuring their taste for quality. Thus, a consumer who buys from a seller offering the ancillary service enjoys value $v + \theta\Delta$, with $\Delta \geq k$. Consumers can access the platform for free, but have an idiosyncratic outside option worth $\omega \sim U[0,1]$ and join the platform only if they expect their surplus from trading there to exceed ω.

The timing of the game is as follows:

1. The platform chooses whether to tie A and B or to offer them independently and sets its fees.

2. Sellers choose whether to adopt the ancillary service, B.

3. Sellers simultaneously set their prices.

4. Each consumer chooses whether to join the platform or not.

5. Consumers learn their θ and make purchase decisions.

We have in mind a situation where consumers repeatedly make use of a general purpose platform over a long period of time (e.g., downloading many categories of app on a smartphone). We therefore assume that the firms in any one category are too small for their decisions to affect consumer participation decision, and consumers do not observe their θ (which may be category-specific) until they have joined.

We solve for sub-game perfect equilibria in pure strategies. We restrict attention to cases where the market is covered in the sense that both sellers serve a positive fraction of the consumers who choose to join the platform.

3 Equilibrium analysis

We begin the analysis by taking the platform's tying decision as given and studying the resulting equilibrium in the ensuing sub-game.

As a first observation, the sellers are undifferentiated Bertrand competitors when they both offer the ancillary service and they therefore set prices equal to their effective marginal cost, $p = c + f_A + f_B$. Likewise, if neither seller offers the service then they compete à la Bertrand over the base good only and $p = c + f_A$.

3.1 Case without tying

If the platform does not tie then sellers have free choice whether to offer the ancillary service or not. If only one offers the service then the two sellers are vertically differentiated in the manner of Shaked and Sutton (1982). Adopting the convention that seller 1 offers the ancillary service and seller 2 does not, a consumer is indifferent between the two firms if

$$v + \theta\Delta - p_1 = v - p_2 \iff \theta = \theta^* \equiv \frac{p_1 - p_2}{\Delta}.$$

At an interior equilibrium, seller 2 serves consumers with $\theta < \theta^*$, while seller 1 serves those with $\theta \geq \theta^*$. This implies expected seller profits per consumer on the platform are

$$\pi_1 = (p_1 - c - f_A - f_B)(1 - \theta^*),$$

$$\pi_2 = (p_1 - c - f_A)\theta^*.$$

Solving the first-order conditions, $\left\{\frac{\partial \pi_i}{\partial p_i} = 0\right\}_{i=1,2}$, yields equilibrium prices

$$p_1^{\text{NT}} = c + f_A + \frac{2\Delta + 2f_B}{3}, \quad p_2^{\text{NT}} = c + f_A + \frac{\Delta + f_B}{3}. \tag{1}$$

As long as $f_B < 2\Delta$, it is immediate that $p_1^{\text{NT}} > c + f_A + f_B$ and $p_2^{\text{NT}} > c + f_A$: sellers earn positive profit by differentiating in their decision to adopt the ancillary service. Indeed, evaluating profits at the equilibrium prices yields

$$\pi_1^{\text{NT}} = \frac{(2\Delta - f_B)^2}{9\Delta}, \quad \pi_2^{\text{NT}} = \frac{(\Delta + f_B)^2}{9\Delta}. \tag{2}$$

It must therefore be the case that sellers differentiate in equilibrium, otherwise they would earn zero profit and one seller would wish to deviate in their decision (not) to offer the service.[1]

Lemma 1. *If the platform offers the ancillary service without tying then sellers differentiate in equilibrium, with one seller offering the service and the other not.*

Anticipating the equilibrium prices, consumers' expected surplus from joining the platform is

$$Q^{\text{NT}}(f_A, f_B) = \int_0^{\theta^*} (v - p_2)\, d\theta + \int_{\theta^*}^1 (v + \theta\Delta - p_1)\, d\theta. \tag{3}$$

Consumers participate if their outside option is worse than Q^{NT}. Because the outside option is uniformly distributed, the mass of participating consumers is simply Q^{NT}.

