The Effects of Platform MFNs on Competition and Entry

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Abstract

In the context of sellers who sell their products through intermediary platforms, a platform MFN (most-favored-nation clause) is a contractual restriction requiring that a particular seller will not sell at a lower price through another platform than through the platform with which it has the platform MFN agreement. Contractual restrictions observed in markets for ebooks, travel services, and credit card transaction processing, among other settings, can be viewed as examples of this phenomenon. We show that platform MFNs typically raise platform fees and retail prices, and also curtail entry or skew positioning decisions by potential entrants pursuing low-end business models.

1 Introduction

Recent interest from competition authorities in contracts that reference rivals has dovetailed with interest in platforms and two-sided markets to draw significant attention to the effects of a type of contract known variously as a platform parity agreement or platform most-favored nation agreement. In settings in which a seller sets a price and transacts with a buyer through an intermediary platform (which may charge a fee or a commission to the seller), such contracts restrict the seller not to sell through any alternative platform at a lower price. Most-favored-nation contracts and other contracts that reference rivals have recently been the subject of a US Department of Justice Antitrust Division workshop (Baker and Chevalier, 2013), a UK Office of Fair Trading report (Lear, 2012), and a speech by the Deputy Assistant Attorney General of the US DOJ Antitrust Division (Scott Morton, 2012). Platform MFN agreements in particular have played a key role in recent antitrust cases involving credit cards, ebooks, and travel booking sites (see Salop and Scott Morton (2013) for an overview). The policy-oriented literature conjectures that these agreements can raise prices for consumers and profits for platforms, and also that they may limit entry of low-end business models. However, there exists little theoretical work to support or qualify these assertions. Analyzing these agreements in an explicit model, we find support for some of these claims, but with important caveats.

To fix ideas, consider an example of such a platform MFN policy, which comes from a current class action proceeding in the US, known as *Turik v. Expedia* (see Cernak and Chaiken, 2013). The

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alleged damages (higher airfares and hotel prices, e.g.) are argued to arise from the suppression of competition and the foreclosure of entry in the platform market. Most popular travel booking sites (Expedia, Travelocity, Orbitz, etc.) are platforms that connect buyers (travellers) and sellers (airlines, hotels, and car rental agencies); they are not resellers that buy from suppliers and resell to consumers. The platforms provide a platform on which the sellers can offer their products to potential buyers at prices that the sellers themselves determine, and the platform collects a fee from the seller. In this context, a platform MFN is an agreement between a platform and a seller (e.g., between a travel booking website and an airline) that commits that seller (i.e., airline) not to offer a lower price for the same item through any other platform (i.e., other travel booking website). This institutional arrangement, and these PMFN contracts, are quite common in many categories of online commerce, including websites specializing in ebooks, music and video content, and travel services, as well as websites with broader coverage such as Amazon Marketplace or eBay (with respect to its non-auction listings).

The conventional wisdom about these agreements, which appears with varying degrees of clarity or explicitness in Schuh, Shy, Stavins, and Triest (2012), Salop and Scott Morton (2013), in chapter 6 of the Lear (2012) report for the OFT, and in the expert testimony of economists in select cases (e.g., Carlton (2012) and Winter (2012))–as well as in the investigative documents, complaints, and decisions that have come out of antitrust enforcement activity relating to these policies–is simple.[1] These policies create an incentive for the platform to raise fees because the platform MFN limits the ability of the platform to pass through higher fees in the form of higher retail prices. These higher fees in turn lead to higher retail prices and potentially to higher profits for platforms. In addition, such policies disadvantage potential platform entrants–especially those with low-end business models–by eliminating an entrant's ability to win customers away from incumbent platforms through lower prices. The incongruity of the arguments that these policies both raise profits and deter entry is not generally addressed.

We explore these arguments and demonstrate a number of important qualifications and nuances. With respect to price and profit effects, we find that platform MFN agreements do tend to raise fees and prices, but also that they may raise fees and prices so much that they hurt platform profits. Whether this is the case depends on the elasticity of aggregate demand, which is in some cases related to the substitutability of the platforms. With respect to effects on entry, we find that a platform MFN agreement may encourage or discourage entry. For an exogenously symmetric entrant, the policies obviously encourage rather than deter entry whenever the fee and price effects just described raise platform profits. We extend the analysis of entry and positioning effects to exogenously and endogenously differentiated potential entrants. When the entrant's product position is exogenous, there is a tradeoff between higher equilibrium fees relative to the no-PMFN equilibrium (which arise through the mechanism described above) and the inability of a platform to increase market share by lowering fees, which disproportionately hurts the profits of the firm that is disadvantaged in demand. When the entrant's product position is endogenous, a platform MFN agreement may again encourage or deter entry; in addition, it may distort the entrant's choice away from a lower-end business model (and toward a model more similar to that of the incumbent) even when it fails to deter entry. Our results therefore support some aspects of the conventional wisdom, but add important caveats and refinements that enrich our understanding of the effects of these platform MFN policies.

[1] One of the authors of the present paper (Corts) was retained by Lear to coauthor the cited report.

1.1 Relationship to traditional MFNs

It is worth emphasizing that these platform MFN policies are not the same as traditional MFN policies, which have been the subject of considerable theoretical inquiry. In a traditional MFN, one or more sellers commits to one or more buyers not to sell to other buyers at a lower price. When these policies are in place across all buyers for the adopting sellers, as is typically the case in this literature, this amounts to a commitment to uniform pricing–that is, a commitment not to price discriminate. A series of theory papers examines mechanisms through which this uniform pricing commitment may be profitable. For example, Schnitzer (1994) shows that with sequential arrival of consumers such policies make high early prices serve as a kind of commitment to low later prices by making discounting later prices more expensive. If a firm knows that price cuts to present buyers will also result in price cuts or rebates to early buyers, they will be reluctant to cut prices. This commitment to relatively unaggressive pricing may be a profitable strategic commitment in a pricing game of strategic substitutes. Besanko and Lyon (1993) show that a similar logic applies if there are heterogenous buyer groups, such as contested and captive buyers. By committing to uniform pricing each firm makes it less attractive for itself to compete aggressively for the contested buyers, since low prices to contested consumers also reduce prices and profits on captive buyers. This can profitably soften price competition. Cooper and Fries (1991) show that with sequential arrival of heterogenous buyers, a traditional MFN can commit a firm that lacks price-setting power to be a tougher bargaining in its negotiations over terms with late-arriving buyers.

In all of these cases, the mechanism at work is that a "discount" to some set of buyers is made less attractive to the seller with the MFN because it necessarily triggers a discount to other buyers, and this is in turn a profitable strategic commitment vis-a-vis some other strategic player. This leads the seller to adopt the traditional MFN in order to soften competition and raise profits. This depends on some sort of heterogeneity in the buyer groups, whether that is in their choice sets, preferences, or timing of arrival. It also requires a rival seller (in all of these papers other than Cooper and Fries (1991)) or a situation in which the seller is not a price-setter (as in Cooper and Fries (1991)). A traditional MFN policy would certainly not raise prices if adopted by a single seller that sells to a single population of homogenous buyers since the commitment to uniform pricing is of no consequence in the monopoly price-setting problem when uniform prices are already optimal (because consumers are homogenous).

Note that a platform setting is quite different in several ways. Most notably, a platform MFN is an agreement between a seller and a platform about prices charged by the seller to a third party–the buyer. When there are multiple platforms present, this creates an incentive for the platform to increase its fees to the seller (something entirely absent in the traditional MFN literature), which generally increases prices for reasons that have nothing to do with strategic commitment on the part of the seller vis-a-vis other sellers and nothing to do with heterogenous buyers. In the platform MFN setting, as evident in our model, the price-raising effects of PMFNs arise even in the case of a price-setting monopoly seller facing homogenous consumers.

While there does exist this formal theory literature on the price effects of traditional MFNs, there exists only informal discussion of the effects of traditional PMFNs on entry. Both the OFT report on price relationship agreements (paragraph 3.17 in Lear (2012)) and Cooper and Fries (1991) suggest informally that traditional MFNs could limit downstream entry with sequential arrival of potential entrants. With an MFN in effect between an upstream seller of some input and an incumbent downstream firm, a subsequent downstream entrant would find it more difficult to obtain a price from the seller low enough to make entry profitable. This occurs for the same reasons that discounts to late-arriving final buyers are less attractive in the Cooper (1986), Schnitzer (1994), and Cooper and Fries (1991) papers.

1.2 The literature on platform MFNs

There exists a small literature that addresses the price effects of PMFNs (as opposed to traditional MFNs) in explicit theory models. The paper most related to ours is Johnson (2013), which studies an environment in which multiple sellers sell through multiple intermediaries under either the "wholesale" model (in which sellers set wholesale prices and *resellers* set retail prices, as in traditional bricks-and-mortar retailing) or the "agency" model (in which sellers set retail prices and *platforms* set commissions paid by the retailer, as in many online marketplaces such as Amazon Marketplace, eBay's fixed price auctions, the ebooks market, and most online travel booking sites). That paper is primarily concerned with the comparison between these two models; however, one section addresses the effect of platform MFN agreements on the equilibrium under the agency model. That paper finds, as do we, that platform MFNs raise platform fees and retail prices; however, it also shows, in contrast to our results, that platform MFNs always raise industry profits and are always adopted by platforms in equilibrium. These differences arise because the Johnson model assumes perfectly inelastic aggregate demand; how this leads to this difference in results is discussed in more detail in the text. In addition, Johnson (2013) does not consider asymmetric firms and does not formally address effects on entry.

Two other papers consider platform MFN agreements in explicit theory models. In a paper on the dissemination of mobile applications, Gans (2012) studies a model in which the firm controlling the mobile platform can offer direct access to app purchases within the platform, while app developers can also sell directly to consumers. He is primarily focused on the difficulties platforms have in charging for the platform in the presence of hold-up by apps developers, and he shows that a platform MFN policy can help solve this problem. The literature on payment processing arrangements in credit card markets largely either ignores the no-surcharge rule (which is arguably tantamount to a platform MFN in this setting) or takes it for granted. A notable exception is Rochet and Tirole (2002), which briefly discusses the ambiguous welfare effects of abolishing the no-surcharge rule in their model.

While these papers formally consider price effects of platform MFNs, to our knowledge there exists no formal theoretical analysis of the effects of platform MFNs on entry or choice of product position. There do exist informal discussions in the policy literature suggesting that platform MFNs can deter or limit downstream entry. For example, the OFT report on price relationship agreements (paragraphs 6.49 and 6.50 in Lear (2012)) suggest that by eliminating the possibility that a seller will charge a comparatively lower price on an entrant platform, PMFNs limit the ability of entrants–and in particular, low-end business model entrants–to establish themselves and increase market share by charging a lower fees to the seller than do incumbent platforms.

Thus, the literature on platform MFNs is quite limited, and the literature on traditional MFNs does not apply directly to this different institutional context. We make a significant contribution by explicitly considering the fee and price effects of platform MFN policies in a more general setting, in which aggregate demand can be downward sloping, and by being the first to analyze formally the effects of platform MFNs on entry and positioning decisions.

1.3 Related current and recent cases

The competitive effects of platform MFNs–relating to fees, pricing, entry, and positioning–are currently of great interest in the antitrust policy and enforcement community due to a number of significant investigations and suits that are currently underway or recently resolved. In many cases the investigative documents, the complaint, the expert testimony, or the decision advances arguments that platform MFNs create incentives to raise fees and prices and can deter entry of platforms. To establish the importance of this topic and to give context to the model, it is worth briefly summarizing some of these investigations and cases.

