Predatory Platforms *

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Abstract

The ability of buyers and sellers to transact directly limits the market power of an intermediary but creates incentives for the intermediary to predate bilateral exchanges. We provide a model of predation by a platform in which in equilibrium the intermediary chooses an inefficient random matching technology and fee-setting to pre-empt the emergence of a competing exchange. We show that this kind of predation is profitable and reduces both consumer surplus and social welfare if the competing exchange is sufficiently efficient. These conclusions are robust to a variety of alternative specifications.

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JEL-Classification: C72, D41, D43, L13.

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1 Introduction

Fee-charging intermediaries, such as Booking.com, Expedia, Uber, and Apple's iTunes, have recently been viewed controversially by policy makers and the public, with one of the concerns being that they extract excessive rents from the two sides of the market.[1] While new Internet intermediaries have been particularly prominent, the debate on excessive rents by intermediaries goes back much longer, through the investigations of real-estate brokers by the Department of Justice and the conviction of Sotheby's and Christie's for collusion in the 2000s,[2] the International Labor Organization's call for a ban of private fee-charging employment agencies, to the referendum on banning private labor market intermediaries in Washington state in 1914.[3]

The two most wide-spread forms of intermediation are price posting and fee-setting. A price posting intermediary posts a bid and an ask price at which buyers and sellers can trade and earns the bid ask spread. Examples include used car dealers, currency exchange offices, and specialists in stock markets. Fee-setting intermediaries charge transaction fees and let buyers and sellers bargain over the transaction price. Examples include real-estate brokers, auction houses and websites like Sotheby's, Christie's and eBay, head hunters, and stock brokers.

The market power of an intermediary is limited by the ability of buyers and sellers to circumvent the intermediary's exchange and to transact directly with each other. By itself, the self-correcting tendency of two-sided markets to tame the market power of platforms is welcome news to lawmakers, regulators, and antitrust authorities who strive to protect the public's interests and contrasts with monopoly producers who face no such

[1] In Europe, online hotel booking sites Booking.com and Expedia have come under scrutiny of antitrust authorities, in the wake of which the platforms have abandoned their "favorite nation" clauses. The Apple e-books case is another prominent example of an intermediary – Apple as the provider of the iPad, contracting with publishing companies – alleged of and fined for aiming to foreclose an alternative exchange. Most recently, it has been argued that Uber is trying to "corner" capital required to subsidize drivers in emerging markets like India and China; see, for example, see http://www.nytimes.com/2016/06/21/business/dealbook/why-uber-keeps-raising-billions.html?_r=0

[2] Competitive concerns were also at the source of investigations of the US Department of Justice on real-estate brokerage in 1983 and 2007 (see e.g. DOJ, 2007) and allegations of (and convictions for) collusion by the auction houses Sotheby's and Christie's (see e.g. Ashenfelter and Graddy, 2005).

[3] The International Labor Organization of the United Nations passed a convention in 1949 that banned private fee-charging employment agencies, to be revoked by a second convention by the International Labor Organization only as late as 1997. See conventions C96 and C181 of the International Labor Organization, C96 Fee-Charging Employment Agencies Convention (Revised), 1949, http://www.ilo.org/ilolex/cgi-lex/convde.pl?C096, C181 Private Employment Agencies Convention, 1997, http://www.ilo.org/ilolex/cgi-lex/convde.pl?C181. Similar developments were also present in the US: in 1914 a referendum in Washington state banned private labor market intermediaries, a law that was later overruled by the US supreme court. See Adams v. Tanner, 244 U.S. 590 (1917) and a description of the controversy in Foner (1965, p. 177-185).

countervailing constraints.[4] However, it also provides intermediaries with incentives to foreclose or reduce the efficacy of alternative transaction possibilities for traders and, to the extent that such foreclosure is possible and profitable, the public with a new concern for anticompetitive behavior.

This paper provides an equilibrium analysis of an intermediary's incentives to predate an alternative exchange. We study a setup with a continuum of buyers and sellers in which, all else equal, price posting is the optimal mechanism for the monopoly intermediary. However, while a profit-seeking intermediary sets a positive bid-ask spread, buyers and sellers with values and costs within the price gap cannot beneficially trade with the intermediary but possibly and plausibly with each other. Consequently, price posting comes hand-in-hand with a competing exchange, whose efficiency reduces the profit of the price posting intermediary because it raises the value of the outside option even for the agents who in equilibrium trade with the intermediary. This raises the question of what the intermediary could do to avoid being deprived of profits by increasingly efficient bilateral exchanges.

We contrast price posting with the other common mode of intermediation, fee setting. We assume that the intermediary can employ a large number of brokers who use fee-setting, matching buyers and sellers randomly in pairs across brokers.[5] Buyers and sellers bargain in this random matching market, which leads to price dispersion: the transaction price varies due to the idiosyncratic preferences of the involved buyer and seller in a specific match. Price dispersion makes the bid-ask spread disappear: Even buyers with low valuations and sellers with high costs trade with positive probability, provided that they randomly meet a particularly motivated trading partner. Without a gap between the bid and the ask price, no traders have an incentive to go to the bilateral market from the intermediary, so that the bilateral market dries out. This shows that predation of the alternative exchange is possible. Various specifications of our model then establish that predation is profitable if the random matching market is sufficiently efficient. For these specifications, it is also the case that whenever predation occurs it is harmful to society although profitable predation need not be socially harmful universally (as we show in the Appendix).

To the best of our knowledge, ours is the first paper to analyze an intermediary's incentives and options to predate an alternative exchange. Notwithstanding prophecies

[4] As a case in point, Picasso was in control of the level of his production. The market power of the art dealer trading Picasso paintings, in contrast, is limited by the ease with which owners of these paintings can find buyers without having to rely on the art dealer's services.

[5] The multiple listings service used by real-estate brokers is one device that makes this assumption plausible for the real world.

of a dawning age of disintermediation because of reduced consumer search costs, the emergence of the Internet and e-commerce have gone hand in hand with the emergence of intermediaries and, accordingly, an upsurge of research on two-sided markets. Starting with the pioneering work by Caillaud and Jullien (2001, 2003), Rochet and Tirole (2003, 2006), Anderson and Coate (2005) and Armstrong (2006), this literature has primarily focused on the monopoly platform or competition between platforms, abstracting both from the exact mechanisms the platforms employ to generate surplus and from traders' option to circumvent the platform and trade directly.[6] Two notable exception for the former are Gomes (2014) and Niedermayer and Shneyerov (2014). Competition between price posting intermediaries and competing exchanges fares prominently in the works of Rubinstein and Wolinsky (1987), Stahl (1988), Gehrig (1993), Spulber (1996), Bloch and Ryder (2000), Rust and Hall (2003), Loertscher (2007) and Neeman and Vulkan (2010), which, however, do not address intermediaries' incentives and options to drive out the competing exchanges.

Our paper builds on the existing literature. Participation fees, which are equivalent to price posting, have been analyzed by Niedermayer and Shneyerov (2014), while Loertscher and Niedermayer (2016) analyze fee-setting by brokers from an optimal pricing perspective. These papers assume that there is no competing bilateral exchange[7] or a platform's incentives to foreclose a competing exchange when its efficiency is too high.

In the Industrial Organization literature, predatory practices have received a lot of attention. Predatory pricing is made credible, without invoking differential access to financing, by the presence of learning by doing as analyzed by Cabral and Riordan (1994, 1997), Besanko, Doraszelski, Kryukov, and Satterthwaite (2010), and Besanko, Doraszelski, and Kryukov (2014). In this strand of literature, the cumulative effects of learning-by-doing render predatory pricing credible. In our model it is the continued threat of the emergence of an alternative exchange between buyers and sellers that makes use of predatory fee-setting credible. In both approaches, profitable predation can enhance social welfare. However, the incentives and methods used for predation in the aforementioned literature and the present paper are different and complementary. A novel feature of our model is that a strategic player, the intermediary, may predate the emergence of an alternative exchange, which is not a player.

Our paper also contributes to the literature on intermediation and specifically on real-estate brokerage such as Yavas (1996), Hsieh and Moretti (2003), Rutherford, Springer,

[6] That circumventing the platform is an option will come will not strike any academic as surprising who ever hired a research assistant from a developing country using an online platform.

[7] Equivalently, these papers can be viewed as having a bilateral exchange, for which the payoffs are exogenously given and cannot be influenced by the intermediary.

and Yavas (2005), Levitt and Syverson (2008), Hendel, Nevo, and Ortalo-Magné (2009) and Loertscher and Niedermayer (2016). The use of fee-setting is difficult to reconcile with a principal-agent perspective, but can be explained from an optimal pricing perspective, as we show in our companion paper (Loertscher and Niedermayer, 2016).[8] The choice problem faced by an individual broker in our model under fee-setting is a special case of the model studied in Loertscher and Niedermayer (2016). In the companion paper, we also take the theory to the data and estimate demand and supply under the assumption that payoffs from a bilateral exchange market are exogenous (or that no bilateral exchange market exists). Yavas (1996) has investigated whether real-estate brokers have an incentive to induce inefficiently many trades by matching buyers and sellers "horizontally" rather than "vertically" (i.e. high cost sellers to high value buyers rather than inducing trades amongst the most efficient pairs) because brokers earn commissions that depend on the price and not on the surplus trades generate. While the specifics of the the models and mechanisms are different, we obtain the similar result that under fee-setting horizontal matchings occur with positive probability. This contrasts with price posting, which induces trade amongst the most efficient buyers and sellers with probability one.

The remainder of this paper is organized as follows. Section 2 describes the setup. In Section 3, we derive the main tradeoff at the heart of the model, showing that predation with fee-setting is possible and becomes more attractive as the efficiency of the alternative exchange increases. Section 4 derive the equilibrium and welfare outcomes for a specific parametrization and bargaining protocol in the matching market. In Section 5, we show that our findings are qualitatively robust with respect to a number of alternative assumptions, discuss commitment issues, policy implications, and equilibrium selection. Section 6 concludes. The appendix contains omitted proofs.

2 Setup

Consider a one-period model with a continuum of buyers and a continuum of sellers, each with mass one. Buyers have unit demand and sellers have unit capacities. All agents are

[8] A principal-agent theory explanation of real-estate brokerage fees typically looks like the following. The seller proposes a contract to his broker that makes sure that the broker gets more if he manages to drive up the sales price. Such a theory is inconsistent with many empirical observations from the real-estate brokerage market. To name only one, consider transactions in which both the seller and the buyer have a broker. In such cases both the seller's broker and the buyer's broker – the latter being contractually obliged to act in the buyer's interest – get 3% of the transaction price. The fee of the buyer's broker is clearly inconsistent with a principal-agent explanation of fees: the buyer's broker gets more if the transaction price is higher, i.e. if the outcome is less favorable for the buyer. For more details see Loertscher and Niedermayer (2016, p. 35ff).

risk-neutral, have quasilinear preferences and outside options with value zero. Buyers draw their valuations v independently from the distribution $F(v)$ with support $[0,1]$ and density $f(v) > 0$ for all $v \in [0,1]$ and sellers draw their costs c independently from the distribution $G(c)$ with support $[0,1]$ and density $g(c) > 0$ for all $c \in [0,1]$. We assume that each agent is privately informed about his type (valuation or cost),[9] and we make the standard assumption of Myerson regularity, that is, that the virtual type functions

$$\Phi(v) := v - \frac{1 - F(v)}{f(v)} \quad \text{and} \quad \Gamma(c) := c + \frac{G(c)}{g(c)}$$

are increasing in their arguments (Myerson, 1981). Notice that $\Phi(1) = 1$ and $\Gamma(0) = 0$. As first observed by Bulow and Roberts (1989), $\Phi(v)$ has the interpretation of marginal revenue while $\Gamma(c)$ can be interpreted as marginal cost. Our analysis below will illustrate directly why this is so. Myerson's regularity assumption thus boils down to assuming that marginal revenue is decreasing and marginal cost is increasing in quantity, which is perhaps the most standard assumption in the Industrial Organization literature.[10] Because Φ and Γ are increasing, they are invertible.