We now have the necessary ingredients to formulate the platform's fee-setting problem. It earns f_A from serving transactions to each of the Q^{NT} participating consumers, and an additional $f_B - k$ from providing the ancillary service to the $1 - \theta^*$ consumers who buy

[1]We focus on pure strategies. Adoption of the ancillary service is a coordination game and there is also a (symmetric) mixed strategy equilibrium where each seller offers the service with positive probability. Focusing on that mixed strategy rather than the asymmetric pure strategy considered here does not substantively alter our results.

from seller 1:

$$\max_{f_A, f_B} \left[f_A + (f_B - k)(1-\theta^*)\right] Q^{\mathrm{NT}}(f_A, f_B),$$

Solving the resulting pair of first-order conditions yields optimal fees

$$f_A^{\mathrm{NT}} = \frac{v-c}{2} - \frac{17\Delta^2 + 3k^2 + 2\Delta k}{100\Delta}, \quad f_B^{\mathrm{NT}} = \frac{1}{5}(\Delta + 3k), \tag{4}$$

and equilibrium platform profit

$$\Pi^{\mathrm{NT}} = \left(\frac{v-c}{2} - \frac{\Delta^2 - k^2 + 6\Delta k}{20\Delta}\right)^2. \tag{5}$$

We see that $f_B^{\mathrm{NT}} < 2\Delta$ as required.

The equilibrium prices and fees imply $\theta^* = \frac{2}{5} - \frac{k}{5\Delta}$, which is interior for $k \leq \Delta$. Full market coverage additionally requires that a consumer who buys from seller 2 gets non-negative utility, $v - p_2^{\mathrm{NT}} \geq 0$.[2]

3.2 Case with a tied ancillary service

Next, suppose that the platform ties the ancillary service, meaning all sellers are forced to offer it. Since it is then only the aggregate fee that matters, write $f_{AB} = f_A + f_B$. As noted above, this leaves sellers competing à la Bertrand, with the resulting price being $p^{\mathrm{T}} = c + f_{AB}$. Consumer surplus (and participation) is therefore

$$Q^{\mathrm{T}}(f_{AB}) = \int_0^1 (v + \theta\Delta - p)\, d\theta = v + \frac{\Delta}{2} - c - f_{AB}.$$

The platform solves

$$\max_{f_{AB}} (f_{AB} - k) Q^{\mathrm{T}}(f_{AB}).$$

This implies the equilibrium fee and platform profit:

$$f_{AB}^{\mathrm{T}} = \frac{1}{2}(v - c + k) + \frac{\Delta}{4}, \tag{6}$$

$$\Pi^{\mathrm{T}} = \left(\frac{v-c}{2} + \frac{\Delta - 2k}{4}\right)^2. \tag{7}$$

Note that the platform could also choose a fee such that the lowest types do not buy any product. One can show that $v - c > k + \Delta/2$ is a necessary and sufficient condition for this not to be optimal.

[2] It then follows that consumers get non-negative utility from seller 1 because a type θ^* consumer is indifferent between 1 and 2 and any $\theta > \theta^*$ strictly prefers seller 1.

3.3 Case with no ancillary service

The platform may choose to offer no ancillary service or, equivalently, to set f_B prohibitively high. Again, this leaves sellers undifferentiated, with the resulting price $p^{\text{NS}} = c + f_A$. Consumer surplus and participation is $Q^{\text{NS}}(f_A) = v - c - f_A$. The platform maximizes $f_A Q^{\text{NS}}(f_A)$, implying

$$f_A^{\text{NS}} = \frac{v-c}{2},$$

$$\Pi^{\text{NS}} = \left(\frac{v-c}{2}\right)^2. \tag{8}$$

3.4 Platform's tying decision

In the first period of the game, the platform chooses how to offer the ancilary good by comparing (5), (7), and (8).

Proposition 1. *If $k < \Delta/2$ the platform ties the ancillary service. If $k \geq \Delta/2$ the platform does not offer the ancillary service. The platform never chooses to offer the service without tying.*

Tying and 'no service' both induce a kind of inefficiency. Tying forces the provision of the ancillary service to all consumers, even though those with $\theta < k/\Delta$ value it below the cost of production. Meanwhile, not offering the service sacrifices the surplus that it would create for consumers with $\theta > k/\Delta$. Nevertheless, the platform always prefers one of these options to offering the service without a tie. The reason is that the latter course of action allows the sellers to use the service to differentiate. This leads to increased prices, which deter consumers from participating on the platform. The platform internalizes these participation effects through its tying decision.

4 Policy

4.1 A ban on tying

A policy-relevant question is whether it would ever be to consumers' benefit to ban tying of the ancillary service. The answer to this question is negative:

Proposition 2. *A policy that bans the platform from tying the ancillary service leads to (i) the platform not offering the service, and (ii) weakly lower consumer surplus.*

To prove the proposition, first compare (5) and (8) to note that offering no service dominates offering the service without tying. For the second part, if $k < \Delta/2$ then the platform would choose to tie absent a ban and the ban's effect on consumer surplus is

$$Q^{\text{NS}} - Q^{\text{T}} = \left(\frac{v-c}{2}\right) - \left(\frac{v-c}{2} + \frac{\Delta - 2k}{4}\right) < 0.$$

If $k \geq \Delta/2$ then the platform would not choose to tie anyway, so a ban is neutral.