One set of high-profile cases that focused attention on platform MFN agreements concerned Apple's sales of ebooks. The US Department of Justice and the European Commission both brought actions against Apple and a set of publishers, which concerned the coordinated transition of a number of publishers to the "platform" or "agency" model of bookselling, with platform MFNs, from the "reseller" or "wholesale" model that had prevailed when Amazon dominated the market. These cases included discussions of the effects of PMFNs among many other issues, including issues of price coordination and coordination in the adoption of the new business model. Consent decrees were reached in 2013 in both jurisdictions (in the US case separately for Apple and for the publishers); all of these consent decrees contained among other provisions a five-year ban on the use of platform MFN clauses in the contracts governing e-book sales.

Cases against Visa, Mastercard, and American Express in the US and Canada also have focused attention on similar issues. The relationship to platform MFNs is more subtle here and bears further elaboration. The platforms in this case are payment methods–credit cards, debit cards, and cash, among others. These platforms connect sellers (merchants) to buyers (consumers). Merchants set prices to consumers, and platforms collect fees from merchants. The platform MFN is the virtually universal requirement in the merchants' agreements with credit card providers that they do not surcharge consumers for the use of credit cards. That is, the price through their platform (credit cards) would be no higher than on any other platform (e.g., cash). In fact, this no-surchage rule was typically part of a broader set of policies aiming to ensure equal treatment of all their credit card offerings; this includes "honor all cards" policies, which prevent the refusal of high-amenity rewards cards that may carry a higher fee to the merchant, as well as other "no-steering" provisions. Here, the concerns were that the PMFN would raise fees; that it would lead to the introduction of cards with higher and higher fees, which would result in an effective cross-subsidization of rewards cards by users of cash and no-frills cards; and that it would deter entry of low-fee (to the merchant) cards. In 2011 (for Visa and Mastercard) and 2013 (for American Express), the US DOJ case resulted in settlements that banned, among other practices, the no-surcharge rule. In 2013, the Canadian case brought by the Commissioner of Competition was dismissed because the Competition Tribunal found that there was no resale of the services provided by the credit card companies, and the Commissioner had brought the action exclusively under the resale price maintenance provisions of the Competition Act. However, in the decision the Competition Tribunal also concluded that the no-surcharge rule had lessened competition and raised fees, albeit through a mechanism other than resale price maintenance. The Competition Tribunal strongly encouraged additional government oversight, and the Minister of Finance has indicated that competition-restricting practices such as the no-surcharge rule may soon come under stricter regulatory (as opposed to antitrust) scrutiny (Greenwood, 2013).

1.4 The paper

Section 2 lays out the model. Section 3 considers the effects of platform MFN agreements on competition between two symmetric incumbent platforms. Section 4 considers the equilibrium adoption of such agreements. Section 5 analyzes the effect of such policies on incentives for entry and endogenous choice of competitive position for an entrant platform. Section 6 concludes.

2 Model

A single seller S sells its products to buyers through one or both of two platforms (or "marketplaces") M_i, $i = \{1, 2\}$. The seller incurs three kinds of costs: fixed cost K_S, constant marginal and average production cost c_S, and a per-unit transaction fee f_i charged by each platform i.[2] The seller sets a price p_i on each platform i. Buyer demand through a particular platform i is given by $\widehat{q}_i(p)$. Each platform i incurs a fixed cost K_i and a constant marginal and average production cost c_i.

The timing is as follows. The platforms simultaneously choose whether to require platform MFN policies. They then simultaneously choose transaction fees f_i. The seller then sets prices p_i, abiding by the terms of any platform MFN policies in place. The seller earns profits $\pi_S = \sum_{i=1,2}[p_i - f_i - c_S]\widehat{q}_i(p)$; each platform i earns profit of $\pi_i = [f_i - c_i]\widehat{q}_i(p)$. For the analysis of competition between incumbent platforms (sections 3 and 4), we ignore any fixed costs, which will not affect pricing or fee-setting incentives. Fixed costs are introduced in section 5, in which we focus on the effect of platform MFN policies on entry decisions.

Because the final stage involves only the single seller's pricing decision, it is convenient to suppress this stage of the game in the analysis by writing platform-level demand functions as a function of the transaction fees f_i rather than prices p_i, where these demand functions indicate demand at the seller's optimal prices given the transaction fees. Note that the seller is effectively a simple multi-product monopolist (where the underlying product sold through each of the platforms is thought of as a distinct product) facing demand $\widehat{q}_i(p)$ and with potentially different marginal costs $(c_S + f_1)$ and $(c_S + f_2)$ for its two "products". However, the seller may also face a constraint imposed by the presence of one or more platform MFN agreements. Therefore, this implied demand function varies with the platform MFN regime. We denote this implied demand function $q_i^k(f)$, where $k = 0, 2$ denotes how many platform MFN agreements are present. The case of a single platform MFN agreement is analyzed separately and does not require its own implied demand functions for reasons that will become apparent later.

We analyze this model under two different scenarios for demand: "general" and "linear". We first assume that an unspecified underlying general demand function induces a unique optimal pricing rule for the single multi-product seller, yielding a differentiable and well-behaved implied demand function on transaction fees, $q_i^k(f)$. We later assume that the underlying demand function is a familiar linear differentiated-products demand function, which we show satisfies all of the assumptions we maintain in the general demand case.

[2] In many applications, platforms charge a commission proportional to retail price rather than a fixed per-unit fee. We expect that our qualitative results would apply to both types of fees. In general, in these kinds of models, a proportional commission has the effect of raising the seller's "perceived marginal cost" (as in Johnson (2013)) because of the divergence between the taxed revenue and the maximized profit, whereas in our model the fixed unit fee directly raises that marginal cost.

2.1 General Demand

In the general demand case, we assume that the multi-product seller's optimal pricing yields an implied demand function $q_i^k(f)$ with the following properties.

(A1) Implied demand is a twice differentiable function $q_i^k(f)$ and is symmetric ($q_i^k(x,y) = q_j^k(x,y)$).

(A2) Implied demand is not too nonlinear; in particular, second-order effects do not overwhelm first-order effects in signing second-order conditions or the slopes of best-response functions.

(A3) Implied demand for each platform is downsloping in that platform's own fee, $\frac{\partial q_i^k}{\partial f_i} < 0$, and aggregate implied demand is downsloping in a common fee (for $f_1 = f_2 = \overline{f}$, $\frac{\partial q_i^k}{\partial \overline{f}} < 0$).

(A4) Quantity demanded is more responsive to one's own fee when there are no platform MFN agreements than when there are two platform MFN agreements: $\frac{\partial q_i^0}{\partial f_i} < \frac{\partial q_i^2}{\partial f_i} < 0$.

(A5) Quantity demanded is increasing in the rival's fee if and only if there are no platform MFN agreements: $\frac{\partial q_i^0}{\partial f_j} > 0 > \frac{\partial q_i^2}{\partial f_j}$.

It is simplest to analyze this game as a fee-setting game between platforms facing an implied demand function satisfying these conditions. However, this approach is also is fully consistent with the full game in which the multi-platform seller chooses optimal prices given an underlying demand function satisfying basic regularity conditions. Each of these conditions (A1)-(A5) is shown in the subsequent analysis to hold for a particular linear differentiated products demand model. In addition, Appendix 1 shows that these properties follow from assumptions that underlying demand $\widehat{q}_i^k(p)$ is differentiable, not too non-linear, symmetric, and satisfies the typical assumptions that the own-price derivative is negative, that the cross-price derivative for the substitute is positive, and that the absolute value of the own-price derivative exceeds that of the cross-price derivative. It is shown there that these assumptions on underlying demand suffice to show that the seller's pass through of one's own platform fee is positive regardless of whether platform MFNs are in place, but larger if they are not ($\frac{dp_i^0}{df_i} > \frac{dp_i^2}{df_i} > 0$), and that the seller's pass-through of the rival platform's fee is weakly negative in the absence of platform MFNs, but positive (and in fact equal to own-fee pass-through) in the presence of platform MFNs ($\frac{dp_i^2}{df_j} > 0 \geq \frac{dp_i^0}{df_j}$). These properties suffice, as shown in Appendix 1, for properties (A1) to (A5) to hold.

It is useful to consider the intuitive relationship between fee pass-through and these conditions. First consider (A4). When there are no PMFNs in effect, the multi-product seller reacts to a fee increase by one platform by raising that platform's price, which diverts demand to the other, now relatively higher-margin, platform. When there are two PMFNs in effects, the seller is constrained to set a uniform prices across platforms. As a result, it has reduced flexibility in diverting sales to the other platform. Raising price on one platform means raising price on both platforms. While the higher fee on one platform does induce the seller to raise price on that platform (and on the other platform), this is now more costly in lost demand on both platforms, and the seller optimally chooses to raise price on the fee-raising platform less than it would have absent the PMFN agreements. Now consider (A5). Absent PMFNs, the seller's price increase for a platform in response to a fee increase on that platform increases demand for the non-fee-raising platform. But, with two PMFNs, the seller's uniform price increase reduces demand for both platforms.

2.2 Linear Demand

We show that all of the above assumptions for general demand do in fact hold when the underlying demand takes the familiar linear differentiated products form: $\widehat{q}_i(p) = a - bp_i + dp_j$,where $a, b, d > 0$ and $b > d$. In this case we also assume $c_i + c_s < \frac{a}{b-d}$, where this quantity is the symmetric choke price. It is in fact straightforward to determine the optimal pricing rule for the two-product monopoly seller under both the 0-PMFN and 2-PMFN regimes. Maximizing the seller's profit yields optimal prices that are linear in the platform fees. These are given by

$$\begin{aligned} p_i^0 &= \frac{a + (b-d)(c_s + f_i)}{2(b-d)} \\ p_i^2 &= \frac{2a + (b-d)(2c_s + f_i + f_j)}{4(b-d)} \end{aligned}$$

These optimal pricing rules give non-negative quantities as long as the seller's total effective marginal cost is less than the symmetric choke price–that is, $c_S + f_i < \frac{a}{b-d}$, which can be shown to hold for all profit-maximizing f_i under the assumption on $c_S + c_i$ above.

Substituting the optimal pricing rules into the demand function yields implied demand as a function of transaction fees:

$$\begin{aligned} q_i^0(f) &= [a - b(c_s + f_i) + d(c_s + f_j)]/2 \\ q_i^2(f) &= [2a - (b-d)(2c_s + f_i + f_j)]/4. \end{aligned}$$

It is easy to check that these implied demand functions immediately satisfy conditions (A1)-(A5).

3 Competitive effects of platform MFNs

This section analyzes a model with two symmetric incumbent platforms: the platforms have the same cost structure and demand is symmetric ($\widehat{q}_i(p_i = y, p_j = z) = \widehat{q}_j(p_j = y, p_i = z)$). In this section, we analyze the best-response functions and equilibrium transaction fees that arise in the stage 2 subgame in which platforms simultaneously set fees. This allows us to characterize the impact of PMFN policies on competition, comparing the cases with and without PMFN policies present.

3.1 General Demand

Platform i's profit is given by $\pi_i = (f_i - c_i)q_i^k(f)$, which yields a first-order condition of

$$\frac{\partial \pi_i}{\partial f_i} = (f_i - c_i)\frac{\partial q_i^k(f)}{\partial f_i} + q_i^k(f) = 0.$$

This yields a second-order condition of

$$\frac{\partial^2 \pi_i}{\partial f_i^2} = (f_i - c_i)\frac{\partial^2 q_i^k(f)}{\partial f_i^2} + 2\frac{\partial q_i^k(f)}{\partial f_i} \leq 0.$$

The last term is negative by (A3); the second-order condition therefore holds by (A2).