For ease of illustration, we will sometimes use the *(Generalized) Pareto distributions* $F(v) = 1-(1-v)^\sigma$ and $G(c) = c^\sigma$ as an example in the following. These distributions are convenient because they exhibit constant elasticities of supply $\eta_s(c) = cg(c)/G(c) = \sigma$ and of demand $\eta_d(v) = (1-v)f(v)/(1-F(v)) = \sigma$.[11] Further, the distributions imply the linear virtual type functions $\Phi(v) = v(1+\sigma)/\sigma - 1/\sigma$ and $\Gamma(c) = c(1+\sigma)/\sigma$. Further, by symmetry of F and G, the Walrasian price satisfying $1 - F(p) = G(p)$ is $p = 1/2$.

For most of the analysis, we impose the following assumption, which turns out to be fairly weak.

Assumption 1 (Elasticity Condition)**.**

$$\Phi^{-1}(0) \leq \Gamma^{-1}(1). \tag{1}$$

We will discuss this assumption in more detail in Section 5.5, show why it is fairly weak, explain why the term "Elasticity Condition" describes it well, and what happens

[9] A qualification is in order. In a specification that assumes Nash bargaining between buyers and sellers, we drop this assumption.

[10] This equivalence is more obvious for $\Gamma(c)$ than for $\Phi(v)$; notice, however, that $\Phi(v)$ is increasing in the willingness to pay v. Therefore, the function $MR(q) := \Phi(F^{-1}(1-q))$, which is marginal revenue as a function of quantity demanded q, is decreasing in q.

[11] We are simplifying terminology here. Technically speaking, F is a finite support Generalized Pareto distribution and G is a mirrored finite support Generalized Pareto distribution. While the elasticity of supply is the standard definition, the elasticity of demand is mostly defined as $vf(v)/(1-F(v))$, but for dealing with markets with intermediaries, the above definition is more convenient.

if this assumption does not hold. For now, observe that for the Pareto distributions described above, the condition boils down to $\sigma \geq 1$, that is, that the elasticity of demand and supply are weakly larger than one.

We assume that there is a single intermediary or platform that is a strategic player. Buyers and sellers can trade via this intermediary, choose to remain inactive, or to try to trade in a bilateral matching market in which the matching probability is $\lambda \in [0, 1]$ if the mass of buyers and sellers is the same. This matching probability as well as the bargaining protocol in the matching market are commonly known. In Section 3, we will take a general reduced-form approach to the payoffs accruing from the bilateral matching market. In Section 4, we will analyze the model under specific bargaining protocols such as randomized take-it-or-leave-it offers, Nash bargaining, double-auctions, and what we call fixed-price bargaining.

Throughout the paper, we assume that the intermediary moves first and chooses a mechanism. Observing the mechanism, buyers and sellers simultaneously decide whether to join the intermediated market, the bilateral matching market, or to remain inactive. We assume that all agents whose expected payoff from participating in any market is zero remain inactive. This can be justified as the limit of a slightly richer model in which a positive fixed cost of market participation goes to zero. Below, we will be more specific about the mechanisms available to the intermediary.

3 Market Structures and Trading Mechanisms

In this section, we first describe the various mechanisms available to the intermediary and the equilibrium that ensues as a function of the intermediary's choice.

3.1 Price Posting

Monopoly Let us start with a simple setup, in which there is no bilateral exchange. This can also be viewed as the case when a bilateral exchange exists, but is completely inefficient, so that buyers and sellers meet with probability $\lambda = 0$.

Under **monopoly price posting**, the intermediary chooses a pair of prices (p_B, p_S) to maximize his profit

$$(p_B - p_S) \min\{1 - F(p_B), G(p_S)\},$$

where $\min\{1 - F(p_B), G(p_S)\}$ is the quantity traded. As there is no point leaving money on the table, at the optimal prices p_B^0 and p_S^0 we will have

$$1 - F(p_B^0) = G(p_S^0). \tag{2}$$

We refer to this as *monopoly price posting* because the intermediary posts prices and is a monopoly insofar as buyers and sellers do not have any other alternative to trade than via the intermediary. It is useful to model price posting simply as choosing a quantity q and letting prices adjust to clear the market. Inverting $1 - F(p_B) = q$ and $G(p_S) = q$, we get $p_B = F^{-1}(1-q)$ and $p_S = G^{-1}(q)$. Thus, the intermediary's profit maximization problem is equivalent to maximizing

$$\Pi_p(q) := (F^{-1}(1-q) - G^{-1}(q))q$$

over q. The first-order condition is

$$0 = F^{-1}(1-q^*) - \frac{q^*}{f(F^{-1}(1-q^*))} - G^{-1}(q^*) - \frac{q^*}{g(G^{-1}(q^*))}. \tag{3}$$

Substituting $p_B^0 = F^{-1}(1-q^*)$ and $p_S^0 = G^{-1}(q^*)$, this is equivalent to

$$0 = \Phi(p_B^0) - \Gamma(p_S^0). \tag{4}$$

Because Φ and Γ are monotone functions, it follows that the second-order condition is satisfied, implying that (3) and (4) characterizes the unique maximum. The derivation also illustrates why or in what sense Φ and Γ, respectively, have the interpretation of marginal revenue and marginal cost as first observed by Bulow and Roberts (1989).[12]

Consider, for example, the specification with the Generalized Pareto distributions mentioned above. For this specification, equations (2) and (4) are equivalent to

$$p_B^0 = \frac{1}{2} + \frac{1}{2(1+\sigma)} \quad \text{and} \quad p_S^0 = \frac{1}{2} - \frac{1}{2(1+\sigma)} \tag{5}$$

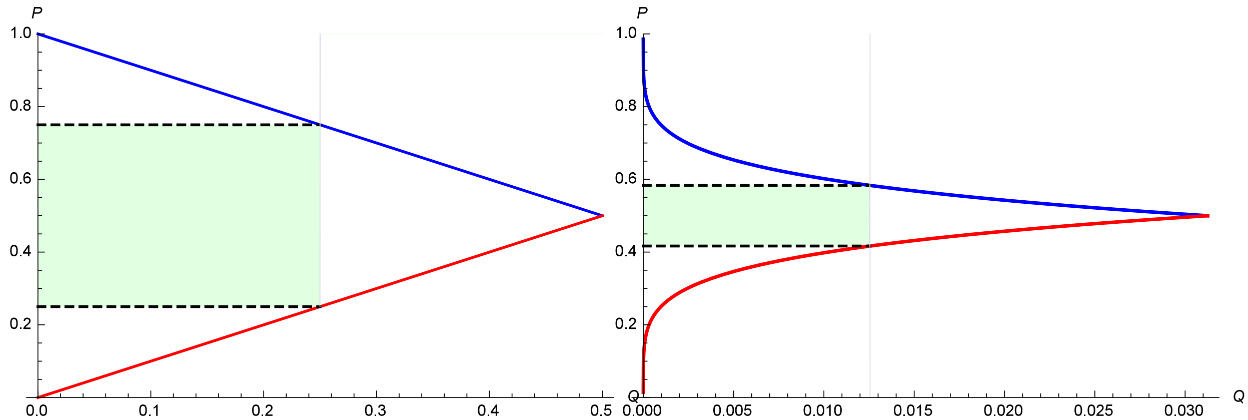
and to the quantity traded being $q^* = \sigma^\sigma(1+\sigma)^{-\sigma}2^{-\sigma}$. Because the bid-ask spread is $p_B^0 - p_S^0 = \frac{1}{1+\sigma}$, it follows that the intermediary's profit is

$$\Pi_p^0 = \frac{1}{1+\sigma}\left(\frac{\sigma}{1+\sigma}\right)^\sigma 2^{-\sigma}. \tag{6}$$

Increases in the elasticity of supply and demand, parameterized by σ, reduce the bid-ask spread.

The ratio of equilibrium quantity traded over the efficient quantity traded is $\left(\frac{\sigma}{1+\sigma}\right)^\sigma$, which is decreasing in σ, equal to $1/2$ at $\sigma = 1$ and converging to $1/e$ as σ goes to infinity. As the elasticity of supply and demand increases, the monopoly intermediary charges a smaller spread and trades a smaller quantity (even relative to the efficient quantity, which also decreases in σ). Consequently, profits under price posting decrease in σ. This is illustrated in Figure 1. With $\sigma = 1$, both distributions are uniform and we

[12] See the Appendix for the optimality of price posting.



(a) $\sigma = 1$ (b) $\sigma = 5$

Figure 1: Price posting for $\sigma = 1$ and $\sigma = 5$ for $F(v) = 1 - (1 - v)^\sigma$ and $G(c) = c^\sigma$ with equilibrium prices $p_B^0 = \frac{1}{2} + \frac{1}{2(1+\sigma)}$ and $p_S^0 = \frac{1}{2} - \frac{1}{2(1+\sigma)}$ and profits as shaded areas in between these price gaps.

have $p_B^0 = 3/4$ and $p_S^0 = 1/4$ and a profit of $\Pi_p = 1/8$, as illustrated in the left-hand panel.

Alternative mechanisms with the same allocation rule (that make no payments to and require no payments from agents who do not trade) induce the same profit and are therefore equivalent to price posting. An example in this class of alternative yet equivalent mechanisms is a mechanism with **fixed participation fees**. Suppose, for example, that, like in Niedermayer and Shneyerov (2014), the intermediary charges up-front **participation fees** τ_B from buyers and τ_S from buyers and then allows buyers and sellers to randomly match and bargain by a random proposer game in which the seller makes an offer with probability α and the buyer with probability $1 - \alpha$. In equilibrium, any seller that makes an offer, offers p_B^0; any buyer that proposes offers p_S^0; and only buyers with $v \geq p_B^0$ and sellers with $c \leq p_S^0$ enter. The optimal fixed participation fees $\tau_S = \alpha(p_B^0 - p_S^0)$ and $\tau_B = (1 - \alpha)(p_B^0 - p_S^0)$ extract the same rents as price posting and provide the same incentives, so that the outcome is equivalent to price posting.

Competing Bilateral Random Matching Market Profit maximizing price posting comes with a bid-ask spread $p_B^0 - p_S^0 > 0$. Buyers and sellers with values and costs in the price-gap interval $[p_S^0, p_B^0]$ cannot profitably trade with the intermediary but possibly with each other. We will assume that they do so. In this section, rather than imposing specific assumptions we take a general approach to the payoffs in the random matching market. This is possible at small overhead cost and has the advantage of illustrating the general tradeoffs at work. In the following section, we will consider a variety of specific bargaining protocols, all of which will satisfy the conditions we impose here.