Both with and without a ban, the platform eliminates seller market power (either by tying or by withdrawing the ancillary service). The effect of the ban is to ensure that the platform chooses the latter course of action. But consumers have private information about their willingness to pay for the service and therefore obtain positive surplus when it is provided, which is lost under a ban.

4.1.1 Virtual tying by platform

It turns out that the platform can achieve tying through designing its unit fee structure and does not need to explicitly tie the two services. To see this, consider the following. In the case that the ancillary service is offered with tying, the fee is $f_{AB}^{\mathrm{T}} = \frac{1}{2}(v - c + k) + \frac{\Delta}{4}$, as calculated earlier in (6). Now, in the case that the ancillary service is offered without tying, suppose the platform sets

$$f_A^{\mathrm{V}} > v - c, \tag{9}$$

$$\text{and } f_B^{\mathrm{V}} = f_{AB}^{\mathrm{T}} - f_A^{V}. \tag{10}$$

By (9), if the seller does not buy the ancillary service, it cannot make a non-negative profit. By (10), the fee for the ancillary service is set such that by both sellers taking the service each will pay a total fee $f_A^V + f_B^V = f_{AB}$ (as in the case of tying) and make zero profits; therefore, they will take the service. In this case, all outcomes under tying will be obtained. This analysis shows that banning tying is not, by itself, enough to prevent the platform from tying. However, since banning tying weakly hurts the consumer, a policymaker should not ban tying in the first place.

4.2 Divestiture

Since a ban on tying harms consumers by leading to withdrawal of the ancillary service, an alternative course of policy action would be to force the platform to divest the ancillary service. That would ensure the service continues to operate as an independent entity. An immediate problem with such an approach is the well-known double-marginalization effect: both the platform and the newly independent ancillary service provider would introduce their own layer of monopoly distortion when setting their respective fees. To eliminate this effect and give a break-up policy the best chance of success, we suppose that there is competitive entry into the supply of the ancillary service following divestiture. Thus, the post-divestiture ancillary service is supplied at marginal cost.

Analysis of competition between sellers now follows the case without tying (after substituting $f_B = k$). If the sellers differentiate the adoption decision then prices are given by (1) and, in particular, are above marginal cost. Thus, Lemma 1 continues to apply and the sellers will indeed differentiate. Consumer participation is $Q^{\mathrm{D}}(f_A) := Q^{\mathrm{NT}}(f_A, k)$.

Post-divestiture, the platform no longer internalizes revenue from the ancillary service. It therefore solves for the optimal transaction fee

$$f_A^{\mathrm{D}} = \underset{f_A}{\operatorname{argmax}}\, f_A Q^{\mathrm{D}}(f_A) = \frac{2\Delta[9(v-c)-\Delta-5k]+k^2}{36\Delta}.$$

Evaluating platform profits and consumer participation at the equilibrium fee levels yields

$$\Pi^D = \frac{\left(k^2-10\Delta k-2\Delta(9c+\Delta-9v)\right)^2}{1296\Delta^2}, \tag{11}$$

$$Q^{\mathrm{D}}(f_A^{\mathrm{D}}) = \frac{k^2-10\Delta k-2\Delta(9c+\Delta-9v)}{36\Delta}. \tag{12}$$

Suppose the integrated platform would choose to tie ($k < \Delta/2$). The effect of break-up on consumer surplus is

$$Q^{\mathrm{D}}(f_A^{\mathrm{D}}) - Q^{\mathrm{T}}(f_{AB}) = \frac{k^2+8\Delta k-11\Delta^2}{36\Delta} < 0.$$

Thus, divestiture harms consumers even in the absence of double marginalization. This happens because the break-up enables the sellers to differentiate and increases product market prices.

We could also consider a similar 'divestiture' policy in the case where $k \geq \Delta/2$ and the platform would choose to offer no service. Conceptually, this corresponds to a situation where a policy authority forces the platform to allow third-party ancillary service providers to access the platform even when it would choose not offer such services itself. The effect on consumer surplus would be

$$Q^{\mathrm{D}}(f_A^{\mathrm{D}}) - Q^{\mathrm{NS}}(f_A) = \frac{k^2-10\Delta k-2\Delta^2}{36\Delta} < 0.$$

Again, the resulting price increase on the product market means that break-up harms consumers. To summarize:

Proposition 3. *A policy that forces the platform to divest the ancillary service reduces consumer surplus.*

5 Tying with ancillary market competition

One concern associated with platform tying of services is that it might foreclose competition from other (potentially more efficient) suppliers of those services. We investigate this issue by supposing that the ancillary service is supplied by both the platform and by a competitive fringe of independent providers. All providers of the service have the same marginal cost, k. But the non-integrated providers have a quality advantage: their version of the service is worth $\tilde{\Delta}$ whereas the platform's is worth $\Delta < \tilde{\Delta}$.