Totally differentiating the FOC with respect to f_j gives the slope of the best-response function in the fee-setting game:

$$\frac{df_i^k}{df_j} = -\frac{\frac{\partial q_i^k(f)}{\partial f_j} + (f_i - c_i)\frac{\partial^2 q_i^k(f)}{\partial f_i \partial f_j}}{(f_i - c_i)\frac{\partial^2 q_i^k(f)}{\partial f_i^2} + 2\frac{\partial q_i^k(f)}{\partial f_i}}.$$

The denominator is exactly the second-order condition; therefore, the slope of the best-response function has the same sign as the numerator. By (A2), the best-response function therefore has the same sign as the first-order cross-partial $\frac{\partial q_i^k(f)}{\partial f_j}$. By (A5), this implies a game of strategic substitutes with 0 PMFNs and a game of strategic complements with two PMFNs. Assume the existence of a symmetric equilibrium under both 0 PMFNs and 2 PMFNs. Each of these equilibria must be unique by the monotonicity of the best-response functions. Denote these equilibrium fees f_i^{k*}.

The first result of interest arises from comparing these equilibria. In fact, as the conventional wisdom suggests, fees and prices are higher when both firms adopt PMFN policies. To see this, note that by (A4) the FOC for 2 PMFNs evaluated at the 0 PMFN equilibrium fees is positive. Thus, the symmetric equilibrium fees must be higher under 2 PMFNs than under 0 PMFNs. Moreover, (A3) implies that these higher fees also lead to higher prices. Specifically, the fact that quantity falls as both fees rise implies that the seller's prices are rising along with fees. These results can be summarized in the following proposition.

Proposition 1 *Assume that (A1)-(A5) hold. Then there exists a unique symmetric equilibrium in transaction fees if no platforms have PMFN agreements or if both platforms have PMFN agreements. Equilibrium fees and prices are higher when both platforms have PMFN agreements.*

The intuition for this result should be quite clear. Consider the case in which both platforms have PMFN agreements and consider hypothetical fees equal to the 0 PMFN equilibrium fees. These are best-response fees absent PMFN agreements. They weigh off the increased margin of a higher fee against the reduction in quantity that results from the multi-product seller raising that platform's price and diverting demand to the other platform. When PMFNs are present and the seller is constrained in its price-setting, this trade-off is altered in two ways. First, the higher fee is no longer passed through to the same extent, since it is costly for the seller to also raise the other platform's price as required by the PMFNs. A lower pass-through of the fee increase implies a smaller reduction in quantity demanded and an increase in profit. Second, the PMFNs imply that both prices will rise as a result of the platform's fee increase. Because the platforms are substitutes from the buyers' point of view, this increase in the price of the rival platform also implies a smaller decrease in quantity demanded for the fee-raising platform. These effects lead to implied demand that is less responsive to fee increases, which in turn leads to higher equilibrium fees and prices.

We can also compare the 2PMFN equilibrium fees and prices to those that would arise under collusive platform fee-setting absent PMFNs. Perhaps surprisingly, PMFNs necessarily lead to fees and prices even higher than those chosen by perfectly colluding platforms. To see this, note first that under either symmetric collusive fees or symmetric 2PMFN equilibrium, the seller optimally chooses a symmetric price. In the 0PMFN equilibrium the seller's variable profit following collusive symmetric fee-setting reduces to $\sum_{i=1,2}[p - c_S - f]\widehat{q}_i(p)$. In the 2PMFN equilibrium, the seller variable profit reduces to $\sum_{i=1,2}[p - c_S - f_i]\widehat{q}(p) = 2[p - c_S - (f_1 + f_2)/2]\widehat{q}_1(p)$. Importantly, in both of these cases (and unlike the non-collusive 0PMFN case) the seller's optimal pricing rule can be reduced to a function of the average fee $(f_1 + f_2)/2$. Therefore, both situations generate the same implied demand function, which can be denoted $q^{SYM}(\overline{f})$. It immediately follows from this that the collusive fee is the same regardless of whether PMFNs are adopted or not. Finally, compare the collusive fee-setting FOC with 2PMFNs with the equilibrium fee-setting FOC under 2PMFNs. The former yields $(f_i - c_i)\frac{\partial q_i^2}{\partial f_i} + q_i^2(f_i) + (f_j - c_j)\frac{\partial q_j^2}{\partial f_i} = 0$, while the latter yields $(f_i - c_i)\frac{\partial q_i^2}{\partial f_i} + q_i^2(f_i) = 0$. The first two elements in each expression are identical. The third term in the former, $(f_j - c_j)\frac{\partial q_j^2}{\partial f_i}$, is negative by (A5). This implies that at the collusive fees (which are the same with 0 or 2 PMFNs), the non-collusive 2PMFN fee-setting FOC (the latter of these two) is positive, which in turn implies 2PMFN equilibrium fees higher than collusive fees. By (A3), 2PMFN equilibrium final prices are also higher than those that arise under collusive fee-setting. This yields the next proposition.

Proposition 2 *Assume that (A1)-(A5) hold. Then the unique symmetric equilibrium fees and prices when both platforms have PMFN agreements are higher than the symmetric equilibrium fees and prices that would arise under collusive fee-setting by platforms absent PMFNs.*

Note from the expressions derived above that this higher-than-collusive result follows directly from an "aggregate demand effect." The $\frac{\partial q_j^2}{\partial f_i}$ term is negative because an increase in f_i under 2 PMFNs leads the seller to raise the price at both platforms. This increase in the common price in turn causes a loss of quantity for the other platform whenever there is any amount of aggregate demand elasticity. It is only aggregate demand elasticity that can account for this term being negative because shares of demand are fixed by the restriction to a common price under symmetric demand. What one can see from this analysis is that the "higher-than-collusive" result would not arise in the absence of aggregate demand elasticity, or in a situation where there was no pass-through of a platform's fee to the common price by the seller (which cannot happen with smooth demand). Indeed, this is precisely why this "higher-than-collusive" results does not arise in Johnson (2013). His paper features perfectly inelastic demand at all prices up to the point at which all buyers switch to the outside option. At that price, the seller would no longer pass through further increases in fees as higher prices. Thus, in his model the 2PMFN fees coincide with the collusive fees, and those fees are fees that induce the seller to price precisely at the chokepoint where the outside option is binding.

In our general and linear models there is always some elasticity to aggregate demand. Because this is the source of the divergence between collusive and equilibrium fee-setting, it is clear that as aggregate demand approaches perfectly inelastic, the equilibrium 2PMFN fees will approach the collusive fees.

Proposition 3 *Assume that (A1)-(A5) hold. Then 2-PMFN equilibrium profits are higher than 0-PMFN equilibrium profits if aggregate demand is sufficiently inelastic.*

To see this formally, note that the divergence between the collusive fees and the 2-PMFN equilibrium fees arises because of the presence of an additional term $(f_j - c_j)\frac{\partial q_j^2}{\partial fi}$. It follows that the two fees converge, implying that 2-PMFN equilibrium profits approach the collusive profits and exceed 0-PMFN profits, as this term goes to 0. Recalling again that $q_i^k(f) = \widehat{q}_i(p^k(f))$, this partial derivative can be written as $\frac{\partial q_j^2}{\partial f_i} = \frac{\partial \widehat{q}_j}{\partial p_j}\frac{dp_j^2}{df_i} + \frac{\partial \widehat{q}_j}{\partial p_i}\frac{dp_i^2}{df_i}$. Because $p_i^2 = p_j^2$ under PMFNs, this can be rewritten as $\frac{\partial q_j^2}{\partial f_i} = \left[\frac{\partial \widehat{q}_j}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right]\frac{dp_i^2}{df_i}$. This square-bracketed term is the effect on quantity demanded a mutual increase in price, which is also one-half the aggregate demand response to a mutual increase in price given the symmetry of the model. As this square bracketed term approaches zero, aggregate demand becomes perfectly inelastic, the 2-PMFN fees converge to the collusive fees, and the 2-PMFN equilibrium profits must exceed the 0-PMFN equilibrium profits.

3.2 Linear demand

The linear model allows us to explore some aspects of the model for which we do not have general results. Proposition 2 suggests the possibility that 2-PMFN profits might actually fall below the 0-PMFN profits, since fees and prices are higher than in the case of collusive fee-setting. The linear model allows us to examine under what conditions this may arise. Note that the earlier analysis indicated that the fees go higher than collusive when aggregate *implied* demand is elastic; implied demand is related to, but not identical to, underlying final demand, which is what the linear model's parameters directly determine. Nonetheless, this analysis suggests the conjecture that 2-PMFN fees might nonetheless be more profitable than 0-PMFN fees as long as underlying aggregate demand is not too elastic. Similarly, it suggests the conjecture that 2-PMFN fees might sometimes be less profitable than 0-PMFN fees if underlying aggregate demand is highly elastic. This subsection's results confirm that these conjectures are correct.

Note that in the linear model the responsiveness in aggregate quantity demanded to price is given by $d-b$; this is both the change in quantity demanded for a single platform in response to a common price increase and the change in aggregate quantity demanded in response to a single platform's increase in price. Two times this quantity is the change in aggregate quantity demanded in response to a common increase in price. We will say that aggregate demand is more elastic (less elastic) if $b-d$ is larger (smaller) and that it approaches perfectly inelastic as $b-d$ approaches 0.

Proposition 4 *In the linear model, 2-PMFN profits are higher than 0-PMFN profits if aggregate demand is sufficiently inelastic–that is, if $b-d$ is sufficiently small. Specifically, for any $b>0$, 2-PMFN equilibrium profits are higher than the 0-PMFN profits for all $d>\frac{b}{2}$.*

Proposition 5 *In the linear model, PMFNs lead to fees so high that profits are lower than those that would arise if PMFNs were not adopted if aggregate demand is sufficiently elastic–that is, if $b-d$ is sufficiently large. Specifically, for any $b>0$, 2-PMFN equilibrium profits are lower than the 0-PMFN profits for all $d<\frac{b}{2}$.*

Both propositions are proved algebraically by analyzing $\pi^{2*}-\pi^{0*}$. The individual profit expressions are given in Appendix 2. The sign of this difference can be shown to be of the same sign as $2(2b-d)^2-9b(b-d)$. Substituting $d=\alpha b$ in this expression, it is straightforward to show that the expression is negative if $\alpha<\frac{1}{2}$ and positive if $\alpha>\frac{1}{2}$.

In this particular linear model, aggregate demand elasticity goes hand in hand with product substitutability. When price on one platform increases, that platform loses sales of b; of those b units, some portion d are purchased from the other platform. The remainder, $b-d$, are lost to some outside option. When $b=d$, no buyers are lost to the outside option, and aggregate demand is perfectly inelastic with aggregate quantity equal to $2a$. As d approaches b, more of the buyers who leave one platform are switching to the other, and fewer are dropping out of the market altogether. Thus, an increase in d toward b is an increase in product substitutability; it is also by the algebra of this demand function a decrease in aggregate demand elasticity. This relationship between substitutability and aggregate elasticity does not hold across all demand models, of course. Nonetheless, the results of this subsection can be read–literally in the context of this linear model, or suggestively in a broader sense–with the interpretation that PMFNs are more likely to be attractive and increase platform profits when platforms are closer substitutes.

4 Endogenous adoption of PMFN policies

This section considers stage 1 of the full game, in which firms simultaneously decide whether to endogenously adopt PMFN policies. The above results on whether PMFNs raise profits for the platforms do not suffice to demonstrate whether PMFNs will be adopted in equilibrium when chosen by the platforms simultaneously; rather, we must characterize the outcome when only one firm adopts a PMFN and compare the profits under that equilibrium to 0PMFN and 2PMFN profits. This section continues to employ the symmetric duopoly model.