Denote the measure of buyers joining the intermediary with μ_B and the measure of sellers joining the intermediary with μ_S. Further, denote the expected utility a buyer of type v gets if he joins the bilateral market as $\bar{V}_B(v, \mu_B, \mu_S)$. Analogously, denote a seller c's utility from the bilateral exchange as $\bar{V}_S(c, \mu_B, \mu_S)$. The analysis becomes simpler, if the bargaining protocols are such that $\bar{V}_B$ and $\bar{V}_S$ have a single-crossing property. For the buyers, the single crossing-property is the following: if a buyer $\overline{v}$ is indifferent between going to the intermediary (and getting payoff $\overline{v} - p_B$) and going to the bilateral exchange, then all buyers with a higher valuation than $\overline{v}$ will (weakly) prefer going to the intermediary. The single-crossing property is analogous for the seller. We state this formally in the following assumption.

Assumption 2 (Single-Crossing Property)**.** *$\bar{V}_B$ and $\bar{V}_S$ have the single-crossing property. Formally, for any $\overline{v}$, μ_B, μ_S, p_B,*

$$\bar{V}_B(\overline{v}, \mu_B, \mu_S) = \overline{v} - p_B$$

implies $\bar{V}_B(v, \mu_B, \mu_S) \geq v - p_B$ for all $v \geq \overline{v}$. Similarly, for the sellers for any $\underline{c}$, μ_B, μ_S, p_B,

$$\bar{V}_S(\underline{c}, \mu_B, \mu_S) = p_S - \underline{c}$$

implies $\bar{V}_S(c, \mu_B, \mu_S) \geq p_S - c$ for all $c \leq \underline{c}$.

This assumption is fairly weak. A sufficient condition for it to hold is the "no overshooting condition" that is satisfied for all standard bargaining protocols we will discuss in the following. Informally, the "no overshooting condition" for buyers states that an increase of a buyer's valuation by Δv, leads to an increase of $\bar{V}_B(v, \mu_B, \mu_S)$ by weakly less than Δv. The idea behind this is that a buyer whose valuation is $v + \Delta v$ will not be able to buy at a price that is lower than a buyer whose valuation is v, the price might be the same (in which case his utility is larger by Δv) or higher. The same holds for the seller. Formally, the "no overshooting condition" is

Assumption 3 (No Overshooting Condition)**.** *For all v, μ_B, μ_S,*

$$\frac{\partial \bar{V}_B(v, \mu_B, \mu_S)}{\partial v} \leq 1,$$

and for all c, μ_B, μ_S,

$$\frac{\partial \bar{V}_S(c, \mu_B, \mu_S)}{\partial c} \geq -1.$$

Under the single-crossing condition, we can focus attention to buyers with v in $[\overline{v}, 1]$ and to sellers with c in $[0, \underline{c}]$ going to the intermediary for some marginal buyer $\underline{v}$ and marginal seller $\overline{c}$.[13]

We denote by $V_B(v, \overline{v}, \underline{c})$ the expected payoff to a buyer of type v who participates in the matching market, conditional on being matched, when the buyer with the highest type who participates in the matching market is $\overline{v}$ and the seller with the lowest cost who is active in the matching market is $\underline{c}$. Analogously, $V_S(c, \overline{v}, \underline{c})$ denotes the expected payoff of a seller with cost c who participates in the matching market, conditional on being matched, when the buyer with the highest type who participates in the matching market is $\overline{v}$ and the seller with the lowest cost who is active in the matching market is $\underline{c}$.

Given the single-crossing condition, all equilibria will be stratified in the sense that, for given prices (p_B, p_S) satisfying $0 < p_S < p_S < 1$ the least efficient traders – buyers with low valuations and sellers with high costs – remain inactive, traders of intermediate type participate in the bilateral matching market and the most efficient traders – buyers with high values and sellers will low costs – join the intermediary.

In equilibrium, the buyers' of type $\overline{v}$ and the sellers of type $\underline{c}$ will be indifferent between joining the intermediary and the matching market, and the intermediary will post market clearing prices, that is, p_B and p_S will be such that $1 - F(\overline{v}) = q = G(\underline{c})$. Therefore, we can express $\underline{c}$ and $\overline{v}$ as $\underline{c} = G^{-1}(q)$ and $\overline{v} = F^{-1}(1 - q)$. The expected payoffs for the marginal buyers and sellers of matching market participation, conditional on being matched, can thus be expressed as a function of the intermediary's quantity q traded only:

$$V_B(q) := V_B(F^{-1}(1-q), F^{-1}(1-q), G^{-1}(q))$$

and

$$V_S(q) := V_S(G^{-1}(q), F^{-1}(1-q), G^{-1}(q)).$$

Let M_B and M_S be the mass of buyers and sellers who are active in the matching market. We assume that buyers are matched with probability $\lambda \min\{M_S/M_B, 1\}$ and sellers are matched with probability $\lambda \min\{M_B/M_S, 1\}$.

The willingness to pay for intermediated trade by the marginal buyer whose value is $F^{-1}(1-q)$ is thus $F^{-1}(1-q) - \lambda \min\{M_S/M_B, 1\} V_B(q)$. Similarly, the marginal sellers' costs are $\underline{c} = G^{-1}(q)$, and their reservation price for selling to the intermediary is $G^{-1}(q) + \lambda \min\{M_B/M_S, 1\} V_S(q)$. The profit maximization problem for a price posting intermediary who faces a matching market is therefore equivalent to maximizing

$$\Pi_p(q) := (F^{-1}(1-q) - G^{-1}(q) - \lambda V(q))q \tag{7}$$

[13] Formally, we focus on measures such that $\mu_B([\overline{v}, 1]) = 1 - F(\overline{v})$ and $\mu_B((\overline{v}, 1]) = 0$ for buyers and $\mu_S([0, \underline{c}]) = G(\underline{c})$ and $\mu_S((\underline{c}, 1]) = 0$ for sellers.

over q, where

$$V(q) := \min\{M_S/M_B, 1\}V_B(q) + \min\{M_B/M_S, 1\}V_S(q)$$

is proportional to the aggregate payoff of the marginal buyers and sellers from matching market participation.[14] The first-order condition for a maximum is[15]

$$0 = F^{-1}(1-q^*) - \frac{q^*}{f(F^{-1}(1-q^*))} - G^{-1}(q^*) - \frac{q^*}{g(G^{-1}(q^*))} - \lambda[V(q^*)q^*]'. \tag{8}$$

Just like in the case of monopoly price posting the first-order condition (8) can be re-written as

$$\lambda[V(q^*)q^*]' = \Phi(\overline{v}^*) - \Gamma(\underline{c}^*)$$

with $\overline{c}^* = F^{-1}(1-q^*)$ and $\underline{c}^* = G^{-1}(q^*)$. The optimal prices are then $p_B^\lambda := F^{-1}(1-q^*) - \lambda \min\{M_S/M_B, 1\}V_B(q^*)$ and $p_S^\lambda := G^{-1}(q^*) + \lambda \min\{M_B/M_S, 1\}V_S(q^*)$. For example, when F and G are uniform and buyers and sellers in the matching market make randomized take-it-or-leave-it offers with equal probability, we have

$$V_B(q) = \frac{1}{4}(1-2q) = V_S(q),$$

as we show below in Section 4.1. It follows that under these assumptions, we have $V(q) = (1-2q)/2$ and $q^* = 1/4$ just like when $\lambda = 0$. The equilibrium prices, however, depend on λ with $p_B^\lambda = 3/4 - \lambda/8$ and $p_S^\lambda = 1/4 + \lambda/8$, implying a profit of $(2-\lambda)/16$.

While the comparative statics depend, again, on V, the key point here is robust across all specifications. Letting Π_p be the intermediary's profit given optimal quantity q, we have the following:

Proposition 1. *More efficient matching markets, measured by increases in λ, decrease the profit Π_p of the price-posting intermediary.*

Proof. By the envelope theorem, the derivative of $\Pi_p(q^*)$ with respect to λ is $-q^*V(q^*) < 0$. □

3.2 Fee-Setting

Consider a broker who is matched to one buyer whose value is drawn from the distribution $\tilde{F}$ and one seller whose cost is drawn from $\tilde{G}$. Later on, we will show that $\tilde{F}$ and $\tilde{G}$ are left and right truncations of F and G, respectively. Define the corresponding virtual

[14] It is only proportional to the this payoff because it does not include the matching probabilities.

[15] This condition is only necessary; sufficiency will depend on the intricacies of the function $V(q)$ but because it is necessary the global maximizer q^* will satisfy (8).

type function $\tilde{\Phi}(v) = v - (1 - \tilde{F}(v))/\tilde{f}(v)$ and $\tilde{\Gamma}(c) = c + \tilde{G}(c)/\tilde{g}(c)$. We shall maintain the assumptions on F and G for $\tilde{F}$ and $\tilde{G}$.

Assume that the broker uses fee-setting, that is, chooses a fee-function $\omega(p)$ that specifies the commission the broker earns if a transaction occurs at the price p. Observing the function ω and his cost c, the seller chooses the take-it-or-leave-it offer p to maximize his expected profit. The seller's objective function given ω and c is thus to choose p to maximize

$$(1 - \tilde{F}(p))(p - \omega(p) - c),$$

where $1 - \tilde{F}(p)$ is the probability that the buyer accepts because her dominant strategy is to accept whenever $v \geq p$. The broker's problem, then, is to choose the fee function ω, anticipating that the seller will choose the price that maximizes $(1 - \tilde{F}(p))(p - \omega(p) - c)$ but not knowing c. On the surface, this problem is complicated because one needs to know what price the seller with cost c wants to to set, given the fee. Once the seller's behavior is understood for a given fee function, one needs to determine the optimal function $\omega(p)$. In the Appendix, we prove the following proposition, which derives the optimal fee:

Proposition 2. *Define the pricing function $P(c) := \tilde{\Phi}^{-1}(\tilde{\Gamma}(c))$. The fee function that is optimal for the broker is*

$$\omega^*(p) = p - E_{v \sim \tilde{F}}[P^{-1}(v) | v \geq p]. \tag{9}$$

This induces a seller with cost c to set the price $P(c)$.

Proof. The proof of the Proposition follows from Loertscher and Niedermayer (2016) Proposition 2. To make the analysis self-contained, we provide a self-contained proof in the Appendix. □

For the simple illustrative example $\tilde{F}(v) = 1 - (1 - v)^\sigma$ and $\tilde{G}(c) = c^\sigma$ one gets $\omega^*(p) = p/(1 + \sigma)$ by using the implied $\tilde{\Phi}$ and $\tilde{\Gamma}$. With $\sigma = 1$, this specializes to two uniform distributions and we get $\omega(p) = p/2$. To get an idea why this holds, consider an intermediary that sets a percentage fee, $\omega(p) = bp$ for some b. This induces a seller with cost c to set a price $\tilde{P}(c)$ that maximizes $((1 - b)p - c)(1 - \tilde{F}(p))$. This price satisfies the first-order condition $(1 - b)\Phi(\tilde{P}(c)) = c$ of the seller. The intermediary then chooses b to maximize his profits, which are given by integrating over c, $\int_0^{\tilde{P}^{-1}(1)} b\tilde{P}(c)(1 - \tilde{F}(\tilde{P}(c)))d\tilde{G}(c)$. Plugging in the functional forms and solving the first-order condition for b results in $b^* = 1/(1 + \sigma)$. Also observe that $\tilde{P}(c) = P(c)$.