The analysis (in Appendix A.1.1) follows a similar template to the baseline case. The main difference is that even if the platform withdraws the ancillary service, sellers can still buy it from the competitive fringe. This is bad news for the platform because the fringe's superior version of the serves allows sellers to achieve high levels of vertical differentiation and sustain high prices. Thus, if it can't tie, the platform will sometimes find it worthwhile to subsidize the adoption of its own inferior version (i.e., to set $f_B < k$) to minimize equilibrium seller differentiation. Because such a subsidy feeds through into product market prices, it makes the case without tying more attractive for consumers relative to the one with no competition and thus no subsidy. Nevertheless, it remains the case that a ban on tying would harm consumers.

Proposition 4. *Suppose the platform faces a competitive fringe of higher-quality ancillary service providers. Then a ban on tying will leave consumers worse-off.*

6 Discussion

6.1 Ad valorem fees

In this section, we allow the platform to charge an ad valorem fee instead of a fixed unit fee for the main service A. Charging ad valorem fees is a common practice and we conduct this analysis to show that even under this practice the key insight from the main model — that there are conditions under which a ban on tying reduces consumer surplus — holds.

Suppose the platform charges ad valorem fee (i.e., transaction commission), $\tau_A \in [0, 1]$ for the main service and a unit fee, f_B for the ancillary service. We consider the three possible market configurations: neither seller takes the service, one seller takes the service, and both sellers take the service.

First, consider the case in which no seller takes the service. The sellers are undifferentiated and given Bertrand competition the profits will be zero. The price set by each seller will be $p_1 = p_2 = c/(1 - \tau_A)$. The consumer surplus is given by $Q = v - c/(1 - \tau_A)$; by uniformity of the outside option, this is also the consumer participation. The margin of the platform per consumer is $\tau_A \cdot c/(1-\tau_A)$, and the platform maximizes $\Pi = \tau_A \cdot c/(1-\tau_A) \cdot Q$. This gives the optimal ad valorem fee as $\tau_A^{\text{NS}} = (v - c)/(v + c)$, the optimal consumer participation as $(v - c)/2$, and the optimal platform profit as $(v - c)^2/4$.

Second, consider the case in which one seller (seller 1) takes the service. The demand for seller 1 will be $S_1 = 1 - (p_1 - p_2)/\Delta$ and for seller 2 will be $S_2 = (p_1 - p_2)/\Delta$. The profits for sellers 1 and 2 will be, respectively, $((1-\tau_A)p_1 - f_B - c)S_1$ and $((1-\tau_A)p_2 - c)S_2$. We can now derive the optimal prices, profits and the consumer participation. These are given by:

$$p_1 = \frac{3c + 2(f_B + \Delta(1-\tau_A))}{3(1-\tau_A)} \text{ and } p_2 = \frac{3c + f_B + \Delta(1-\tau_A)}{3(1-\tau_A)},$$

$$\pi_1 = \frac{(f_B - 2\Delta(1-\tau_A))^2}{9\Delta(1-\tau_B)} \text{ and } \pi_2 = \frac{(f_B + \Delta(1-\tau_A))^2}{9\Delta(1-\tau_B)},$$

$$\text{and } Q = v + \frac{1}{18}\left(\frac{f_B^2}{\Delta(1-\tau_A)^2} - \frac{2(9c+5f_B)}{1-\tau_A} - 2\Delta\right).$$

The platform's profit is given by $\Pi = ((\tau_A p_1 + f_B - k)S_1 + \tau_A p_2 S_2)Q$. The platform maximizes this with respect to τ_A and f_B. Unfortunately, this is not analytically tractable.

Third, consider the case in which both sellers take the service. Due to Bertrand competition, the price charged by each seller will be $p_1 = p_2 = (c + f_B)/(1-\tau_A)$. The sellers being undifferentiated, both earn zero profit. The consumer surplus, which is also the cosumer participation, is given by $Q = v + \Delta/2 - \frac{c+f_B}{1-\tau_A}$. The platform's profit is

$$\Pi = \left(\tau_A \frac{c+f_B}{1-\tau_A} + f_B - k\right) Q,$$

which it maximizes with respect to τ_A and f_B. A solution to this is

$$\tau_A = \frac{\Delta + 2(v+k-c)}{\Delta + 2(v+k+c)} \text{ and } f_B = 0,$$

which gives

$$\Pi = \frac{1}{16}\left(\Delta + 2(v-k-c)\right)^2 \text{ and } Q = \frac{1}{4}(\Delta + 2(v-k-c)).$$

Since the case of one seller adopting the service is not analytically tractable, we need to conduct a numerical analysis. The primary goal of the numerical analysis is to show that there indeed exist parametric conditions, even with ad valorem fees for the main service, where a ban on tying reduces consumer surplus. We indeed find this to be true.