4.1 General Demand

The results on equilibrium fees and best-response functions can be graphed to develop further intuition about competition under PMFNs and, in particular, about incentives to adopt PMFNs in the first stage of the full game. Figure 1 lays out two sets of best-response functions–those that prevail under 0PMFN and 2PMFN–in a single graph in $f_1 \times f_2$ space. We denote platform i's best-response curve under a scenario with k PMFNs by b_i^k. Best-response functions are for simplicity portrayed as linear, as they are under the linear differentiated product demand model. The two points along the 45-degree line at which b_1^k and b_2^k cross define the 0PMFN and 2PMFN equilibria. The primary value in this figure is in the analysis of competition in the scenario in which only one platform (which we assume to be platform 1) has a PMFN in place. We therefore proceed to construct the best-response functions in this scenario, using bold solid and dashed lines to denote these best-response functions, as indicated in Figure 1.

INSERT FIGURE 1 HERE

First, note that for a particular platform, pricing incentives are determined under either the 0PMFN best-response calculation (there is no PMFN binding and $q^0(f)$ is relevant) or the 2PMFN best-response calculation (there is a PMFN binding and $q^2(f)$ is relevant). Which of these calculations is relevant depends on the relative prices of the two platforms. In particular, the PMFN is irrelevant if $f_1 < f_2$, and the 0PMFN incentives apply. Alternatively, when $f_1 > f_2$, the PMFN binds; the fact that platform 2 does not have a PMFN is irrelevant; and the 2PMFN incentives apply.

Consider platform 2, the platform without the PMFN agreement. At low f_1, platform 2 prices off its b_2^0 curve; since this calls for overpricing the platform with the PMFN, the presence of the PMFN is irrelevant. Once that b_2^0 curve falls below the 45-degree line (at the 0-PMFN equilibrium fee), however, this best-response curve is no longer relevant as the price it dictates will trigger 2PMFN pricing by the seller. Considering this, platform 2 prefers to price off its b_2^2 curve. However, any price above the 45-degree line renders the PMFN not binding, triggering 0PMFN pricing by the seller. As a result, the best response by the non-adopting platform 2 is to match platform 1's fee for all fees between the 0PMFN equilibrium and 2PMFN equilibrium fees. (Put another way, over this range of f_1, profits under the PMFN-binding regime are increasing in f_2 below f_2^2 and profits under the PMFN-not-binding regime are decreasing in f_2 above f_2^0.) Once f_1 exceeds the 2-MFN equilibrium fee, platform 2's b_2^2 is relevant since it prescribes undercutting platform 1, triggering the PMFN policy and making the 2PMFN best-response the relevant curve.

Now consider platform 1. At any f_2 equal to or below the 0-PMFN equilibrium fee, platform 1's best-response is given by b_1^2, which prescribes overpricing platform 2, making the PMFN bind. Since even its 0-PMFN best-response involves overpricing platform 2, the PMFN will certainly be binding; given this, b_2^2 reflects the correct incentives. Thus, f^{0*} cannot be the equilibrium fees under 1PMFN. For any fee equal to or above the 2-PMFN equilibrium fee, platform 1's best-response is given by b_1^0. Since even the PMFN-binding incentives (reflected in the 2-PMFN best-response) imply a best-response fee at which the PMFN is not binding (i.e., lie above the 45-degree line), the PMFN will not be binding and b_1^0 gives the correct best-response. Thus, f^{2*} also cannot be the equilibrium fees under 1PMFN; it follows that there can be no intersection of the relevant best-response functions and no pure-strategy equilibrium in fees under 1PMFN.

Somewhere between the 0- and 2-PMFN equilibrium fees there lies a fee $\widehat{f_2}$ at which firm 1 is indifferent between undercutting and overpricing platform 2's fee. Since firm 1 is indifferent between these two strategies, it is part of a mixed strategy equilibrium for firm 1 to randomize between $b_1^0(\widehat{f_2})$ and $b_1^2(\widehat{f_2})$ with any probabilities σ and $1-\sigma$, respectively. In addition, there is a unique $\hat{\sigma}$ for which $\hat{f}_2$ is the best response of platform 2 to platform 1's mixing strategy; more formally, there exists a $\hat{\sigma}$ such that $\hat{f}_2 = \arg\max_{f_2} \quad \hat{\sigma}\pi_2(b_1^0(f_2), f_2) + (1-\hat{\sigma})\pi_2(b_1^2(f_2), f_2)$. This follows from the continuity of the profit function. If $\hat{\sigma} = 0$ then the argmax is f_2^2, and if $\hat{\sigma} = 1$ then the argmax is f_2^0. There is some $\hat{f}_2$ in between that is the best response of platform 2 to platform 1's mixing strategy $\hat{\sigma}$. This $\hat{f}_2$ and $\hat{\sigma}$ constitute a mixed strategy equilibrium to the simultaneous pricing subgame when only platform 1 has adopted a PMFN policy. This yields the figure as drawn (for an arbitrary and illustrative $\widehat{f_2}$ between the two equilibrium fees). The following proposition follows from this analysis.

Proposition 6 *Assume (A1)-(A5) hold. Then (1) there can be no pure-strategy equilibrium in fees when exactly one firm has a PMFN agreement, and (2) there is a mixed-strategy equilibrium in which firm 2 sets $\widehat{f_2}$ (such that $f_i^{0*} < \widehat{f_2} < f_i^{2*}$) and firm 1 randomizes with appropriate probabilities between $b_1^0(\widehat{f_2})$ and $b_1^2(\widehat{f_2})$.*

Without further structure on demand, it is impossible to evaluate $\widehat{f_2}$ or the profits in this mixed strategy equilibrium. It is therefore not possible to assess in general the profitability of the unilateral adoption of a PMFN policy as required to characterize the equilibrium of the full game with adoption of PMFN policies preceding price-setting. However, this analysis is sufficient to characterize the pure strategy equilibria of the related game in which PMFNs are adopted or not simultaneously with the setting of transaction fees.

Proposition 7 *Consider a game with the alternative timing in which platforms simultaneously set fees and adopt PMFNs in the same stage. Then there are exactly two pure strategy equilibria; one in which both firms adopt PMFNs and set fees f_i^{2*} and one in which both firms do not not adopt PMFNs and set fees f_i^{0*}.*

PMFNs may or may not be adopted in this game depending on the equilibrium selection mechanism. It remains true as in the earlier propositions that either of these equilibria may be the more profitable one for the platforms, depending on the characteristics of demand. Note that this implies that in this game with alternative timing it is possible to experience a coordination trap in two forms: firms might fail to adopt PMFNs when it is profitable and firms might also adopt PMFNs when they raise prices so high as to lower profits. Finally, note that Proposition 3 immediately implies a corollary to this last proposition.

Corollary 8 *Consider a game with the alternative timing in which platforms simultaneously set fees and adopt PMFNs in the same stage, and assume an equilibrium selection rule that eliminates equilibria that are Pareto-dominated from the point of view of the platforms. Then in the unique Pareto-undominated pure strategy equilibrium both platforms adopt PMFNs if aggregate demand is sufficiently inelastic.*

4.2 Linear Demand

The linear demand model allows us to characterize equilibrium adoption in the full game, with simultaneous adoption of PMFN policies preceding simultaneous fee-setting by the platforms. What is required to characterize the conditions for equilibrium mutual adoption of PMFN policies is an understanding of the 1PMFN equilibrium profits. In what follows, asterisks indicate profits under the fees that arise in equilibrium of the ensuing fee-setting subgame, the superscript indicates the number of platforms with PMFN policies, and the subscript indicates the platform, where platform 1 is the adopter in the 1PMFN subgame. If $\pi_i^{0*} < \pi_1^{1*}$ (a single PMFN adopter finds the policy profitable) and $\pi_2^{1*} < \pi_i^{2*}$ (a single PMFN non-adopter finds it profitable also to adopt the policy), then mutual adoption is the unique equilibrium in the full game. We proceed by showing that both of these are true in the linear model when aggregate demand is sufficiently inelastic.

That the first inequality holds is easy to see. The sole adopter's profit is $\pi_1^{1*} = \pi_1^0(b_1^0(\widehat{f}_2), \widehat{f}_2) > \pi_i^0(f^{1*})$. That is, the sole adopter's 1PMFN equilibrium profit is the profit at that firm's best response to a rival's higher price, compared to the 0PMFN equilibrium. This is clearly higher since higher rival's prices directly raise profits under 0PMFN pricing by the seller.

The second inequality is much more complicated to assess, as it requires the non-adopter's profit under 1PMFN, which is a weighted average of being undercut and overpriced by the adopting firm while maintaining the price $\widehat{f}_2$. First, note that being overpriced in the mixed strategy equilibrium is always worse than being in the 2PMFN equilibrium. To see this, note that $\pi_2^2(b_1^2(\widehat{f}_2), \widehat{f}_2) < \pi_2^2(b_1^2(\widehat{f}_2), b_2^2(b_1^2(\widehat{f}_2))) < \pi_2^2(f_1^{2*}, b_2^2(b_1^2(\widehat{f}_2))) < \pi_2^2(f_1^{2*}, f_2^{2*})$. The first of these inequalities follows from the fact that platform 2 would certainly rather be best-responding to the adopter's price (in the figure, platform 2 would rather be on b_2^2, directly above the point at which platform 1 overprices against $\widehat{f}_2$). The second inequality follows from the fact that profits under the 2PMFN equilibrium are decreasing in the rival's fee, and the third inequality follows from the fact that platform 2 would rather be at the 2PMFN equilibrium where f_2^{2*} is a best response to f_1^{2*} than at the lower fee of $b_2^2(b_1^2(\widehat{f}_2))$.

Now, in addition we show, as a sufficient condition, that platform 2 also prefers the 2PMFN equilibrium to being undercut.[3] This seems natural, in the sense that the situation in which platform 1 is able to best-respond to $\widehat{f}_2$ with an undercutting fee, and in which the seller, in turn, is unconstrained by any PMFNs in altering prices to reflect these relative prices, seems very grim indeed for the non-adopting platform 2. However, it does not immediately follow that the non-adopter prefers the

[3] Note that this condition is sufficient but not necessary. What is necessary is that the *weighted average* of the nonadopter's 1PMFN profits under the mixed strategy equilibrium is lower than its 2PMFN profit. For tractability, we focus instead on conditions for which *each component* of that weighted average is smaller.

2PMFN equilibrium to this since it is at least conceptually possible that the 2PMFN pricing is so high that it is preferable to be undercut at some price intermediate to the 0PMFN and 2PMFN equilibrium pricing. The earlier results suggest that this will not be the case when aggregate demand is sufficiently inelastic, so that the 2PMFN fee equilibrium is not so high as to be terribly destructive of platform profits. This is true, although the algebra to prove the result is extremely tedious; it is therefore presented in Appendix 3.

Proposition 9 *Consider the full game, in which platforms simultaneously adopt PMFNs prior to simultaneously setting fees. Then if aggregate demand is sufficiently inelastic, both firms adopt PMFN policies.*

5 The effects of PMFNs on entry incentives

This section explores the effects of PMFNs on entry incentives. Obviously, for symmetric firms, whether PMFNs induce additional entry or curtail entry depends on how they affect equilibrium profits. This follows directly from the results proved earlier on when adoption of PMFNs raises equilibrium platform profits. What is of interest in this section, therefore, is the effect that PMFNs might have on the entry of firms with different characteristics in demand or cost, or on the endogenous selection of those characteristics. We will consider the sequential entry of a firm facing different demand or cost parameters against an incumbent firm with a PMFN in place. Given that PMFNs explicitly rule out a low-price entry strategy for an entrant, and given that such a strategy is likely to be especially important for an entrant who has a lower cost or a lower-value platform, it is natural to assume (as in the conventional wisdom described in the introduction) that a PMFN policy by an incumbent inhibits entry by lower-cost, lower-value platforms. For example, one might expect that adoption of a PMFN by a full-service platform would make entry by platform with a bare-bones, low-cost (and potentially) low-price business model much more difficult, given the constraint it places on the seller's ability to pass through those lower costs or to offer a discount price for transactions through the lower-quality platform. Similarly, one could argue that these same forces would lead an entrant endogenously determining its cost and value characteristics to choose a higher-cost, higher-value position or business model than it might have done otherwise.