More generally, it can be shown that the optimal fee ω^* induces the seller to set the price $P(c) = \tilde{\Phi}^{-1}(\tilde{\Gamma}(c))$, by solving the first-order condition of the seller's maximization problem. This induces trade to occur if and only if $v \geq P(c) = \tilde{\Phi}^{-1}(\tilde{\Gamma}(c))$ or, equivalently if and only if $\tilde{\Phi}(v) \geq \tilde{\Gamma}(c)$. Recall the Bulow and Roberts (1989) intuition for $\tilde{\Phi}$ and $\tilde{\Gamma}$: They can be viewed as marginal revenue and marginal cost, respectively. Hence, an intuition for the above result is that trade occurs if and only if marginal revenue is larger than marginal cost.

To deal with selective entry into the intermediary's market, first assume that all buyers and all sellers enter, so that $\tilde{F} \equiv F$ and $\tilde{G} \equiv G$. Then buyers with values below $P(0) = \Phi^{-1}(0)$ and sellers with costs above $P^{-1}(1) = \Gamma^{-1}(1)$ will never trade under the optimal fee. Given our assumptions, these types will never join an intermediated market that uses the fee $\omega(p)$. Notice also that the functions $\Phi(v)$ is invariant to truncation from below and $\Gamma(c)$ invariant to truncation from above.[16] Therefore, if only buyers with valuations below some threshold and sellers with valuations above some threshold enter, the virtual type functions remain $\tilde{\Phi} \equiv \Phi$ and $\tilde{\Gamma} \equiv \Gamma$. This implies that the results in Proposition 2 still hold when replacing $\tilde{F}$, $\tilde{G}$, $\tilde{\Phi}$, $\tilde{\Gamma}$ with F, G, Φ, Γ.

Therefore, the optimal fee does not change if only buyers with values $v \geq \Phi^{-1}(0)$ and only sellers with costs $c \leq \Gamma^{-1}(1)$ join the intermediated market. Consequently, by employing enough brokers who set the fee $\omega^*(p)$ to deal with the mass $1 - F(\Phi^{-1}(0))$ of buyers and mass $G(\Gamma^{-1}(1))$ sellers, randomly matching these buyers and sellers in pairs (and randomly ration the long side if there is any) the intermediary can dry out the competing bilateral random matching market: Because of our assumption $\Phi^{-1}(0) \leq \Gamma^{-1}(1)$, the buyer with the *highest* valuation left who could join the bilateral random matching market has value less than $\Phi^{-1}(0)$, which is less than $\Gamma^{-1}(1)$, which is the *lowest* cost of a seller could join the bilateral random matching market.[17] One way to interpret these results is that an intermediary has an incentive to price discriminate if there is a form of "network externality" present, since price discrimination expands the quantity traded through the intermediary.[18]

The expected profit of the intermediary per matched pair whose values and costs are

[16]That is, for $v_0 \in [0,1]$ and $v \in [v_0, 1]$, let $\hat{F}(v) = \frac{F(v)-F(v_0)}{1-F(v_0)}$ with virtual valuation function $\hat{\Phi}(v) = v - \frac{1-\hat{F}(v)}{\hat{f}(v)} = \Phi(v)$ where $\hat{f} = f/(1-F(v_0))$. Similarly, for $c_0 \in [0,1]$ and $c \in [0, c_0]$ the virtual cost function $\hat{\Gamma}(c)$ associated with the distribution $\hat{G}(c) = G(c)/G(c_0)$ satisfies $\hat{\Gamma}(c) = \Gamma(c)$.

[17]Of course, as some agents inevitably remain unmatched under fee-setting, they could ultimately still join a competing exchange. The point we are making here is that fee-setting brokers add an alternative and that search in the brokerage market consumes time and attention. One way to capture the possibility of joining an alternative exchange as the limit of a two-period model where, after period one matching is done, unmatched trading join the competing exchange, with period-two payoffs being discounted two with a discount factor δ. Our model then corresponds to the limit case when $\delta \to 0$.

[18]It should be noted though that in our setup, the form of "network externality" is indirect: it is not about the efficiency of the intermediated market, but about the efficiency of the bilateral market.

drawn from the distributions $F(v)$ and $G(c)$ on $[0,1]$ is

$$\int_0^{P^{-1}(1)} (1 - F(P(c))\omega^*(P(c)))dG(c),$$

where $P(c)$ is the price the seller with cost c sets, $1 - F(P(c))$ is the probability that the buyer accepts this price, and $\omega^*(P(c))$ is the commission the broker earns if a transaction occurs. If F and G are both uniform, we have $P(c) = c + 1/2$, $1 - F(P(c)) = 1/2 - c$ and, as mentioned, $\omega^*(p) = p/2$. Therefore, the broker's expected profit is $1/2 \int_0^{1/2}(c + 1/2)(c - 1/2)dc = 1/24$.

If only buyers with values $v \geq P(0)$ and sellers with costs less $P^{-1}(1)$ come to the broker (these are the agents who can profitably trade with positive probability), the conditional distribution of the buyer's values $v \in [P(0), 1]$ and the seller's costs $c \in [0, P^{-1}(1)]$ are $(F(v) - F(P(c)))/(1 - F(P(0)))$ and $G(c)/G(P^{-1}(1))$, respectively. Accordingly, if this kind of sorting takes place, which is implicitly embedded in our assumption that only agents with positive expected surplus participate, the broker's expected profit per pair needs to be multiplied by the factor $\frac{1}{1-F(P(c))}\frac{1}{G(P^{-1}(1))}$ to account for the conditional distributions. In the uniform-uniform case, this factor is 4 because $F(P(0)) = 1/2 = G(P^{-1}(1))$.

Aggregating over all matched pairs and all brokers, the intermediary's expected profit under fee-setting is

$$\Pi_f := \frac{\min\{1 - F(P(0)), G(P^{-1}(1))\}}{(1 - F(P(0)))G(P^{-1}(1))} \int_0^{P^{-1}(1)} (1 - F(P(c)))[\omega^*(P(c))]dG(c)$$

Ror $F(v) = 1 - (1 - v)^\sigma$ and $G(c) = c^\sigma$, one can show that

$$\Pi_f = \left[\frac{\sigma}{1+\sigma}\right]^\sigma B(1 + \sigma, 1 + \sigma) \tag{10}$$

where $B(x, y) := \int_0^1 t^{x-1}(1 - t)^{y-1}dt$ is the Beta function. For F and G uniform, this simplifies to $\Pi_f = 1/12$.

Regardless of the specifics of the distributions, the key insight here is that, because it is successful in drying out or predating the bilateral matching market, the profit under fee-setting is independent of λ, the parameter measuring the efficiency of the random matching market. This contrasts with price posting, which is not capable of drying out the competing matching market and, therefore, becomes less profitable the larger is λ. Consequently, the profitability of fee-setting relative to price posting increases in λ. The ratio Π_f/Π_p measures the *incentives for predation* via fee-setting. We summarize these findings in the following proposition.

Proposition 3. *(i) Under Assumption 1, predation is possible, that is no traders have an incentive to switch over to the bilateral exchange from the intermediary's market. (ii) The intermediary's incentives for predation increase in* λ.

Proof. The first part follows because the marginal type of a buyer who joins the fee-setting intermediary has a value $\Phi^{-1}(0)$, which by assumption (1) is not more than $\Gamma^{-1}(1)$, which is the marginal seller type who joins the fee-setting intermediary. Therefore, if all buyers with $v \geq \Phi^{-1}(0)$ and all sellers with $c \leq \Gamma^{-1}(1)$ join the intermediated market, there are no buyers and sellers left who can trade to their mutual benefit in the random matching market. The second part follows from the invariance of profits under fee-setting in λ established in the first part of the proposition and from Proposition 1. □

It seems intuitive that the larger is λ, the greater will be the social harm of predatory fee-setting. For the specifications we study below, this will indeed be the case, but it need not always be true because the welfare effects of predation depend on the payoffs from random matching market participation for all agents whereas the incentives for predation only depend on these payoffs for the marginal types.

4 Predation and Standard Bargaining Protocols

The general tension the profit-seeking intermediary faces has been derived above and highlighted in Propositions 1 and 3. In this section, we illustrate this result by showing that predatory fee-setting is an equilibrium outcome for a number of standard bargaining protocols in the random matching market, such as take-it-or-leave-it offers, Nash bargaining, double-auctions, and fixed-price bargaining. Because, as is well known, deriving equilibrium predictions is notoriously difficult for bargaining under incomplete information with general distributions, we assume uniform distributions in this section, that is, $F(v) = v$ and $G(c) = c$.

4.1 Random Proposer Take-it-or-leave-it-offer

An often considered bargaining protocol is the random proposer take-it-or-leave-it-offer. With probability α the buyer makes an offer p_b which the seller can either accept or reject. With probability $1 - \alpha$, the seller makes the take-it-or-leave-it-offer p_s.

The marginal buyer who is indifferent with trading with the intermediary has valuation $\overline{v} = 1 - q$, the marginal seller cost $\underline{c} = q$. Buyers with a valuation below $\underline{c}$ and sellers with costs above $\overline{v}$ do not bother to enter the bilateral market. Hence, in the bilateral market, buyer valuations and seller costs are uniformly distributed on $[\underline{c}, \overline{v}]$. Denote this distribution as $\tilde{G}(x) = \tilde{F}(x) = (x - \underline{c})/(\overline{v} - \underline{c})$.

The optimal price offer $p_b(v)$ of a buyer with value $v \in [\underline{c}, \overline{v}]$ maximizes $(v - p_b)\tilde{G}(p_b)$, yielding $p_b(v) = (v + \underline{c})/2$. Likewise, the optimal offer $p_s(c)$ of a seller with cost $c \in [\underline{c}, \overline{v}]$ is the p_s that maximizes $(p_s - c)(1 - \tilde{F}(p_s))$, yielding $p_s(c) = (\overline{v} + c)/2$. Observe that the offers of the marginal traders – of the buyer with value $\overline{v}$ and the seller with cost $\underline{c}$ – are accepted with probability 1/2. Setting $\underline{c} = q$ and $\overline{v} = 1 - q$, the expected payoff for the marginal seller who is matched to a buyer therefore is

$$V_S(q) = (1-\alpha)(p_s(\underline{c}) - \underline{c})(1 - \tilde{F}(p_s(\underline{c}))) + \alpha \int_{\underline{c}}^{\overline{v}} (p_b(v) - \underline{c}) d\tilde{F}(v) = \frac{\overline{v} - \underline{c}}{2} = \frac{1-2q}{4}.$$

Because this is independent of α, it follows by symmetry that $V_B(q) = V_S(q)$, yielding $V(q) = 2V_S(q) = (1-2q)/2$. It is easy to check that the No Overshooting Condition and hence also the Single Crossing Condition hold.[19]

Plugging this $V(q)$ into the price posting intermediary's profit maximization problem $(F^{-1}(1-q) + G^{-1}(q) - \lambda V(q))q$, we get the maximizer $q^* = 1/4$ and the maximum

$$\Pi_p = \frac{2-\lambda}{16}.$$

As derived before, under fee setting, the intermediary's profit is $\Pi_f = 1/12$. Hence, the intermediary prefers fee setting to price posting ($\Pi_f > \Pi_p$) if $\lambda > 2/3$.