We illustrate this by fixing the following numerical values: $v = 1; c = 0.1; \Delta = 0.5$ while leaving k free. Figure 1 plots, w.r.t. k, platform profits (dashed lines) and consumer surplus (solid lines) under the cases of no ancillary service (black), both sellers using ancillary service, i.e., tying (red), and one seller using ancillary service, i.e., ban on tying (blue). If tying is not banned then before the point of intersection of the dashed lines the platform will practice tying and after this point it will offer no service; this leads to greater consumer surplus than the case in which one seller will take the service if it is offered but tying is banned. However, different from the main model, if there is a ban on tying then before the point of intersection of the dashed lines the platform will offer the service, and in this case for small enough k the consumer surplus is higher than the case of offering no service (though still lower than the case of offering the service with

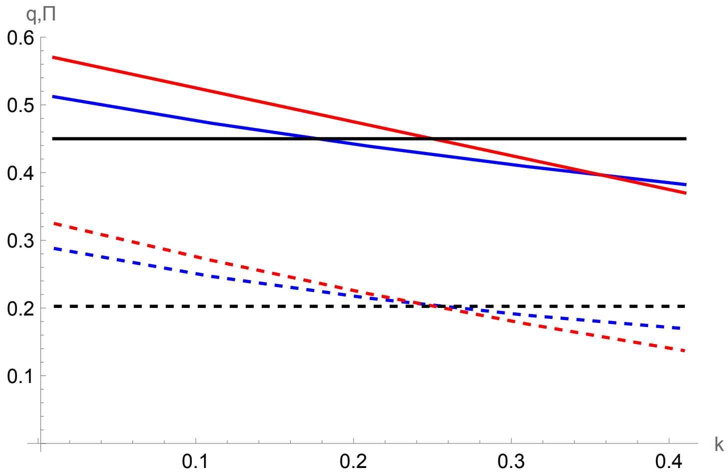

Figure 1: Platform profit (dashed lines) and consumer surplus (solid lines) w.r.t k under the cases of no ancillary service (black), both sellers using ancillary service, i.e., tying (red), and one seller using ancillary service, i.e., ban on tying (blue).

tying), whereas for large enough k the consumer surplus is lower than the case of offering no service. In any case, we find in the figure that a ban on tying would always harm consumers if it affects the platform's behavior. Numerical analysis has not yielded any example where consumers benefit from a ban.

Overall, this section shows that the same key forces are operative under both ad valorem fee and unit fee for the main service, and these forces interact in similar ways (even if some qualitatively new results are obtained). Specifically, we find that there are conditions under which a ban on tying reduces consumer surplus.

6.2 Optimal (two-part tariff) contracts

Suppose that the platform can offer optimal contracts, which for our model would be two-part tariff contracts, for both the main service and the ancillary service. We use F_A and f_A for the fixed and unit fees for the main service, and F_B and f_B for the fixed and unit fees for the ancillary service. There are three configurations: neither seller has the service, one seller has the service, and both sellers have the service.

Consider the case in which the platform does not offer the service such that neither seller has it. The sellers will be undifferentiated and due to Bertrand competition will have zero profits. This means that $F_A = 0$ because the sellers will not pay a fixed fee to join the platform if after joining they make zero profit. The prices will be $c + f_A$ and the expected consumer surplus is $Q = v - c - f_A$. The platform's profit is $\Pi = f_A Q$, which is maximized at $f_A = (v-c)/2$, and the equilibrium platform profit and consumer surplus are $\Pi^{00} = (v-c)^2/4$ and $Q^{00} = (v-c)/2$, respectively.

Next, consider the case in which the platform offers the service and only seller 1 takes it. Let $f_1 = f_A + f_B$ and $f_2 = f_A$ be the total unit fees faced by sellers 1 and