To analyze these questions we focus on the linear demand model but allow two kinds of asymmetry. Specifically, we allow $c_2 < c_1$, where firm 1 refers to the incumbent throughout this section. We also permit the possibility that the entrant has a lower value offering, resulting in a reduction in demand of $x > 0$ for any given prices: $\widehat{q}_1(p) = a - bp_1 + dp_2$ and $\widehat{q}_2(p) = a - x - bp_2 + dp_1$. Note that lower x need not reflect an "inferior" platform in a general sense; it is a platform that faces lower demand at given prices, but this may be accompanied by lower variable or fixed costs that make the entrant quite a viable competitor and a potential contributor to total welfare. Similarly, a lower cost need not make a firm a superior creator of value if it is accompanied by a demand disadvantage.

Given the results on equilibrium PMFN adoption above, we assume that the 2PMFN regime will prevail post-entry. This is basically an assumption that either the entrant adopts a PMFN along with the incumbent, or the entrant is asymmetric enough that the fee-setting equilibrium behaves as if there are 2 PMFNs. It is evident in Figure 1 that if the non-adopting platform has a much lower best-response function, there will come to be an intersection of the bolded 1PMFN best-responses where both firms are on their 2PMFN portions of the best-responses; in this case, the (incumbent's) single PMFN is binding because platform 2 is undercutting platform 1 and whether platform 1 (the entrant) in fact has adopted a PMFN policy is irrelevant. We present in Appendix 2 the expressions for the relevant optimal pricing rules, implied demand functions, and equilibrium fees for the asymmetric case.

5.1 The effects on implied demand

The basic logic of this argument that PMFNs skew entry away from lower-cost, lower-value business models and toward higher-cost, higher-value business models can be seen directly from the implied demand functions. Again, the basic intuition is that a firm seeking to compete on the basis of low-price (typically, a demand-disadvantaged or marginal cost-advantaged firm) has a hard time competing when the possibility of undercutting the higher-value, or higher-cost incumbent is precluded.

For the case of x this is evident in the implied demand functions if $\frac{\partial q_2^{2*}}{\partial x} < \frac{\partial q_2^{0*}}{\partial x} < 0$–that is, if increases in x lower demand more quickly in the presence of 2PMFNs. This reflects the seller's inability to discount the lower-value platform in order to attract customers to it. It is easy to check from the (linear) implied demand functions that this is true: $\frac{\partial q_2^{2*}}{\partial x} = -\frac{3}{4} < -\frac{1}{2} = \frac{\partial q_2^{0*}}{\partial x} < 0$.

For the case of $c_2 < c_1$ this is evident in the implied demand functions if $\frac{\partial q_2^{0*}}{\partial f_2} < \frac{\partial q_2^{2*}}{\partial f_2} < 0$–that is, if lowering one's fees in response to one's lower marginal cost has a smaller effect on one's sales in the presence of 2PMFN. It is easy to check from the (linear) implied demand functions that this is true: $\frac{\partial q_2^{0*}}{\partial f_2} = -\frac{b}{2} < -\frac{b-d}{4} = \frac{\partial q_2^{2*}}{\partial f_2} < 0$.

Thus, with respect to choices in both willingness-to-pay and marginal cost, the entrant's residual demand more quickly diminishes as its position deviates from the incumbent's (toward lower costs or lower value) when the incumbent has adopted a PMFN policy. In this sense, the incumbent's PMFN can be said to skew incentives for choice of business model or inhibit entry of low-cost, low-value business models.

5.2 The effects on profits

Of course, a full analysis of the incentives for entry are more complex. The analysis in previous sections suggests that PMFNs may raise *levels* of profits, even as they increase the absolute value of the *slope* of profits in quality or costs (that is, making profits fall more quickly as a platform becomes more downward differentiated). It seems entirely possible that the former effect might outweigh the latter, causing PMFNs to encourage the entry of competing platforms even as they skew incentives for competitive positioning. To make progress in understanding these competing effects, we need to characterize the relationship of profits to competitive position across regimes both with and without PMFNs. For tractability, we pursue this for the case of differentiated products ($x > 0$) with zero costs throughout the model ($c_1 = c_2 = c_S = 0$). We are interested in the entrant's profits as a function of x and as a function of whether the incumbent has adopted a PMFN policy. Because we are interested in entry, we are interested in net profits, accounting for fixed entry costs, which we allow to vary with x. The entrant will enter if $\pi_2^{j*}(x) - k_2(x) \geq 0$, where $j = 0, 2$ indicates whether PMFN policies are adopted. (Recall that we assume that the outcome is as if the entrant follows suit, if the incumbent has already adopted a PMFN policy.) We can establish three facts about the relationship between $\pi_2^{0*}(x)$ and $\pi_2^{2*}(x)$, which form the basis for this analysis.

First, from the results proved in the earlier sections, we know that as $x \to 0$ and $d \to b$, $\pi_2^{2*}(x) > \pi_2^{0*}(x)$. Second, for x not too large relative to a (specifically, $x < \frac{2}{7}a$), both profit functions are downsloping in x ($\frac{\partial \pi_2^{j*}(x)}{\partial x} < 0$, for $j = 0, 2$). This follows from straightforward algebraic manipulation of the derivatives of $\pi_2^{j*}(x)$ with respect to x. This condition is the one that ensures negativity of $\frac{\partial \pi_2^{2*}(x)}{\partial x}$, which is the stronger of the two conditions. Third, for small x, PMFNs make profits diminish more rapidly in the demand disadvantage ($\frac{\partial \pi_2^{2*}(x)}{\partial x} < \frac{\partial \pi_2^{0*}(x)}{\partial x} < 0$). This is intuitive given the earlier result that PMFNs make implied demand decrease more rapidly in the demand disadvantage. This follows from the straightforward comparison of the derivatives of $\pi_2^{j*}(x)$.

5.3 The effects on entry when entrant's quality is exogenous

Together, these facts yield the scenario captured in Figure 2.[4] For small demand disadvantages, PMFN policies raise equilibrium post-entry profits. However, because PMFNs also make profits more sensitive to the demand disadvantage, this relationship may reverse for large enough x. As the demand disadvantage increases, the presence of PMFNs causes the entrant's profit to fall more quickly, implying that the ordering of profits $\pi_2^{0*}(x)$ and $\pi_2^{2*}(x)$ may potentially reverse. As a result, whether the incumbent's PMFN policy encourages or discourages entry depends on the exogenous demand disadvantage x of the entrant and its associated fixed cost $k_2(x)$.

INSERT FIGURE 2 HERE

Figure 2 depicts the effect of PMFNs on entry for any pair of exogenous x and $k_2(x)$. At the top of the figure, fixed entry costs are so high that the entrant does not enter regardless of whether the incumbent adopts a PMFN policy. At the bottom, fixed entry costs are so low that the entrant enters regardless of whether the incumbent adopts a PMFN policy. At left is a region in which the profit-increasing effects of PMFNs encourage the entry of the relatively similar entrant. To be clear, here the entrant would not enter absent a PMFN policy, but does enter when the incumbent adopts PMFN. At right is a region in which the augmentation of the demand disadvantage by the PMFN policy is so strong that it outweighs the profit-increasing effects of PMFNs, and entry of the more demand-disadvantaged entrant is deterred. Again, in this region the entrant would have entered absent the incumbent's PMFN policy but is deterred by that policy. This figure clearly demonstrates both the legitimacy and the limits to the conventional wisdom that PMFNs curtail entry by low-end platforms. The conventional wisdom applies in the shaded region, but only there, when the entrant contemplates entry with an exogenous competitive position. These arguments are summarized in the following proposition (which, in addition, relies only on continuity arguments).

Proposition 10 *Assume that all costs are approximately zero ($c_1, c_2, c_S \simeq 0$) and that a potential entrant has an exogenous differentiated position ($x > 0$). Then the incumbent's adoption of a PMFN policy encourages entry (raises post-entry profits relative to those that arise absent PMFNs) if the entrant is not too differentiated; if the policy discourages entry (lowers post-entry profits relative to those that arise absent PMFNs), it is only for entrants with a sufficiently large difference in position.*

[4] It is easy to graph a numerical example corresponding to this graph. For example, for $a = 10$, $b = 4$, $d = 3$, and $x \in [0, 1]$, the figure looks much like this, with a slight convexity to both profit curves and an intersection at about $\frac{1}{2}$.

5.4 The effects on entry when entrant's quality is endogenous

We can also consider the effect on entry by an entrant that endogenously chooses its competitive position x, by evaluating $\pi_2^{j*}(x) - k_2(x) \geq 0$ for an endogenously chosen $x_2^{j*} = \arg\max_x \pi_2^{j*}(x) - k_2(x)$. For $k_2(x)$ convex enough, the net profit will be concave for $j = 0, 2$, and we maintain this assumption throughout this section. We also restrict x to some compact interval, $x \in X$. Because increases in x correspond to lower quality, it is natural to model k_2 as decreasing. Convexity of $k_2(x)$ then implies that the largest cost savings come from the first departures from symmetry ($x = 0$), with these cost savings becoming smaller at the margin as the platform becomes more downward-differentiated (x increases). Note that the third fact above (that the slope of profit in x is greater under PMFNs) means that PMFNs will bias the entrant's optimal x down (toward more similar platforms). This is most easily seen by considering the fact that the first-order condition under PMFNs at the no-PMFN optimal x must be negative. As a result, if there is an interior optimal x under either regime, then $x_2^{2*} < x_2^{0*}$ (i.e., regardless of whether the other regime has an interior or corner optimum).

Proposition 11 *Assume that a potential entrant chooses its position $x \in X$ after observing the incumbent's PMFN adoption decision, and that the entrant's optimal x is interior to X either with or without PMFNs (or both). Then if entry occurs regardless of PMFN adoption, the entrant chooses a less differentiated position (strictly smaller x) when the incumbent adopts a PMFN policy.*

Whether entry is encouraged or deterred due to the incumbent's PMFN now rests on the profit that is obtainable by the entrant at its optimal competitive position, which may vary with the incumbent's PMFN decision. We must separately determine x_2^{j*}, and then evaluate $\pi_2^{j*}(x_2^{j*}) - k_2(x_2^{j*})$ for each j.

Two possibilities arise. It may be that the optimized net profit $\pi_2^{j*}(x_2^{j*}) - k_2(x_2^{j*})$ is higher under 0PMFN or 2PMFN. When it is higher under 0PMFN this indicates that the incumbent's PMFN policy may deter entry, in the sense that it is reducing the maximal profit available to the entrant. When it is higher under 2PMFN then the incumbent's PMFN policy may encourage entry, in the sense that it is increasing the maximal profit available to the entrant. Given the analysis of the exogenous-x case, it seems natural that the former (entry-deterring) scenario is more likely when the optimal x absent PMFNs is high, which will be the case when cost savings associated with higher x are significant. Similarly, the latter (entry-encouraging) scenario is more likely when the optimal x absent PMFNs is low, as when cost savings are relatively small.