Welfare under price posting generated by trade via the intermediary is 3/16.[20] The surplus generated in the matching market is

$$(1-2q)\lambda \left[\alpha \frac{\int_{1/2}^{1-q} \int_q^{2v-(1-q)} (v-c) dc dv}{(1-2q)^2} + (1-\alpha) \frac{\int_q^{1/2} \int_{2c-q}^{1-q} (v-c) dv dc}{(1-2q)^2} \right] = \lambda \frac{1-2q}{8}|_{q=1/4} = \frac{\lambda}{32},$$

where the term $1 - 2q$ is the mass of traders in the matching market. Therefore, social welfare under price posting is

$$W_p = \frac{3}{16} + \frac{\lambda}{32}.$$

Because welfare under fee-setting is only 1/6, it follows that predation always decreases social welfare.

[19]The single-crossing condition is satisfied because for all $v \in [\underline{v}, \overline{v}]$, $V_B(v, 1-q, q)$ is increasing in v with a slope smaller than 1 because even conditional on being matched such a buyer trades with probability less than 1. For $v > \overline{v}$, the slope of $V_B(v, 1-q, q)$ is, obviously, also positive but depends on whether such a buyer optimally makes offers that are always accepted, which in turn depends on v and q. If the optimal offer is always accepted, the slope is 1 and less otherwise. Because the payoff $V_B(v, 1-q, q)$ is multiplied by the matching probability λ, it follows that the single-crossing condition is always satisfied for buyers. Symmetric arguments apply to sellers.

[20]A simple geometric argument can be used. Social welfare under efficiency is 1/4 while Harberger's triangle to due the intermediary's monopoly power is 1/16.

Under price posting, consumer surplus, defined as the surplus of buyers and sellers and denoted CS_p,

$$CS_p = W_p - \Pi_p = \frac{2+3\lambda}{32}$$

while consumer surplus under fee-setting is $CS_f = 1/12$. Thus, $CS_p > CS_f$ is equivalent to $\lambda > 2/9$, implying that fee-setting is always detrimental to consumer surplus when it is preferred by the intermediary. Consumer surplus under price posting is more responsive to increases in λ than social welfare because increases in λ not only improve the lot of the agents who are active in the matching market but also increase the consumer surplus of agents who trade with the intermediary under price posting. In contrast, social welfare generated by intermediated trade under price posting does not vary with λ because λ only shifts rents.

4.2 Nash Bargaining

Under generalized Nash bargaining, where the buyer with value v gets α of the joint surplus $\max\{v-c, 0\}$ when matched to a seller with cost c, the expected payoff of a buyer of type v conditional on being matched in the random matching market is $\alpha \int_q^v (v-c)dc/(1-2q) = \alpha(v-q)^2/(2(1-2q))$. This implies that the No Overshooting Condition holds ,since an increase of v by Δv is partially bargained away and leads to an increase of the buyers utility by at most $\alpha \Delta v$ (it may be less if the probability of being matched is less than 1 and the probability that $v \geq c$ is less than 1).

The marginal buyer with value $v = 1-q$ has an expected payoff from participating in the matching market, conditional on being matched, of $V_B(q) = \alpha(1-2q)/2$. Analogously, $V_S(q) = (1-\alpha)(1-2q)/2$ can be established under generalized Nash bargaining where the seller gets the share $(1-\alpha)$ of the surplus. Just like with take-it-or-leave-it offers, with generalized Nash bargaining, α does not affect $V(q) = V_B(q) + V_S(q) = (1-2q)/2$, but in contrast to random take-it-or-leave-it offers, α affects the division of the sum of the marginal utilities $V(q)$ into $V_B(q)$ and $V_S(q)$. Consequently, α will affect the equilibrium prices under generalized Nash bargaining but neither the bid-ask spread nor the quantity traded. Moreover, because $V(q)$ is the same under generalized Nash bargaining and under take-it-or-leave-it offers, the intermediary's equilibrium profits will be the same and so will be the conditions under which predation occurs, that is, for $\lambda > 2/3$.

The only payoff-relevant differences regard the surplus that is generated in the random matching market.[21] With generalized Nash bargaining, this surplus is

$$(1-2q)\lambda\frac{\int_q^{1-q}\int_q^v (v-c)dcdv}{(1-2q)^2}|_{q=1/4} = \frac{\lambda}{24},$$

implying that social welfare under price posting and generalized Nash bargaining is

$$W_p = \frac{3}{16} + \frac{\lambda}{24}.$$

A fortiori, predatory fee-setting will reduce social welfare. Consumer surplus with price posting and Nash bargaining is

$$CS_p = W_p - \Pi_p = \frac{3+5\lambda}{48},$$

which for any $\lambda > 1/5$ is larger than the consumer surplus under fee-setting of 1/12.

4.3 Double Auction

In the $k = 1/2$ double-auction, a buyer and a seller submit bids p_b and p_s simultaneously and trade at the price $p = (p_b + p_s)/2$ if and only if $p_b \geq p_s$; see, e.g., Chatterjee and Samuelson (1983); Rustichini, Satterthwaite, and Williams (1994); Satterthwaite and Williams (2002). If buyers' values and sellers' costs are uniformly distributed on $[\underline{v}, \overline{v}]$ and $[\underline{c}, \overline{c}]$, respectively, this double-auction has a Bayes Nash equilibrium in which the buyer with value $v \in [\underline{v}, \overline{v}]$ bids

$$p_b(v) = \frac{1}{4}\underline{c} + \frac{1}{12}\overline{v} + \frac{2}{3}v$$

and the seller with cost $c \in [\underline{c}, \overline{c}]$ bids

$$p_s(c) = \frac{1}{4}\overline{v} + \frac{1}{12}\underline{c} + \frac{2}{3}c,$$

inducing trade whenever $v \geq c + (\overline{v} - \underline{c})/4$.[22] The marginal traders who will be indifferent between participating and being inactive are the seller with cost $\overline{c}$ equal to $p_b(\overline{v})$, that is $\overline{c} = \overline{v} - (\overline{v} - \underline{c})/4$, and the buyer with value $\underline{v}$ equal to $p_s(\underline{c})$, that is $\underline{v} = \underline{c} + (\overline{v} - \underline{c})/4$. Consequently, the masses of active buyers and sellers will be

$$\overline{v} - \underline{v} = \frac{3}{4}(\overline{v} - \underline{c}) = \overline{c} - \underline{c}.$$

[21] There is another difference regarding the single-crossing condition. Because values and costs are common knowledge in a match under Nash bargaining, there is "hold-up" in the sense that an agent is never the residual claimant to the additional surplus he generates.

[22] See, for example, Chatterjee and Samuelson (1983) and Myerson and Satterthwaite (1983), who also observe that this is a second-best mechanism.

The expected payoff of a buyer of type $v \in [\underline{v}, \overline{v}]$ upon being matched is therefore

$$V_B(v, \overline{v}, \underline{c}) = \frac{1}{\overline{c} - \underline{c}} \int_{\underline{c}}^{p_s^{-1}(p_b(v))} [v - (p_b(v) + p_s(c))/2] dc.$$

Substituting $\underline{c} = q$ and $\overline{v} = 1 - q$, we get

$$V_B(q) \equiv V_B(1 - q, 1 - q, q) = \frac{3}{8}(1 - 2q).$$

Again, the No Overshooting Condition and hence the Single-Crossing Property can be shown to hold for this bargaining protocol.[23]

By symmetric arguments, $V_S(q) = V_B(q)$, so that for the $k = 1/2$ double-auction,

$$V(q) = \frac{3}{4}(1 - 2q).$$

The profit maximizing quantity under price posting is still $q^* = 1/4$. The equilibrium prices are

$$p_B^* = \frac{3}{4} - \frac{\lambda}{16} \quad \text{and} \quad p_S^* = \frac{1}{4} + \frac{3\lambda}{16}, \tag{11}$$

yielding and equilibrium spread of $(4 - 3\lambda)/8$ and thus an equilibrium profit of

$$\Pi_p = \frac{4 - 3\lambda}{32}.$$

Therefore, predation occurs in equilibrium if and only if $\lambda > 4/9$.

Equilibrium welfare under price posting is

$$W_p = \frac{3}{16} + \lambda \frac{3}{64},$$

where

$$\frac{3\lambda}{64} = \frac{3(1 - 2q)}{4} \frac{\int_{q+(1-2q)/4}^{1-q} \int_{q}^{v-(1-2q)/4} (v - c) dc dv}{(3(1 - 2q)/4)^2} |_{q=1/4}$$

is the expected social surplus from the matching market, which is larger than W_f.[24]

[23]The single-crossing condition can be shown to be satisfied using analogous arguments to the case with take-it-or-leave-it offers. The payoff of a buyer with value $v \in [\underline{v}, \overline{v})$, who in equilibrium participates in the matching market, increases by less than 1 in v because such a buyer trades with probability less than 1 conditional on being matched. For $v \geq \overline{v}$, the buyer is essentially the residual claimant on the additional surplus he creates because he optimally submit the bid $p_b(\overline{v})$ and induces trade with probability one conditional on being matched. Therefore, the derivative of $V_B(v, 1 - q, q)$ with respect v is 1 for $v \geq \overline{v}$. But, again, because the payoff $V_B(v, 1 - q, q)$ is multiplied by the matching probability λ, it follows that the single-crossing condition is always satisfied for buyers, and analogously for sellers.

[24]To see that this is true, notice that the density of buyers (and of sellers) in the matching market is 1 divided by the mass of active buyers, that is $1/(3(1-2q)/4)$, which is explains the term $1/(3(1-2q)/4)^2$. The surplus of a trade being $v - c$ and trade occurring, as noted, whenever $v \geq c + (1 - 2q)/4$ explains the upper bounds of the inner integral while the lower bound in the outer integral reflects the fact that $\underline{v} = q + (1 - 2q)/4$. Multiplying by the mass of active traders $3(1 - 2q)/4$ gives the result.

Consumer surplus under price posting is the easily seen to be

$$CS_p = \frac{4+7\lambda}{64},$$

which is larger than consumer surplus under fee-setting for any $\lambda > 4/21$.

In passing, we note that under price posting the double auction in the matching market generates higher welfare and higher consumer surplus than take-it-or-leave-it offers and, maybe more surprisingly, than Nash bargaining. As mentioned, desirable properties of the double auction given the uniform distribution have been noted before (see e.g. Myerson and Satterthwaite, 1983). The present finding adds a new element to this list. As it accounts for private information held by the two parties, it cannot be as efficient as Nash bargaining because of the impossibility theorem of Myerson and Satterthwaite. But exactly because it induces bid shading by the buyer and the seller, it prevents the most inefficient buyers and sellers – the buyers with values below 3/8 and the sellers with costs above 5/8 – from entering the matching market, thereby improving sorting and surplus in the matching market relative to Nash bargaining and take-it-or-leave-it offers.