2, respectively, and $F_1 = F_A + F_B$ and $F_2 = F_A$ be the total fixed fees faced by sellers 1 and 2, respectively. The sellers' expected profits, per participating platform user, are given by $\pi_1 = (p_1 - c - f_1)(1 - \theta^*)$ and $\pi_2 = (p_2 - c - f_2)\theta^*$. The equilibrium prices are given by $p_1 = (3c + 2f_1 + f_2 + 2\Delta)/3$ and $p_2 = (3c + f_1 + 2f_2 + \Delta)/3$. These give the expressions for the profits for sellers 1 and 2, and these profits will be fully extracted by the fixed fees, which implies that $F_1 = \pi_1$ and $F_2 = \pi_2$. Consumer surplus is given by $\int_0^{\theta^*}(v - p_2)\, d\theta + \int_{\theta^*}^1 (v + \theta\Delta - p_1)\, d\theta$. The platform's profit is $\Pi = ((f_1 - k)(1 - \theta^*) + f_2\theta^* + T_1 + T_2)Q$, which is a function of f_1 and f_2. This is maximized at $f_1 = (k^2 + 6k\Delta + (2v - 2c - 3\Delta)\Delta)/(4\Delta)$ and $f_2 = (k^2 - 6k\Delta + (2v - 2c + \Delta)\Delta)/(4\Delta)$. The equilibrium platform profit is $\Pi^{\Delta 0} = (k^2 + 2(v - c - k)\Delta + \Delta^2)^2/(16\Delta^2)$ and the equilibrium consumer surplus is $Q^{\Delta 0} = (k^2 + 2(v - c - k)\Delta + \Delta^2)/(4\Delta)$. If we substitute (f_1, f_2) into (p_1, p_2) and use these equilibrium prices to evaluate sellers' market shares, we obtain $\theta^* = k/\Delta$. Thus, the platform sets its optimal two-part tariffs in such a way that consumers efficiently sort, buying from the firm with the ancillary service if and only if they value that service above-cost ($\theta\Delta > k$).

Now, consider the case of tying in which both sellers take the service. Since the distribution of fees between f_A and f_B (and between F_A and F_B) is irrelevant in this case, we adopt the convention that $f_B = F_B = 0$ and find the optimal (f_A, F_A). Since the sellers are undifferentiated, they earn zero profits, which implies that $F_A = 0$. Therefore, we are left to solve for f_A. Due to Bertrand competition between undifferentiated sellers, product prices are $p = c + f_A$, which means that consumer participation is $Q = \int_0^1 (v + \theta\Delta - p)\, d\theta = v + \Delta/2 - c - f_A$. The platform's profit is $\Pi = (f_A - k)Q$. This is maximized at $f_A = (2v + \Delta + 2k - 2c)/4$. The equilibrium platform profit is $\Pi^{\Delta\Delta} = (2v + \Delta - 2k - 2c)^2/16$ and the equilibrium consumer surplus is $Q^{\Delta\Delta} = (2v + \Delta - 2k - 2c)/4$.

Comparing the consumer surplus expressions $Q^{\Delta\Delta}$ and $Q^{\Delta 0}$, we find that tying harms consumers when optimal contracts are allowed. However, comparing the profit expressions $\Pi^{00}, \Pi^{\Delta 0}$ and $\Pi^{\Delta\Delta}$, while ensuring all regularity conditions hold, we find that $\Pi^{\Delta 0}$ always dominates. In other words, with general contracts, the platform does not want to tie (and, therefore, the analysis of a ban on tying is moot). In fact, the platform prefers asymmetric adoption of the ancillary service. This is because asymmetric adoption of the ancillary service enables surplus extraction from consumers who value the ancillary service highly and get it, while those who do not value it highly will not buy it by going to the other seller. And because the platform has multiple contracting instruments, it can sufficiently extract the surplus while not overly distorting prices. However, as we have argued earlier in the paper, two-part tariff contracts are not practical and not generally used by platforms. Therefore, we argue that the results obtained from our main model with unit fees (and from the model with ad valorem fees) may be more relevant from a practical point of view.

6.3 More than two sellers per-market

Suppose that there are more than two sellers per market. When the platform offers the ancillary service, there can be multiple equilibria but we can think of them as falling into two classes: (i) only one seller adopts the service, and (ii) more than one seller, but not all sellers, adopt the service. In (i), with one seller adopting the service, this seller has market power and tying by the platform is a way to reduce that market power. In (ii), with multiple sellers adopting the service, the sellers who adopt it will compete away the service advantage and tying by the platform will not achieve further reduction of market power. Therefore, we focus on the case in which only one seller, say seller 1, adopts the service without tying such that tying has some bite. In this case, the price charged by all non-adopting sellers will be $p_2 = c + f_A$. The demand for seller 1 will be $S_1 = 1 - (p_1 - p_2)/\Delta$ and for all other sellers combined will be $S_2 = (p_1 - p_2)/\Delta$.