It is possible to use numerical examples to illustrate these possibilities. For simplicity, assume that $k_2(x) = F - w\sqrt{x}$, which is convex as assumed. Fixing w, one can then find the optimal x (which will not depend on the fixed component of cost F), and the profits at that optimal x, net of all costs except F. This then yields the threshold F^j at which entry is realized under the various scenarios. Comparison of this F^j under the 0PMFN and 2PMFN scenarios then determines whether entry is encouraged or discouraged (or unaffected) by the incumbent's PMFN policy. In both of the following examples, $a = 10$, $b = 4$, $d = 3$, and $x \in [0, 1]$.

First consider a case in which cost savings are significant enough to create an interior x_2^{0*} but still relatively small: $w = 1$. Here, $x_2^{0*} = 0.2$ and $x_2^{2*} = 0$. The threshold fixed costs are $F^0 = 8.2$ and $F^2 = 11.1$. Thus, for low fixed costs ($F < 8.2$), there is entry regardless of the incumbent's adoption of a PMFN policy, and the chosen x is reduced by the incumbent's PMFN policy. For intermediate entry costs ($F \in (8.2, 11.1)$), entry occurs only if the entrant incumbent adopts a PMFN policy. For high entry costs ($F > 11.1$), there is no entry regardless of the incumbent's PMFN adoption decision.

Now consider a case with more significant cost savings: $w = 7$. Now, $x_2^{0*} = 1.0$ and $x_2^{2*} = 0.25$. The threshold fixed costs are $F^0 = 13.85$ and $F^2 = 12.75$. For low entry costs ($F < 12.75$), there is entry regardless of the incumbent's adoption of a PMFN policy, and the chosen x is reduced by the incumbent's PMFN policy. For intermediate entry costs ($F \in (12.75, 13.85)$), entry occurs only if the entrant incumbent *does not* adopt a PMFN policy. For high entry costs ($F > 13.85$), there is no entry regardless of the incumbent's PMFN adoption decision. This case is depicted in Figure 3.

INSERT FIGURE 3 HERE

This case, in which cost savings are sufficiently high that an entrant would choose a substantially different position from the incumbent absent PMFN policies, illustrates precisely the conventional wisdom. Here, for low fixed costs, there is entry regardless of the PMFN policy, but the presence of the policy distorts the entrant's choice of position and leads the entrant to choose a less differentiated and higher-end business model. For intermediate fixed costs, the PMFN deters entry that would have occurred absent the policies, because the entrant would have maximized its profits by choosing a very differentiated position that is penalized too heavily by the PMFN. This illuminates the potential for both deterrence of low-cost business model entry and the distortion of business model choice when entry does occur.

Comparing this case with the prior case, in which cost savings were more modest, also demonstrates the limitations of the conventional wisdom. When an entrant would not choose a very differentiated position absent the incumbent's PMFN policy, the skewing of that position by the PMFN is unlikely to deter entry; in fact, it is quite possible that the price-raising effects of the PMFN will encourage entry that would not have occurred absent the PMFN. Obviously, a full analysis of whether the encouragement, deterrence, or skewing of entry increases or decreases social welfare requires much more structure on both demand and costs, and is beyond the scope of this paper.

6 Conclusion

We study the effects on pricing and entry of platform MFN policies–a type of policy not widely studied in the extant literature, but one that is of increasing interest and importance in antitrust enforcement. We show that platform MFN agreements tend to raise fees charged by platforms and prices charged by sellers, and that these policies are adopted in equilibrium and increase platform profits when aggregate demand is sufficiently inelastic. However, in other cases platform MFNs may raise prices so high that industry profits fall. We also show that the adoption of a platform MFN agreement by an incumbent platform can discourage entry by an entrant if it is sufficiently downward-differentiated; however, when the potential entrant has a business model relatively similar to the incumbent's, platform MFNs actually work to encourage entry through their price-raising effects. Moreover, when entry occurs regardless of the incumbent's adoption of a platform MFN policy, platform MFNs have the effect of distorting the entrant's choice of business model towards a model more similar to that of the incumbent. These results have important implications for ongoing antitrust scrutiny of these policies in ebook, travel website, and credit card markets.

The results on fees and prices imply that competition among platforms is softened, and that fees may rise relative to a scenario with more unrestricted competition, with a similar effect on the seller's prices. To our knowledge there is no empirical work assessing this effect, and there are obvious difficulties in formulating identification strategies that would be capable of isolating the effect of a PMFN from other effects at work in these markets. However, one can also see that these policies, especially in the context of these escalating fees, imply a cross-subsidization from consumers using high-cost or high-fee platforms to consumers using low-cost or low-fee platforms. For example, an ebooks or travel website that offers a sophisticated interface with product reviews, recommendations, a user comments system, and a large inventory for fast shipping, might have a higher cost position relative to a no-frills website or other low-cost sales channel. An interesting particular example of a lower-cost sales channel is the direct phone or internet sales offering of the manufacturer/seller. The PMFN policy of the higher-cost website requires a common price across outlets, implying that the seller cannot sell directly at a lower price, even though this direct sales channel might have much lower costs. As a result, consumers who would be happy to utilize the lower cost sales channel pay the same price as those who utilize the higher-cost channel, implying a sort of cross-subsidization of the high-amenities consumer by the low-amenities consumer. To the extent that the consumer requiring lower amenities is likely to be a lower-income consumer, this represents a kind of regressive income redistribution that might be especially problematic from a policy perspective. In the case of credit cards, this takes the form of a cross-subsidy of the users of high-amenity, high-fee platforms such as "platinum" rewards cards by users of lower-fee platforms such as no-frills credit cards or cash.

In addition to this redistributive effect of the common price given a certain set of choices, there is also the possibility that PMFNs limit choice by either deterring entry of low-cost platforms or skewing entry of platforms away from lower-end business models. As with the cross-subsidy, this seems likely to negatively affect especially those with a lower willingness-to-pay for the product (or at least for the amenities associated with the platform). The effect we describe in this paper is consistent with the relative paucity of no-frills alternatives to conventional travel websites or ebookstores. To the extent there are customers who would prefer to save money by buying through a lower-cost, lower-amenity platform, PMFNs may be limiting options targeting those consumers, driving them in effect to purchase bundled platform amenities they do not value. This has the effect of creating another kind of cross-subsidy from low-valuation/low-income to high-valuation/high-income consumers.

7 Appendix 1

Assume the following conditions hold for the underlying demand function $\widehat{q}(p)$.

(S1) $\widehat{q}(p)$ is a twice differentiable function

(S2) Second order conditions are always satisfied, $\frac{\partial^2 \widehat{q}_i}{\partial p_i^2} \leq 0$, $\frac{\partial^2 \widehat{q}_i}{\partial p_j^2} \leq 0$, and cross-price derivatives are independent of the level of prices, $\frac{\partial^2 \widehat{q}_i}{\partial p_i \partial p_j} = 0$ for $i, j = 1, 2$ and $i \neq j$.

(S3) The usual properties of demand for substitutes hold: $\frac{\partial \widehat{q}_i}{\partial p_i} < 0$, and $|\frac{\partial \widehat{q}_i}{\partial p_i}| > \frac{\partial \widehat{q}_i}{\partial p_j} > 0$ for $i, j = 1, 2$ and $i \neq j$.

(S4) Own and cross-price derivatives are symmetric when evaluated at symmetric prices, $\frac{\partial \widehat{q}_i}{\partial p_i} = \frac{\partial \widehat{q}_j}{\partial p_j}$ and $\frac{\partial \widehat{q}_i}{\partial p_j} = \frac{\partial \widehat{q}_j}{\partial p_i}$ for $p_i = p_j$, $i, j = 1, 2$ and $i \neq j$.

In addition, suppose for now that pass-through rates satisfy the following condition, which will be shown later in this appendix to follow from (S1)-(S4).

(*) $\frac{dp_i^0}{df_i} > \frac{dp^2}{df_i} > 0 \geq \frac{dp_j^0}{df_i}$ for $i, j = 1, 2$ and $i \neq j$; in addition, the pass-through of a common fee

$\overline{f}$ is positive: $\frac{dp_i^k}{d\bar{f}} > 0$, for $i = 1, 2$ and $k = 0, 2$.

It is then relatively straightforward to show that (S1)-(S4) imply that (A1)-(A5) must hold. (A1) and (A2) follow from (S1) and (S2) in a straightforward way. This appendix proves the results for (A3)-(A5). These proofs proceed by differentiating implied demand; recall that this can be written $q_i^k(f) = \widehat{q}_i(p^k(f))$, where $p^k(f)$ gives the multi-platform seller's optimal prices (which depend on the PMFN regime) given platform fees f, and $\widehat{q}_i^k(p)$ is underlying demand (which does not depend on the PMFN regime).

7.1 Proof of (A3)

(A3) states that "implied demand for each platform is downsloping in that platform's own fee, $\frac{dq_i^k}{df_i} < 0$, and aggregate implied demand is downsloping in a common fee (for $f_1 = f_2 = \bar{f}$, $\frac{dq_i^k}{d\bar{f}} < 0$)."

The first part of (A3) can be seen directly by expanding $\frac{dq_i^k}{df_i}$. First consider the case of no PMFNs:

$$\frac{dq_i^0}{df_i} = \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^0}{df_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^0}{df_i} < 0.$$

(S3) and (*) immediately imply that both terms of this sum are negative. Now consider the case of 2 PMFNs:

$$\frac{dq_i^2}{df_i} = \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp^2}{df_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp^2}{df_i} = (\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j})\frac{dp^2}{df_i} < 0.$$

The pass-through rate in the case of 2 PMFN is necessarily identical for the two platforms, allowing terms to be combined. The term in brackets is negative by (S3) and the pass through rate with platform MFNs $\frac{dp^2}{df_i}$ is positive by (*).

The second part of (A3) can similarly be seen directly by expanding $\frac{dq_i^k}{d\bar{f}}$:

$$\frac{dq_i^k}{d\bar{f}} = \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^k}{d\bar{f}} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^k}{d\bar{f}} = (\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j})\frac{dp_i^k}{d\bar{f}} < 0.$$

Symmetry (S4) implies a common pass-through of an increase in a common fee, allowing terms to be combined. The bracketed term is negative by (S3), and the pass through rate $\frac{dp_i^k}{d\bar{f}}$ is positive by (*).

7.2 Proof of (A4)

(A4) states that "quantity demanded is more responsive to one's own fee when there are no platform MFN agreements than when there are two platform MFN agreements: $\frac{dq_i^0}{df_i} < \frac{dq_i^2}{df_i} < 0$."

Again differentiating the expression for implied demand as a function of underlying demand,

$$\frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^0}{df_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^0}{df_i} < \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp^2}{df_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp^2}{df_i}.$$

(S2) and (*) together imply both that the second term on the LHS is negative and that the second term on the RHS is positive. Therefore, it suffices for the inequality that $\frac{dp_i^0}{df_i} > \frac{dp^2}{df_i}$, which is true by (*).

7.3 Proof of (A5)

(A5) states that "quantity demanded is increasing in the rival's fee if and only if there are no platform MFN agreements: $\frac{dq_i^0}{df_j} > 0 > \frac{dq_i^2}{df_j}$."

Again differentiating the expression for implied demand as a function of underlying demand, first for 0 PMFNs:

$$\frac{dq_i^0}{df_j} = \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^0}{df_j} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^0}{df_j} > 0.$$

(S2) and (*) together imply that both terms of this sum are positive. In the case of 2 PMFNs,

$$\frac{dq_i^2}{df_j} = \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp^2}{df_j} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp^2}{df_j} = (\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j})\frac{dp^2}{df_j} < 0.$$

The bracketed term is negative by (S3), and the pass through rate $\frac{dp^2}{df_j}$ is positive by (*).