4.4 Fixed-Price Bargaining

With fixed-price bargaining, a buyer-seller pair that is matched either trades at the Walrasian price $p = 1/2$ if both agree, or does not trade. Given that buyers with $v < p$ and sellers with $c > p$ trade with probability 0, they do not enter the market. Therefore, anyone who gets matched trades with probability 1 and the payoff of a buyer conditional on being matched is $v - p$. For the seller it is $p - c$. This clearly implies that the No Overshooting Condition holds. Evaluating the option values of the bilateral market for the marginal buyer with $\overline{v} = 1 - q$ and the marginal seller with $\underline{c} = q$, we get $V_B(q) = 1/2 - q$ and $V_S(q) = 1/2 - q$. This implies for the price posting profit $\Pi_p = (1 - \lambda)/8$. This in turn implies that for $\lambda > 1/3$, the intermediary prefers fee setting to price posting.

Welfare under fee setting is $W_f = 1/6$, whereas under price posting it is $W_p = (3 + \lambda)/16$, that is, always larger than under fee setting. Hence, predatory fee setting is always socially harmful, but preferred by the intermediary if λ is sufficiently large. Consumer surplus under price posting is $CS_p = W_p - \Pi_p = (1 + 3\lambda)/16$, which exceeds the consumer surplus under fee-setting of $1/12$ for any $\lambda > 1/9$.

5 Discussion

In this section, we demonstrate that our findings based on an analysis with uniform distributions and specific bargaining protocols are qualitatively robust in a number of relevant ways. As we depart from the assumption of uniform distributions, we can also relate these equilibrium outcomes to the elasticity of supply and demand.

5.1 Price Elasticity and Equilibrium Predation

To be able to analyze the effect of changes of the elasticity of demand and supply, we derive the above results for general distributions, but fix the bargaining protocol to fixed-price bargaining. Then we specialize the distributions to symmetric Pareto distributions, which allows us to perform a comparative statics with respect to the elasticity of supply and demand.

As mentioned above, a buyer's and a seller's payoff is $v - p$ and $p - c$, respectively, where the Walrasian price p satisfies $1 - F(p) = G(p)$. Therefore, the marginal buyer's option value is $\lambda V_B(q) = \lambda(F^{-1}(1-q) - p)$ and the marginal seller's option value as $\lambda V_S(q) = \lambda(p - G^{-1}(q))$. The intermediary's profits $[F^{-1}(1-q) - G^{-1}(q) - \lambda V(q)]q$, then become $(1-\lambda)[F^{-1}(1-q) - G^{-1}(q)]q$ that is, profits are the same as with $\lambda = 0$, just multiplied by a constant. Therefore, the maximizing q (and also $\overline{v}$ and $\underline{c}$) is the same. The profit can also be obtained from the $\lambda = 0$ case by simply multiplying with a constant, $\Pi_p = (1-\lambda)\Pi_p^0$.

While $\overline{v}$ and $\underline{c}$ remain the same, the intermediary has to adjust his prices as a reaction to the competitive pressure by setting $p_B = (1-\lambda)\overline{v} + \lambda p$ and $p_S = (1-\lambda)\underline{c} + \lambda p$. As $\lambda \to 1$, the prices p_B and p_S converge to the Walrasian price p.

Fee setting is more profitable than price posting, $\Pi_f > \Pi_p = (1-\lambda)\Pi_p^0$ if λ is sufficiently large. There obviously has to be a $\lambda^* \in (0,1)$ such that for $\lambda > \lambda^*$, $\Pi_f > \Pi_p$, and for $\lambda < \lambda^*$, $\Pi_f < \Pi_p$. The reason is that for $\lambda = 0$, we know that price posting results in higher profits, since it is the optimal mechanism as shown in the Appendix. For $\lambda = 1$, $\Pi_p = 0 < \Pi_f$. Therefore, the result follows by continuity and monotonicity.

Welfare under fee setting W_f is as described above. Welfare under price posting can be decomposed into two parts. The surplus created by trade through the intermediary for buyers $v \geq \overline{v}$ and sellers $c \leq \underline{c}$ on the one hand and the surplus created through bilateral trade for buyers $v \in [p, \overline{v})$ and sellers $c \in (\underline{c}, p]$ on the other hand:

$$W_p = \int_{\overline{v}}^{1} (v - p_B) dF(v) + \int_{0}^{\underline{c}} (p_S - c) dG(c) + p_B(1 - F(\overline{v})) + p_S G(\underline{c}) + \lambda \int_{p}^{\overline{v}} (v - p) dF(v) + \lambda \int_{\underline{c}}^{p} (p - c) dG(c).$$

This can be rearranged into

$$W_p = W^* - (1-\lambda)\Delta W$$

where

$$W^* = \int_p^1 (v-p)dF(v) + \int_0^p (p-c)dG(c)$$

is first-best welfare and

$$(1-\lambda)\Delta W = (1-\lambda)\left[\int_p^{\underline{v}} (v-p)dF(v) + \int_{\overline{c}}^p (p-c)dG(c)\right]$$

is the welfare loss due to trade occurring with probability $\lambda < 1$ in the bilateral market. This makes it clear that for λ sufficiently large, price posting is better for welfare than fee setting, $W_p > W_f$.

It is also clear that as λ increases, fee setting becomes more attractive in terms of profits, but less attractive in terms of welfare.

Fixed Price Bargaining and Pareto Distribution The above analysis simplifies further if we assume Pareto distributions $F(v) = 1-(1-v)^\sigma$ and $G(c) = c^\sigma$. The results from fee setting do not depend on the bargaining protocol and are given by the previous analysis. The optimal fee is $\omega(p) = p/(1+\sigma)$ and the intermediary's profit is given by (10); price posting profits in the absence of a bilateral market Π_p^0 are given by equation (6).

As demand and supply become more elastic (σ increases) the optimal fee $\omega^*(p) = p/(1+\sigma)$ decreases, so does the bid-ask spread $p_B^0 - p_S^0 = 1/(1+\sigma)$.

The price set by a seller under fee-setting is $P(c) = c + 1/(1+\sigma)$. Buyers with values greater than $P(0) = 1/(1+\sigma)$ and sellers with costs less than $P^{-1}(1) = \sigma/(1+\sigma)$, trade with positive probability under fee-setting. Because the function $P(c)$ decreases in σ, buyers with lower values and sellers with higher costs will be active when the elasticity increases. Nevertheless, the probability that trade actually occurs decreases in σ, the intuition being that as σ increases, there are more low valuation buyers and more high cost sellers. This more than offsets the less aggressive optimal pricing. Increases in σ decrease the profit from fee-setting like they decrease the profit from price posting, but eventually Π_f decreases faster in σ than Π_p, that is Π_f/Π_p goes to 0 as σ goes to infinity.[25]

While we have stated the above results for Generalized Pareto distributions that exhibit constant elasticities $\eta_s(c) = \sigma$ and $\eta_d(v) = \sigma$ for all v and c, they can be shown

[25] Interestingly, the ratio Π_f/Π_p is increasing in σ for σ close to 1.

to hold in general: An overall increase of the elasticities of demand η_d and supply η_s leads to lower fees and a lower bid-ask spread.

Observe that profit under fee-setting exceeds profit under price posting if and only if $\Pi_f > \Pi_p = (1-\lambda)\Pi_p^0$, which is equivalent to $\lambda > 1 - 2^\sigma(1+\sigma)\sigma B(1+\sigma, 1+\sigma)$, where the right-hand side increases in σ. That is, all else equal, more elastic demand and supply make predation less likely.

For $\sigma = 15$, we have $\omega(p) \approx 0.06p$, which is the empirically observed fee used by real-estate brokers in the U.S. (see e.g. Hsieh and Moretti (2003)). Calibrating the supply side in this way (and assuming that buyers draw their types from a symmetric distribution), we get $\Pi_f \approx 0.00345$ and $\Pi_p^0 \approx 0.0293$. Fee-setting does outperforms price posting when $\Pi_f/\Pi_p^0 \approx 0.118 > 1 - \lambda$, that is, for any $\lambda > 0.882$.

5.2 Policy Implications

A possible policy recommendation implication that would seem to follow from our model is that policy makers concerned with predation by fee-setting intermediaries could simply prohibit the use of such mechanisms and require brokers to use price posting instead. For a variety of reasons that are outside our simple model, this policy recommendation is unlikely to be implementable. For one thing, requiring real-estate brokers to buy and sell houses, like retailers buy and sell all sorts of storable goods, is not going to be feasible in the current, be it alone because of the liquidity constraints these brokers face. However, a more moderate policy intervention that might pre-empt predatory behavior by brokers would be to require brokers to use flat fee mechanisms, i.e. a fixed fee, which is paid when listing the property and which is paid irrespective of whether the property was sold. It can be shown that a flat fee mechanism is equivalent to posted prices in our setup.

The agreement of real-estate brokerage associations with the Department of Justice to stop practices, which have been seen as discriminatory towards flat-fee brokers can be seen as a step in this direction (see DOJ, 2007).[26]

5.3 Self-Enforcing Mechanisms

Our theory provides an explanation for the widely used fee-setting mechanisms and random matching in intermediated markets based on the motive to predate a competing exchange. To the extent that the threat of a competing exchange emerging is sustained,

[26] The allegations were that flat-fee brokers were put at a disadvantage in the Multiple Listing Services, e.g. in cases where a buyer's broker and a seller's broker would usually cooperate, cooperation was refused for flat-fee brokers.

fee-setting is a credible strategy, much like predatory pricing in the presence of a learning curve (Cabral and Riordan, 1994, 1997; Besanko, Doraszelski, Kryukov, and Satterthwaite, 2010; Besanko, Doraszelski, and Kryukov, 2014). Although for the specifications we have studied in the main body of this paper predatory fee-setting is always detrimental to social welfare, like predatory pricing in the presence of a learning curve predatory fee-setting can be socially beneficial. The tradeoff the intermediary faces between price posting and fee-setting depends on the payoffs from competing exchange of the marginal traders whereas the social welfare effect of predation depend on the utility all active agents derive under fee-setting (and price posting). The very purpose of fee-setting is to expand the set of agents who are actively engaged with the intermediary. If the payoffs of the inframarginal traders decline quickly in the competing exchange, predatory fee-setting can be at once profitable and socially beneficial. This is, for example, the case for certain parameter values of the model with binary types that we study in the appendix.

It is remarkable that a market structure that at face value looks very competitive consisting of a large number of active brokers each of whom has a small market share may have predatory effects. What is more, and maybe even more remarkable, is that because it is an optimal mechanism given the matching technology fee-setting is *self-enforcing* in the following sense. Keeping fixed the random matching technology across brokers, the fee $\omega^*(p)$ defined in (9) is optimal given the distributions $F(v)$ and $G(c)$ on $[0,1]$ and optimal when these distributions are truncated, respectively, to $[\Phi^{-1}(0), 1]$ and $[0, \Gamma^{-1}(1)]$, which are the sets of buyer- and seller-types that can trade with positive probability under fee-setting intermediary. More precisely, the fee-setting described above is an optimal mechanism, in the sense that there exists no incentive compatible, individually rational mechanism that could generate higher profits for the intermediary. See the proof of Proposition 2 in Appendix A. See also Tirole (2016) for the importance of time consistency and selection effects for optimal mechanisms.