Consider the case of no tying. Then $\pi_1 = (p_1 - f_A - f_B - c)S_1$ and maximizing this w.r.t. p_1 gives $p_1 = (2c + 2f_A + f_B + \Delta)/2$. The consumer surplus (and demand) is

$$Q = \int_0^{S_2} (v - p_2)\, d\theta + \int_{S_2}^{1} (v + \Delta\theta - p_1)\, d\theta = \frac{1}{8}\left(8v - 8c - 2f_B - 8f_A + \frac{f_B^2}{\Delta} + \Delta\right).$$

The platform's profit is $\Pi = ((f_A + f_B - k)S_1 + f_A S_2)Q$, which is maximized at $f_A = (18v\Delta + 2k\Delta - k^2 - \Delta^2 - 18c\Delta)/(36\Delta)$ and $f_B = (2k + \Delta)/3$. The optimal platform profit is $\left(\frac{v-c}{2} + \frac{(k-\Delta)^2}{12\Delta}\right)^2$.

Note that the profit without service is $\left(\frac{v-c}{2}\right)^2$. Therefore, in the equilibrium considered for offering service without tying, the outcome dominates the outcome without service in terms of platform profit. This is different from the main model and the reason is that the non-adopting sellers compete intensely with each other.

Next, consider the case of tying. Here, there is one fee $f_{AB} = f_A + f_B$ and we simply assume that $f_B = 0$. Tying forces the sellers to be undifferentiated; they charge the Bertrand price of $c + f_A$ and earn zero profit. Consumer participation is $Q = \int_0^1 (v + \theta\Delta - c - f_A)\, d\theta = \Delta/2 + v - c - t$. The platform's profit is $\Pi = (f_A - k)Q$, which is maximized at $(2v + 2k - 2c + \Delta)/2$. For this solution to be consistent, we impose the condition $v > c + k + \Delta/2$.

Comparing these solutions for the case of more than two sellers, we find that the platform offers the service with tying for $k \leq (\sqrt{6} - 2)\Delta$ and offers the service without tying otherwise. If there is a ban on tying, then consumers are harmed whenever the firm would have tied without the ban. The reason is that the ban on tying leads to less competition among sellers (recall that we consider the equilibrium where exactly one seller adopts the service).

6.4 Single seller

In our primary analysis, we have assumed that there are competing sellers. We now investigate the case in which there is a monopoly seller.

First, consider the case in which the platform offers the service without tying and the seller uses the service. The consumer will purchase if $v + \theta\Delta - p \geq 0$ where p is the price of the seller, which gives demand as $1 - (p - v)/\Delta$. The seller's profit is given by $(p - c - f_A - f_B)(1 - (p - v)/\Delta)$. Maximizing this w.r.t. the price p gives the optimal price as $p^M = (c + f_A + f_B + v + \Delta)/2$, and the seller's optimal profit as $\pi^M = (c + f_A + f_B - v - \Delta)^2/(4\Delta)$. The expected consumer surplus is $Q^M = \int_{(p-v)/\Delta}^{1}(v + \theta\Delta - p)\, d\theta = (c + f_A + f_B - v - \Delta)^2/(8\Delta)$.

On the other hand, if the platform offers the service without tying and the seller does not use the service, the consumer's utility is simply $v - p$, the seller will price at $p = v$ and make profit $v - c - f_A$. In this case, there will be no consumer participation, which the platform does not want.

Therefore, the condition that the platform will impose to induce the seller to use the service is $(c + f_A + f_B - v - \Delta)^2/(4\Delta) \geq v - c - f_A$. This gives

$$f_B \leq v + \Delta - c - f_A - 2\sqrt{\Delta(v - c - f_A)} \equiv f_{B,\max}.^{3}$$

The platform therefore solves

$$\max_{f_A, f_B}(f_A + f_B - k)\left(1 - \frac{p - v}{\Delta}\right) Q^M \text{ s.t. } f_B \leq f_{B,\max}.$$

The profit of the platform depends on $f_A + f_B$, and the platform will always be able to induce adoption of the service. We can show that the solution is

$$f_A + f_B = \frac{v + \Delta + 3k - c}{4} \text{ and } f_B < f_{B,\max}.$$

If $f_{B,\max} < k$, then the platform is essentially subsidizing adoption of the service. Indeed, such cases arise (though we can rule out $f_B < 0$).

Overall, in the case of a monopoly seller, this monopoly seller does not internalize that not adopting the service can reduce overall participation. The platform then has to ensure adoption, in some cases by charging a fee for the ancillary service that is lower than the cost of the service. This may appear predatory but it actually increases consumer surplus. Note that under tying the profit of the platform would be the same as in the analysis above but there would only be a single fee f_{AB}. In this sense, in the monopoly seller case, as in the competitive sellers case, the platform induces adoption of the service either by limiting the service fee or by tying, but this is beneficial for consumers.

[3] $f_B \geq v + \Delta - c - f_A + 2\sqrt{\Delta(v - c - f_A)}$ is not in the relevant domain.

7 Conclusion

To be written.