7.4 Pass-through rates

Now we turn to showing that these pass-through rate relationships stipulated in (*) are implied by (S1)-(S4). This proceeds by implicit differentiation of the multi-platform seller's first-order conditions for its optimal prices as a function of fees $p^k(f)$.

First consider the case of 0 PMFNs. The multi-product seller chooses prices p_i^0, p_j^0 across platforms that maximize:

$$(p_i^0 - f_i - c_s)\widehat{q}_i(p_i^0, p_j^0) + (p_j^0 - f_j - c_s)\widehat{q}_j(p_i^0, p_j^0).$$

The first order condition for product i, FOC_i^0, is given by:

$$(p_i^0 - f_i - c_s)\frac{\partial \widehat{q}_i}{\partial p_i} + \widehat{q}_i(p_i^0, p_j^0) + (p_j^0 - f_j - c_s)\frac{\partial \widehat{q}_j}{\partial p_i} = 0.$$

The second order condition for product i, SOC_i^0, is given by:

$$2\frac{\partial \widehat{q}_i}{\partial p_i} + (p_i^0 - f_i - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_i^2} + (p_j^0 - f_j - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_i^2} \leq 0.$$

Totally differentiating FOC_i^0 w.r.t. f_i,

$$\begin{aligned}\frac{dFOC_i^0}{df_i} \implies & \left(\frac{dp_i^0}{df_i} - 1\right)\frac{\partial \widehat{q}_i}{\partial p_i} + (p_i^0 - f_i - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_i^2}\frac{dp_i^0}{df_i} + \\ & \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^0}{df_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^0}{df_i} + \\ & \frac{dp_j^0}{df_i}\frac{\partial \widehat{q}_j}{\partial p_i} + (p_j^0 - f_j - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_i^2}\frac{dp_i^0}{df_i} = 0 \qquad (1)\end{aligned}$$

Totally differentiating FOC_j^0 w.r.t. f_i,

$$\begin{aligned}\frac{dFOC_j^0}{df_i} \implies & \frac{dp_j^0}{df_i}\frac{\partial \widehat{q}_j}{\partial p_j} + (p_j^0 - f_j - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_j^2}\frac{dp_j^0}{df_i} + \\ & \frac{\partial \widehat{q}_j}{\partial p_j}\frac{dp_j^0}{df_i} + \frac{\partial \widehat{q}_j}{\partial p_i}\frac{dp_i^0}{df_i} + \\ & \left(\frac{dp_i^0}{df_i} - 1\right)\frac{\partial \widehat{q}_i}{\partial p_j} + (p_i^0 - f_i - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_j^2}\frac{dp_j^0}{df_i} = 0 \end{aligned} \tag{2}$$

Re-arranging (1) and (2),

$$\frac{dp_i^0}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_i} - \frac{dp_j^0}{df_i}\left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)}{SOC_i^0} \tag{3}$$

$$\frac{dp_j^0}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_j} - \frac{dp_i^0}{df_i}\left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)}{SOC_j^0} \tag{4}$$

Combining (3) and (4),

$$\frac{dp_i^0}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_i}SOC_j^0 - \frac{\partial \widehat{q}_i}{\partial p_j}(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i})}{SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2} > 0 \tag{5}$$

$$\frac{dp_j^0}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_j}SOC_i^0 - \frac{\partial \widehat{q}_i}{\partial p_i}(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i})}{SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2} \leq 0 \tag{6}$$

The denominators of (5) and (6) are identical and positive, while the numerator is positive in (5) and weakly negative in (6). Expanding the denominator, note that from (S2) each of the terms from expanding $SOC_i^0 SOC_j^0$ is positive and that from (S3)-(S4) own-price derivatives plus other positive terms are greater than cross-price derivatives,

$$4\frac{\partial \widehat{q}_i}{\partial p_i}\frac{\partial \widehat{q}_j}{\partial p_j} + (\text{other positive terms}) - \left(\frac{\partial \widehat{q}_i}{\partial p_j}\frac{\partial \widehat{q}_i}{\partial p_j} + 2\frac{\partial \widehat{q}_i}{\partial p_j}\frac{\partial \widehat{q}_j}{\partial p_i} + \frac{\partial \widehat{q}_j}{\partial p_i}\frac{\partial \widehat{q}_j}{\partial p_i}\right) > 0 \tag{7}$$

The numerator in (5) can be shown to be positive by expanding and noting again that from (S3)-(S4) own price derivatives are larger than cross-price derivatives and that from (S2) each of the second order derivatives are negative.

$$\frac{\partial \widehat{q}_i}{\partial p_i}\left(2\frac{\partial \widehat{q}_j}{\partial p_j} + (p_j^0 - f_j - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_j^2} + (p_i^0 - f_i - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_j^2}\right) - \frac{\partial \widehat{q}_i}{\partial p_j}(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}) > 0 \tag{8}$$

Similarly, the numerator in (6) can be shown to be weakly negative by expanding and using (S2)-(S4),

$$\frac{\partial \widehat{q}_i}{\partial p_j}\left(2\frac{\partial \widehat{q}_i}{\partial p_i} + (p_i^0 - f_i - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_i^2} + (p_j^0 - f_j - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_i^2}\right) - \frac{\partial \widehat{q}_i}{\partial p_i}(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}) \leq 0 \tag{9}$$

Note that in the case of linear demand, the terms involving markups disappear and the numerator in (6) equals zero.

Consider the case of 2 PMFNs. The multi-product seller must choose a single price p^2 (where the superscript denotes $k = 2$) across platforms that maximizes:

$$(p^2 - f_i - c_s)\widehat{q}_i(p^2, p^2) + (p^2 - f_j - c_s)\widehat{q}_j(p^2, p^2).$$

The first order condition, FOC^2, is given by:

$$\widehat{q}_i + \widehat{q}_j + (p^2 - f_i - c_s)\left(\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\right) + (p^2 - f_j - c_s)\left(\frac{\partial \widehat{q}_j}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right) = 0$$

The second order condition, SOC^2, is given by:

$$2\left(\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i} + \frac{\partial \widehat{q}_j}{\partial p_j}\right) + (p^2 - f_i - c_s)\left(\frac{\partial \widehat{q}_i^2}{\partial p_i^2} + \frac{\partial \widehat{q}_i^2}{\partial p_j^2}\right) + (p^2 - f_j - c_s)\left(\frac{\partial \widehat{q}_j^2}{\partial p_j^2} + \frac{\partial \widehat{q}_j^2}{\partial p_i^2}\right) \leq 0.$$

Totally differentiating FOC^2 w.r.t. f_i,

$$\begin{aligned}\frac{dFOC^2}{df_i} \implies & \frac{dp^2}{df_i}\left(\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right) + \\ & \left(\frac{dp^2}{df_i} - 1\right)\left(\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j}\right) + (p^2 - f_i - c_s)\left(\frac{\partial \widehat{q}_i^2}{\partial p_i^2}\frac{dp^2}{df_i} + \frac{\partial \widehat{q}_i^2}{\partial p_j^2}\frac{dp^2}{df_i}\right) + \\ & \frac{dp^2}{df_i}\left(\frac{\partial \widehat{q}_j}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right) + (p^2 - f_j - c_s)\left(\frac{\partial \widehat{q}_j^2}{\partial p_j^2}\frac{dp^2}{df_i} + \frac{\partial \widehat{q}_j^2}{\partial p_i^2}\frac{dp^2}{df_i}\right) = 0 \end{aligned} \tag{10}$$

Re-arranging,

$$\frac{dp^2}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_i}{\partial p_j}}{SOC^2} > 0 \tag{11}$$

The numerator is strictly negative from (S3) and the denominator is weakly negative from (S2).

Finally, it must be shown that at symmetric prices $p_i = p_j = p$, $\frac{dp_i^0}{df_i} > \frac{dp^2}{df_i}$. Recall that from equation (5),

$$\frac{dp_i^0}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_i} SOC_j^0 - \frac{\partial \widehat{q}_i}{\partial p_j}(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i})}{SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2} \tag{12}$$

And multiplying the numerator and denominator of $\frac{dp^2}{df_i}$ by SOC_j^0,

$$\frac{dp^2}{df_i} = \frac{\frac{\partial \widehat{q}_i}{\partial p_i} SOC_j^0 + \frac{\partial \widehat{q}_i}{\partial p_j} SOC_j^0}{SOC^2 SOC_j^0} \tag{13}$$

To show that $\frac{dp_i^0}{df_i} > \frac{dp^2}{df_i}$, it is sufficient to show that $SOC_j^0 + (\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}) < 0$ so that the numerator of $\frac{dp^2}{df_i}$ is smaller, and $SOC^2 SOC_j^0 \geq SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2$ so that the denominator of $\frac{dp^2}{df_i}$ is larger. The former follows directly from expanding SOC_j^0 and using (S2)-(S4). The latter requires some algebra. First note that at $p_i = p_j = p$, $SOC^2 = SOC_i^0 + SOC_j^0 + 2\left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)$. The rest follows easily by factoring terms,

$$SOC^2 SOC_j^0 \geq SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2$$

$$\left(SOC_i^0 + SOC_j^0 + 2(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right) SOC_j^0 \geq SOC_i^0 SOC_j^0 - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2$$

$$SOC_j^0 SOC_j^0 + 2(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i})SOC_j^0 + \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2 \geq 0$$

$$\left(SOC_j^0 + \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)\right)^2 \geq 0$$

Together with equations (5), (6) and (11), this completes the proof that $\frac{dp_i^0}{df_i} > \frac{dp^2}{df_i} > 0 \geq \frac{dp_j^0}{df_i}$.

Finally, we turn to showing $\frac{dp_i^k}{d\bar{f}} > 0$, for $k = 0, 2$. Beginning with $k = 0$, imposing $f_i = f_j = \bar{f}$ on FOC_i^0, and implicitly differentiating with respect to $\bar{f}$,

$$\begin{aligned} \frac{dFOC_i^0}{d\bar{f}} \implies & \left(\frac{dp_i^0}{d\bar{f}} - 1\right)\frac{\partial \widehat{q}_i}{\partial p_i} + (p_i^0 - \bar{f} - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_i^2}\frac{dp_i^0}{d\bar{f}} + \\ & \frac{\partial \widehat{q}_i}{\partial p_i}\frac{dp_i^0}{d\bar{f}} + \frac{\partial \widehat{q}_i}{\partial p_j}\frac{dp_j^0}{d\bar{f}} + \\ & \left(\frac{dp_j^0}{d\bar{f}} - 1\right)\frac{\partial \widehat{q}_j}{\partial p_i} + (p_j^0 - \bar{f} - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_i^2}\frac{dp_i^0}{d\bar{f}} = 0 \end{aligned} \tag{14}$$

Symmetrically,

$$\begin{aligned} \frac{dFOC_j^0}{d\bar{f}} \implies & \left(\frac{dp_j^0}{d\bar{f}} - 1\right)\frac{\partial \widehat{q}_j}{\partial p_j} + (p_j^0 - \bar{f} - c_s)\frac{\partial^2 \widehat{q}_j}{\partial p_j^2}\frac{dp_j^0}{d\bar{f}} + \\ & \frac{\partial \widehat{q}_j}{\partial p_j}\frac{dp_j^0}{d\bar{f}} + \frac{\partial \widehat{q}_j}{\partial p_i}\frac{dp_i^0}{d\bar{f}} + \\ & \left(\frac{dp_i^0}{d\bar{f}} - 1\right)\frac{\partial \widehat{q}_i}{\partial p_j} + (p_i^0 - \bar{f} - c_s)\frac{\partial^2 \widehat{q}_i}{\partial p_j^2}\frac{dp_j^0}{d\bar{f}} = 0 \end{aligned} \tag{15}$$

Combining yields (14) and (15), as similarly done for equations (1) and (2), yields

$$\frac{dp_i^0}{d\bar{f}} = \frac{(\frac{\partial \widehat{q}_i}{\partial p_i} + \frac{\partial \widehat{q}_j}{\partial p_i})SOC_j^0 - (\frac{\partial \widehat{q}_j}{\partial p_j} + \frac{\partial \widehat{q}_i}{\partial p_j})(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i})}{\left(SOC_i^0 SOC_j^0\right)|_{f_i=f_j=\bar{f}} - \left(\frac{\partial \widehat{q}_i}{\partial p_j} + \frac{\partial \widehat{q}_j}{\partial p_i}\right)^2} > 0 \tag{16}$$

Both terms in the numerator are positive from (S2)-(S4), and the denominator was previously shown to be positive in equation (6).