Similarly, absent a competing random matching market price posting with prices p_B^0 and p_S^0 is self-enforcing: An intermediary who is matched to a buyer-seller pair randomly drawn from the distributions F and G truncated to $[p_B^0, 1]$ and $[0, p_S^0]$, respectively, would optimally still set the prices p_B^0 and p_S^0 (and thereby induce trade with probability 1).[27] More precisely, there exists no incentive compatible, individually rational mechanism that generates higher profits for the intermediary than price posting. We derive this additional result in Appendix B. Given the matching technology, no further commitment

[27]In contrast, for $\lambda > 0$, price posting with the prices p_B^λ and p_S^λ is not self-enforcing: Because $p_B^\lambda < \overline{v}$ and $p_S^\lambda > \underline{c}$, a broker who is randomly matched to a buyer-seller pair whose types are drawn from the distributed F and G truncated, respectively, to $[\overline{v}, 1]$ and $[0, \underline{c}]$ would be better off charging $\overline{v}$ to the buyer and $\underline{c}$ to the seller.

is thus required under fee-setting to induce every broker to stick to the fee $\omega(p)$. The same would be true for price posting when there is no alternative exchange but not when there is. Lack of commitment in the presence of potentially competing alternative exchanges may thus be another, complementary factor that makes fee-setting a self-enforcing arrangement.[28]

5.4 Equilibrium Selection

Multiplicity of equilibria is inevitable in almost any model of two-sided markets with endogenous participation simply because not going to an exchange if no one else does is typically a best response. Not surprisingly, therefore, our model also exhibits multiple equilibria. For example, if one assumes that under price posting the intermediary is not committed to buying from sellers willing to sell regardless of demand, it is always an equilibrium that no buyer and no seller joins the price posting intermediary. This equilibrium is arguably not very compelling as small perturbations to the mechanism (such as a commitment to buy) would get rid of it.[29] Similarly, there is always an equilibrium in which no agent goes to the random matching market. This is so even when there is no intermediary, but again does not strike us as particularly plausible. Surely, it seems, the agents who would all benefit from mutually advantageous trade from would "figure it out".

Our theory of predatory fee-setting, then, rests on the following assumptions. Given posted prices that leave a positive spread, the buyers and sellers with values and costs inside the price gap $[p_S, p_B]$ would figure out that there are gains from joining the random matching market. Consequently, assuming a positive bid-ask spread $p_B - p_S$, our assumption is that the random matching market is active whenever $\lambda > 0$. For any given posted prices, however, any buyers and sellers who derive greater utility from trading with the intermediary at these prices than they expect from participating in the random matching market trade with the intermediary, where expectations are taken under the assumptions that all traders behave in the same way. Given fee-setting, we maintain the same assumption: For the announced fee $\omega(p)$ all those buyers and sellers join the

[28] Of course, this puts into perspective the policy recommendation that brokers be required to use fixed fee mechanisms, with the intention of inducing these to lead to an active random matching market. A natural conjecture would be that before too long the fixed fees evolve into something that has very similar effects as the fee-setting mechanisms we have analyzed, given the difficulties associated with the lack of commitment just mentioned.

[29] With fixed participation fees, the commitment to buy would not be available. However, following Jullien (2005), one can alternatively focus on stable equilibria with stability referring to a dynamic adjustment process where the two sides alternate in their registration choice and respond myopically to the other side's market share.

intermediated market who expect greater gains from doing so than when joining the random matching market, again taking expectations under the assumption that all other traders behave in the same way. (Of course, the twist now is that expected payoff from random matching market participation is zero for all agents if all agents behave and form expectations in this way.)

5.5 Elasticity Condition

Throughout the paper we have studied environments in which the Elasticity Condition (Assumption 1) holds. As we have seen, this is for example the case for all symmetric Pareto distributions that are at least as price-elastic as the uniform distribution ($\sigma \geq 1$).

With our results on fee-setting at hand, we are in a better position to discuss this condition. For Pareto distributions, the condition does not hold if demand and supply are too inelastic ($\sigma < 1$). This implies that the optimal fee charged by the intermediary $\omega^*(p) = p/(1+\sigma)$ is greater than 50% of the transaction price. If the fee is larger than 50%, a seller with costs $c \geq 1/2$ does not go to the intermediary, since he could not sell at a positive profit: even if he is matched to a buyer with valuation $v = 1$, the seller gets $1-\omega^*(1) < 1/2$, which is less than his costs. By symmetry (and a slightly more involved argument), buyers with a valuation $v \leq 1/2$ will not go to the intermediary either. This means that there will be a gap around 1/2 in which there are buyers and sellers that do not go to the intermediary, but have potential positive gains from trade. These traders will go to the bilateral market, so that fee-setting does not lead to predation. Note, however, that it appears to be plausible that the elasticity is sufficiently high, so that the optimal fee is below 50%.

For general distributions, a sufficient condition for the Elasticity Condition $\Phi^{-1}(0) \leq \Gamma^{-1}(1)$ to hold is that the elasticity of demand $\eta_d(v) \geq 1$ and the elasticity of supply $\eta_s(c) \geq 1$ for all v and c. To see this, observe that the virtual type functions can be written as $\Phi(v) = v[1+1/\eta_d(v)]+1/\eta_d(v)$ and $\Gamma(c) = c[1+1/\eta_s(c)]$, where the elasticities are defined as $\eta_d(v) = (1-v)f(v)/(1-F(v))$ and $\eta_s(c) = cg(c)/G(c)$. Now $\eta_d \geq 1$ and $\eta_s \geq 1$ imply $\Phi(v) \geq 2v - 1$ and $\Gamma(c) \leq 2c$ for all v and c, which in turn implies $\Phi^{-1}(x) \leq 1/2 + x/2$ and $\Gamma^{-1}(x) \geq x/2$ for all x. This yields the Elasticity Condition $\Phi^{-1}(0) \leq 1/2 \leq \Gamma^{-1}(1)$.

Even when the Elasticity Condition fails to hold, predation is still possible with fee-setting and can be an equilibrium outcome under plausible conditions. To illustrate, reconsider the case with $F(v) = 1-(1-v)^\sigma$ and $G(c) = c^\sigma$ but assume now $\sigma < 1$, so that $\Gamma^{-1}(1) = \frac{\sigma}{1+\sigma} > \frac{1}{1+\sigma} = \Phi^{-1}(0)$. This means that the fee $\omega^*(p) = p/(1+\sigma)$ defined in (9) cannot "dry out" the random matching market. Rather than having the brokers set the percentage fee $1/(1+\sigma)$, assume then that they charge a percentage fee b. The seller with cost c then optimally sets the price p satisfying

$$\Phi(p) = \frac{c}{1-b}.$$

The seller with cost 0 will, as before, set the price $p = 1/(1+\sigma)$, which will be the lowest valuation of a buyer joining the brokers' market under fee-setting (if there is no active random matching market). The cost $\overline{c}$ of the highest-cost seller joining the brokerage market sets a price equal to 1. Because $\Phi(1) = 1$, this seller's cost is $\overline{c} = 1 - b$. For fee-setting to predate the random matching market, we need $\overline{c} = 1 - b \geq \frac{1}{1+\sigma}$. Because the objective of the broker is concave, the smallest b that satisfies this constraint will be chosen, yielding

$$b^* = \frac{\sigma}{1+\sigma}.$$

Assuming fixed-price bargaining in the random matching market, one can show that for any $\sigma > 0$ fee-setting with the fee b^* generates larger profits than price posting when the random matching market is sufficiently efficient.

It should be noted that b^* is lower than the optimal fee when sellers draw their costs from the distribution $G(c) = c^\sigma$ with $\sigma < 1$. Consequently, it is no longer self-enforcing. It is well known that in intermediated markets equilibrium outcomes may exhibit peculiar features when the elasticity if demand is less than 1 at the Walrasian price. For example, assuming a winner-take-all tie-breaking rule for intermediaries who first compete à la Bertrand for inputs, Stahl (1988) finds that equilibrium involves wasteful production if and only if the elasticity of demand at the Walrasian price is less than 1. Here we find similarly that in equilibrium more sellers than buyers join the brokerage market when $\sigma < 1$.

5.6 Dynamic Random Matching and Welfare Enhancing Fee Setting

In Appendix C we derive results for a variant of our model with a binary type space, in which buyers' valuations are drawn from $\{v_1, v_2\}$ and sellers' costs are drawn from $\{c_1, c_2\}$. The main results on predation go through in this alternative setting.

The binary type space has the advantage that some of the calculations become more tractable. In particular it is easy to construct examples in which predatory fee-setting is welfare enhancing. The basic idea is that price posting excludes some traders from the efficient intermediated market. Fee-setting reduces this deadweight loss of monopoly, but comes at the price that the probability of trade is less than 1. Fee-setting is welfare enhancing when the former effect dominates the latter effect.

Another question we address in the binary specification is that of dynamics: consider a model in which a trader that does not trade today has the chance to trade in the future. Such traders wait in the market to try to get a future trade opportunity. In such a dynamic random matching setup, the relevant distributions of valuations and costs in the market are different from the primitive distributions for two reasons. First, traders have the option value of future trade which should be added to the seller's cost and subtracted from the buyers valuation. Second, low valuation buyers and high cost seller trade with a lower probability, wait longer until they get to trade, and hence are overrepresented in the pool of traders in the market compared to the distribution of entrants in every period.

Dealing with these two changes of the type distributions in a dynamic model is known to be a very hard problem, see Satterthwaite and Shneyerov (2007, 2008).[30] For binary type spaces, a dynamic model is more tractable, see Duffie, Garlenau, and Pedersen (2005). We analyze predatory fee setting in a dynamic random matching with a binary type space in Appendix C and find that our results go through qualitatively. In a dynamic model, traders' concern about a lower probability of trade becomes less important, but in exchange, traders worry about a longer time on market, which has a similar effect.

5.7 Incomplete Foreclosure

We have stated our results on predatory fee-setting in the clearest possible way, by assuming that predation leads to the bilateral exchange shutting down completely. However, one results also hold for a less extreme version of our model: if predation does not lead to the bilateral exchange shutting down completely, but only to operating at an inefficiently low scale.

Consider a bilateral market that operates at an inefficiently low scale if only a small number of buyers and sellers enter ($\min\{1 - F(\underline{v}), G(\overline{c})\} < T$ for some threshold T), so that the probability of meeting a trading partner is λ_0. Above the threshold T, the probability of meeting a trading partner is λ.

Further assume that there is a small mass ϵ of both buyers and sellers who always go to the bilateral market, possibly because they are sophisticated at searching and do not need an intermediary or because they cannot afford paying the intermediary's fees. As long $\epsilon < T$, predation leads to the bilateral exchange operating at an inefficiently low scale, which reduces (but does not completely eliminate) the competitive threat the

[30] It can be seen from these articles how complex the analysis of dynamic random matching with continuous type spaces is, even if one considers the limit as search frictions vanish. Away from the limit the analysis typically becomes even harder.

bilateral exchange poses to the intermediary's rent extraction.