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A Appendix

A.1 Ancillary market competition

Here we conduct the analysis under the assumption that the platform faces a competitive fringe of ancillary service providers, that offer service of quality $\tilde{\Delta} > \Delta$ at a price equal to their marginal cost, k. For the purpose of this section, to reduce the number of cases, we assume $k < \Delta/2$.

A.1.1 Tying with ancillary market competition

If the platform ties the ancillary service then the presence of the rival service providers is irrelevant because sellers are forced to use the platform's version of the service. The equilibrium is therefore equivalent to the baseline model with tying (Section 3.2). In particular, the platform's profit is (7) and consumer participation is

$$Q^T(f_{AB}^T) = \frac{1}{2}(v - c - k) + \frac{\Delta}{4}.$$

We compare this to a ban on tying, the results of which depend on where sellers choose to buy the ancillary service.

A.1.2 No tying: service sold by the competitive fringe

If the platform chooses not to offer the ancillary service (or, equivalently, sets f_B so high that sellers prefer the fringe's version of the service) then sellers will only consider the rival version. The equilibrium analysis is then identical to that in Section 4.2, with one seller buying the service from the competitive fringe. The corresponding platform profit and consumer participation are (11) and (12) (with $\tilde{\Delta}$ in place of Δ).

Making the comparison, we find that the effect of a ban on tying that results in the fringe supplying the service is

$$\left[\frac{k^2 - 10\tilde{\Delta}k - 2\tilde{\Delta}(9c + \tilde{\Delta} - 9v)}{36\tilde{\Delta}}\right] - \left[\frac{1}{2}(v - c - k) + \frac{\Delta}{4}\right] = \frac{k^2 + 8\tilde{\Delta}k - 9\Delta\tilde{\Delta} - 2\tilde{\Delta}^2}{36\tilde{\Delta}}.$$

This is negative because $\tilde{\Delta} > \Delta > k$. Thus, a ban on tying would harm consumers in this case.

A.1.3 No tying: services sold by the platform

If seller 1 buys the service from the platform then, following the logic of Section 3.1, its profits given in (2):

$$\pi_1 = \frac{(2\Delta - f_B)^2}{9\Delta}.$$

In instead it buys the service from a competitive fringe firm then it pays $f_B = k$ and receives a service of quality $\tilde{\Delta}$, resulting in profit

$$\pi_1 = \frac{(2\tilde{\Delta} - k)^2}{9\tilde{\Delta}}.$$

Comparison reveals that seller 1 prefers to buy from the platform if

$$f_B \leq \bar{f} \equiv \frac{\sqrt{\Delta}\left(2\sqrt{\Delta}\sqrt{\tilde{\Delta}} - 2\tilde{\Delta} + k\right)}{\sqrt{\tilde{\Delta}}}(< k).$$

The fees that the platform would ideally choose in this scenario are given in (4). For $k < \Delta/2$ we have $f_B^{\mathrm{NT}} > k$, meaning the $f_B \leq \bar{f}$ constraint must be binding. Focusing on this case, the platform's problem is

$$\max_{f_A} \left[f_A + \left(\bar{f} - k\right)(1 - \theta^*)\right] Q^{\mathrm{NT}}(f_A, \bar{f}), \tag{13}$$

with solution

$$f_A = \frac{1}{36}\left(-18c + \frac{(k - 2\tilde{\Delta})\left(-14\sqrt{\Delta}\tilde{\Delta} + 6\sqrt{\tilde{\Delta}}(\Delta - k) + 7\sqrt{\Delta}k\right)}{\sqrt{\Delta}\tilde{\Delta}} + 18(v - \Delta)\right).$$

Consumer participation is found by substituting this value of f_A along with $f_B = \bar{f}$ into (3):

$$Q^{\mathrm{NT}}(f_A, \bar{f}) = \frac{1}{2}(v - c - \Delta) + \frac{(k - 2\tilde{\Delta})\left(10\sqrt{\Delta}\tilde{\Delta} + 6\sqrt{\tilde{\Delta}}(k - 3\Delta) - 5\sqrt{\Delta}k\right)}{36\sqrt{\Delta}\tilde{\Delta}}.$$

Comparing to the case with tying, we have

$$Q^{\mathrm{NT}}(f_A, \bar{f}) - Q^T(f_{AB}^T) = \frac{1}{36}\left(-27\Delta - 20\tilde{\Delta} - \frac{5k^2}{\tilde{\Delta}} + \frac{6k(k - 3\Delta)}{\sqrt{\Delta}\sqrt{\tilde{\Delta}}} - \frac{12\sqrt{\tilde{\Delta}}(k - 3\Delta)}{\sqrt{\Delta}} + 38k\right),$$

which is negative for $\tilde{\Delta} > \Delta > k \geq 0$. Thus, a ban on tying also reduces consumer surplus in this case.