Turning to $k = 2$, imposing $f_i = f_j = \bar{f}$ on FOC^2, and implicitly differentiating with respect to $\bar{f}$,

$$\frac{dFOC^2}{d\bar{f}} \implies \frac{dp^2}{d\bar{f}}\left(\frac{\partial\widehat{q}_i}{\partial p_i}+\frac{\partial\widehat{q}_i}{\partial p_j}+\frac{\partial\widehat{q}_j}{\partial p_j}+\frac{\partial\widehat{q}_j}{\partial p_i}\right)+ \left(\frac{dp^2}{d\bar{f}}-1\right)\left(\frac{\partial\widehat{q}_i}{\partial p_i}+\frac{\partial\widehat{q}_i}{\partial p_j}\right)+(p^2-\bar{f}-c_s)\left(\frac{\partial\widehat{q}_i^2}{\partial p_i^2}\frac{dp^2}{d\bar{f}}+\frac{\partial\widehat{q}_i^2}{\partial p_j^2}\frac{dp^2}{d\bar{f}}\right)+ \left(\frac{dp^2}{d\bar{f}}-1\right)\left(\frac{\partial\widehat{q}_j}{\partial p_j}+\frac{\partial\widehat{q}_j}{\partial p_i}\right)+(p^2-\bar{f}-c_s)\left(\frac{\partial\widehat{q}_j^2}{\partial p_j^2}\frac{dp^2}{d\bar{f}}+\frac{\partial\widehat{q}_j^2}{\partial p_i^2}\frac{dp^2}{d\bar{f}}\right)=0 \quad (17)$$

Re-arranging,

$$\frac{dp^2}{d\bar{f}}=\frac{\frac{\partial\widehat{q}_i}{\partial p_i}+\frac{\partial\widehat{q}_i}{\partial p_j}+\frac{\partial\widehat{q}_j}{\partial p_j}+\frac{\partial\widehat{q}_j}{\partial p_i}}{SOC^2|_{f_i=f_j=\bar{f}}}>0 \quad (18)$$

The numerator is negative from (S3), and the denominator is just the second order condition and negative from (S2).

8 Appendix 2

8.1 Closed-form expressions for the symmetric demand case

In the symmetric linear case, we can derive closed form expressions for equilibrium fees under each regime, and thus equilibrium profits. These are given by:

$$f_i^{0*}=\frac{a+b(c_i-c_s)+dc_s}{2b-d}$$

$$f_i^{2*}=\frac{2a+(b-d)(c_i-2c_s)}{3(b-d)}$$

$$\pi_i^{0*}=\frac{b(a-(b-d)(c_i+c_s))^2}{2(d-2b)^2}$$

$$\pi_i^{2*}=\frac{(a-(b-d)(c_i+c_s))^2}{9(b-d)}$$

8.2 Closed-form expressions for the asymmetric demand case

In the asymmetric linear case, we can derive closed form expressions for the optimal pricing rule, implied demand function, and equilibrium fees under each regime. These are given by:

$$p_i^0(f)=\frac{a(b+d)+b^2(c_s+f_i)-d(d(c_s+f_i)+x)}{2(b^2-d^2)}$$

$$p_j^0(f)=\frac{a(b+d)+b^2(c_s+f_j)-d^2(c_s+f_j)-bx}{2(b^2-d^2)}$$

$$p_i^2(f)=\frac{2a+(b-d)(2c_s+f_i+f_j)-x}{4(b-d)}$$

$$q_i^0(f) = \frac{1}{2}(a - b(c_s + f_i) + d(c_s + f_j))$$

$$q_i^2(f) = \frac{1}{4}(2a + 2dc_s + d(f_i + f_j) - b(2c_s + f_i + f_j) + x)$$

$$f_i^{0*} = \frac{2b^2(c_i - c_s) + bd(c_i + c_s) + d(dc_s - x) + a(2b + d)}{4b^2 - d^2}$$

$$f_i^{2*} = \frac{2a + (b - d)(c_i - 2c_s) + 5x}{3(b - d)}$$

9 Appendix 3

With linear demand, platform 2's profits at the 2MFN fee equilibrium are:

$$\pi_2^{2*} = \pi_2^2(f_1^2, f_2^2) = \frac{1}{36(b-d)}\,(2a - (b-d)(c_1 + c_2 + 2c_s))$$

and platform 2's profits in the 1MFN mixed-strategy fee equilibrium when undercut by platform 1 are:

$$\pi_2^0(b_1^0(\hat{f}_2), \hat{f}_2) = (1/2)(\hat{f}_2) - c_2)(a + dc_s - b(\hat{f}_2 + c_s) + (1/2b)\left(d(a + b(c_1 - cs) + d(\hat{f}_2 + c_s)\right)$$

where $\hat{f}_2$ is given by:

$$\hat{f}_2 = \frac{b-d}{b^2 - 3bd + 2d^2}(2(a - (b-d)c_s) - bc_1) \pm \sqrt{2}\sqrt{b(a - (c_1 + c_s)(b-d))^2(b-d)}$$

Substituting $\hat{f}_2$ into $\pi_2^0(b_1^0(\hat{f}_2), \hat{f}_2)$ and defining $Z = \pi_2^2(f_1^2, f_2^2) - \pi_2^0(b_1^0(\hat{f}_2), \hat{f}_2)$, any parameter values for which $Z \geq 0$ support PMFN adoption by platform 2. It is helpful to define $h = \frac{d}{b} \in (0,1)$; by substituting $d = hb$, this simplifies the expressions greatly. Under the maintained assumption of symmetry ($c_1 = c_2$), it can be shown that

$$sign(Z) = sign(2\left(38 + h - 28h^2\right) \pm 9\sqrt{2 - 2h}\left(-6 - 3h + 2h^2\right)).$$

For any h, $\left(38 + h - 28h^2\right) > 0$ and $\left(-6 - 3h + 2h^2\right) < 0$. Therefore the negative root guarantees $Z \geq 0$. For the positive root, it can be shown that $Z \geq 0$ for h larger than the value of a complex expression that can be shown numerically to be approximately 0.303.

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Figure 1: Best-responses with asymmetric PMFN adoption

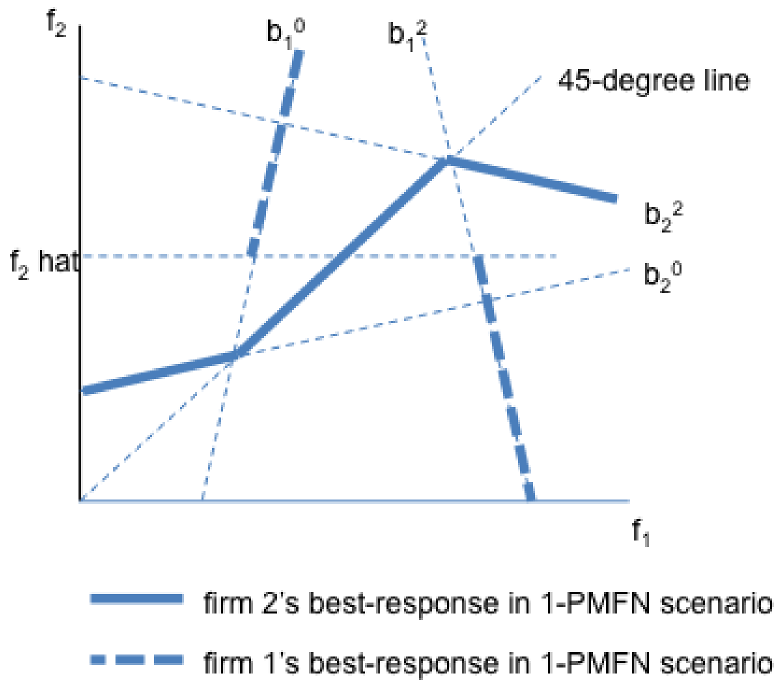


Figure 2: The effects of PMFNs on entry with exogenous position

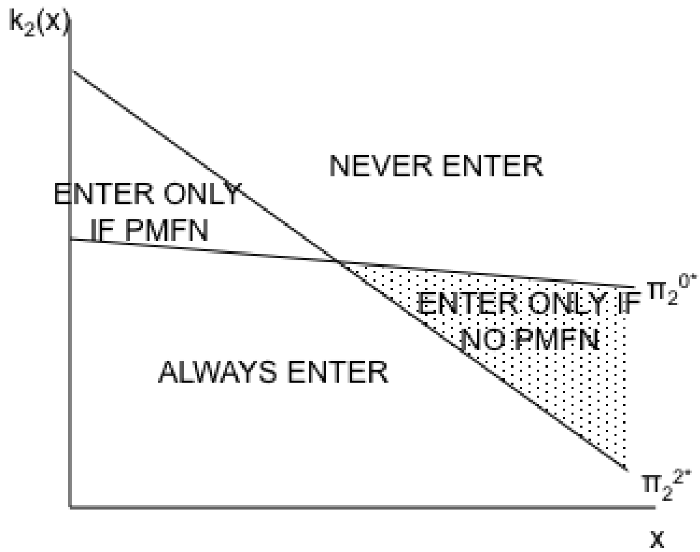
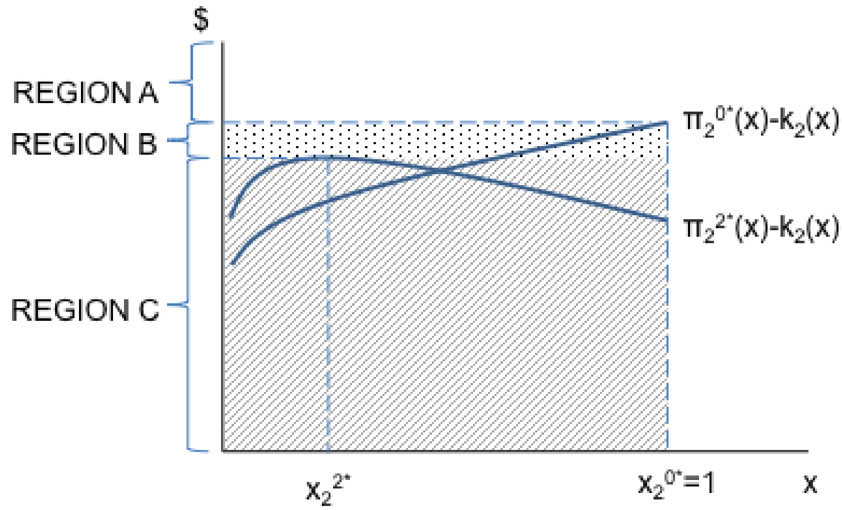


Figure 3: The effects of PMFNs on entry with endogenous position



F in REGION A: incumbent's PMFN has no effect; no entry
F in REGION B: incumbent's PMFN deters entry
F in REGION C: incumbent's PMFN does not deter entry, but does distort entrant's position