5.8 Empirics

An empirical analysis is outside of the scope of this article. However, there are a few issues worth discussing.

One is the extent of price dispersion in search markets. This is difficult to measure empirically because differences in sales prices can be attributed to either observed heterogeneity (for real-estate, the number of bedrooms of a property, whether it has air conditioning, etc.), to unobserved heterogeneity (characteristics of a property that are observed by market participants, but not by the econometrician, e.g. whether the sight from the apartment is beautiful), or to true price dispersion.

In Loertscher and Niedermayer (2016), we structurally estimate a model of fee-setting intermediaries, taking payoffs from a bilateral exchange as exogenously given. The structural estimates allow us to disentangle the three effects leading to differences in sales prices.

We show how the three effects can be disentangled in Figure 2. It should be noted that not only the analysis of observed and unobserved heterogeneity poses challenges, but also its graphical representation: while sales prices are measured in \$100,000s of dollars, the quality adjusted prices one gets after correcting for observed heterogeneity and the counterfactual simulations of how much price variation one would see if there were no unobserved heterogeneity are quality-adjusted prices normalized to a mean of 1. We deal with this challenge by computing "denormalized quality adjusted prices": we multiply the quality-adjusted prices with \$230,000, the average transaction price in the data set in Loertscher and Niedermayer (2016).

Based on the structural estimate of true price dispersion (solid line in Figure 2), we can look at how the 6% fees charged by real-estate brokers compare to price dispersion. Figure 3 shows the distribution of "denormalized quality-adjusted" gross prices (solid) and "denormalized quality-adjusted" prices net of the 6% fee charged by real-estate brokers. It shows that the two distributions have considerable overlap.

An issue Loertscher and Niedermayer (2016) do not deal with is the endogeneity of the bilateral exchange market that is the focus of this article. This is the right approach for that paper, since they analyze data from Boston in the early 1990s when the fraction of bilateral transactions was quite small.

An interesting question for future research would be the analysis of data from regions and periods of time in which a bilateral exchange came into existence and started growing. One such data set is that analyzed by Hendel, Nevo, and Ortalo-Magné (2009), who

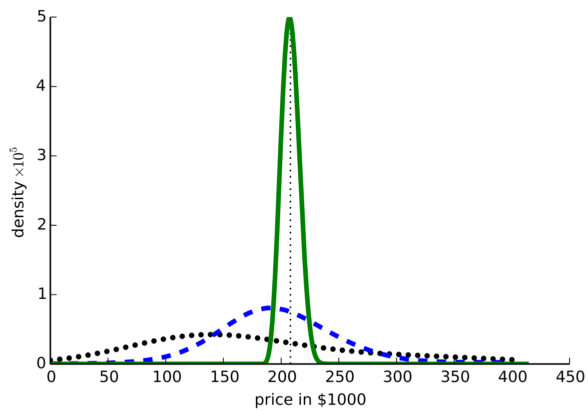


Figure 2: Empirically estimated density of prices without correcting for heterogeneity (dotted, black), correcting for observed heterogeneity (dashed, blue) and correcting for both observed and unobserved heterogeneity (solid, green).

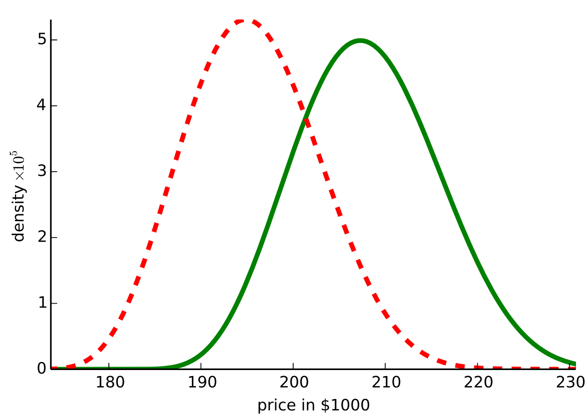


Figure 3: Empirical density of gross (solid, green) and net (dashed, red) transaction prices adjusted by both observed and unobserved heterogeneity. Based on Loertscher and Niedermayer (2016).

consider both real-estate broker sales and For-Sale-By-Owner platform sales in Madison, Wisconsin, from 1998 to 2004. In this period of time, the For-Sale-By-Owner platform grew considerably. They find that properties sold through the For-Sale-By-Owner platform took considerably longer to sell than properties sold through real estate brokers, which is consistent with the our assumption $\lambda < 1$, that is, that matchings through brokers are more efficient than bilateral matchings.[31]

From the perspective of our model, the emergence of the For-Sale-By-Owner platform in Madison could be interpreted as either predation by brokers still being successful and the bilateral market still operating at an inefficiently small scale, but the efficiency at this small scale improving due to technological progress such as the internet (i.e. λ_0 in Section 5.7 increasing). Alternatively, it could be seen as one of the few occasions in which a bilateral market managed to break free from predation.[32]

Another interesting question is the comparison to the used car market. Used car dealers typically choose price posting and the fraction of bilateral transactions is known to be considerably higher for used cars than for real-estate transactions. An empirical study by Gavazza, Lizzeri, and Roketskiy (2014) that studies the (bilateral) used car market from a search theoretic perspective finds that there are considerable search frictions in this market, which from the perspective of our model means a low λ.[33] In a market with a low λ, intermediaries do not have an incentive to collude to foreclose the bilateral market, since it is a lesser competitive threat than in markets with a larger λ. Hence, intermediaries are more likely to choose price posting, which is indeed what we observe for used car dealers.

6 Conclusions

In this paper, we present a model in which the operator of one market can successfully pre-empt the emergence of a competing exchange. Such predatory behavior is more

[31] It should be noted that Hendel, Nevo, and Ortalo-Magné (2009) also find that the probability of sale is slightly higher for the For-Sale-By-Owner platform than for real-estate brokers, however, the difference is not statistically significant.

[32] We do not have an answer to why a bilateral exchange can break free. Possibly, enough sophisticated buyers and sellers are present in a region, who are efficient at searching for a trading partner even without an intermediary.

[33] There are different ways to model frictions in the used car market. In both Gavazza, Lizzeri, and Roketskiy (2014) and our article these frictions are modeled as search frictions, that is, a lower probability of meeting a trading partner in a given period. An alternative is to model frictions as adverse selection: a buyer may find a seller, but there is a high probability that the seller has a used car of inferior quality. While we have no formal model, we conjecture that our results should qualitatively go through also in the latter specification, since the basic driving force is that the intermediary has an incentive to predate if the bilateral market is too efficient.

profitable if the competing exchange would be more efficient if it emerged. The paper thus brings to light a possibility of predatory behavior that seems plausible and, as far as we know, is novel. In our model, a market structure that looks very competitive as it consists of a large number of active brokers each of whom has a negligible market share and chooses fees independently has predatory effects. For the specifications studied in the main body of this paper, predation is always harmful to social welfare and, when it occurs in equilibrium, to consumer surplus defined as social welfare less intermediary's profit.

Policymakers and antitrust authorities concerned with the competitiveness of a brokerage market which uses fee-setting may quite naturally look at the level of the fees used. Intuition suggests that lowering fees will enhance consumer surplus. However, in our model the anticompetitive effects of, say, percentages fees do not stem so much from their level as from their very nature, meaning that of a given percentage fee is used to predate a competitive exchange, then so will any lower percentage fee. Therefore, if fee-setting is used for the purpose of predation, standard regulatory approaches will not be effective, and the first-order welfare gains would be achieved by inducing intermediaries to use price posting or equivalent mechanisms.

We have assumed that, in the presence of a random matching market, the intermediary can use price posting or use fee-setting to extinguish the random matching market. Price posting is an optimal mechanism for large intermediary facing a deep market with a continuum of buyers and sellers when there is no random matching market. Fee-setting is optimal for brokers in thin markets when a broker is randomly matched to a buyer-seller pair. An open question for future research is to derive the optimal mechanism for an intermediary who faces an active competing exchange. Theoretically, this is a challenging because it corresponds to a mechanism design problem with endogenous and type dependent participation constraints. Even *exogenous* type dependent participation constraints are known to be difficult (see e.g. Jullien, 2000). From a practical perspective, it requires being specific about how payoffs in the random matching market are determined. What this paper has shown is that price posting, which is optimal absent random matching markets, will no longer be optimal when there is the threat of an active random matching market.

References

Anderson, S., and S. Coate (2005): "Market Provision of Broadcasting: A Welfare Analysis," *Review of Economic Studies*, 72, 947–72.

ARMSTRONG, M. (2006): "Competition in Two-Sided Markets," *RAND Journal of Economics*, 37(3), 668–691.

ASHENFELTER, O., AND K. GRADDY (2005): "Anatomy of the Rise and Fall of a Pricefixing Conspiracy: Auctions at Soheby's and Christie's," *Journal of Competition Law and Economics 1(1), 320*, 1(1), 3–20.

BESANKO, D., U. DORASZELSKI, AND Y. KRYUKOV (2014): "The economics of predation: What drives pricing when there is learning-by-doing?," *American Economic Review*, 3(3), 868 – 897.

BESANKO, D., U. DORASZELSKI, Y. KRYUKOV, AND M. SATTERTHWAITE (2010): "Learning-by-Doing, Organizational Forgetting, and Industry Dynamics.," *Econometrica*, 78(2), 453 – 508.

BLOCH, F., AND H. RYDER (2000): "Two-Sided Search, Marriages, and Matchmakers.," *International Economic Review*, 41(1), 93 – 115.

BULOW, J., AND J. ROBERTS (1989): "The Simple Economics of Optimal Auctions," *Journal of Political Economics*, 97(5), 1060–90.

CABRAL, L. M. B., AND M. H. RIORDAN (1994): "The Learning Curve, Market Dominance, and Predatory Pricing.," *Econometrica*, 62(5), 1115 – 1140.

——— (1997): "The Learning Curve, Predation, Antitrust, and Welfare.," *Journal of Industrial Economics*, 45(2), 155 – 169.

CAILLAUD, B., AND B. JULLIEN (2001): "Competing cybermediaries," *European Economic Review*, 45, 797–808.

——— (2003): "Chicken and Egg: Competition among Intermediation Service Providers," *RAND Journal of Economics*, 34(2), 309–328.

CHATTERJEE, K., AND W. SAMUELSON (1983): "Bargaining under Asymmetric Information," *Operations Research*, 31, 835–851.

DOJ (2007): "Competition in the Real Estate Brokerage Industry," *Report by the Federal Trade Commission and the U.S. Department of Justice.*

DUFFIE, D., N. GARLENAU, AND L. H. PEDERSEN (2005): "Over-the-Counter Markets," *Econometrica*, 73(6), 1815–1847.

Foner, P. S. (1965): *History of the Labor Movement in the United States: The Industrial Workers of the World, 1905-1917*, vol. 4. New York: International Publishers.

Gavazza, A., A. Lizzeri, and N. Roketskiy (2014): "A Quantitative Analysis of the Used-Car Market," *American Economic Review*, 104(11), 3668–3700.

Gehrig, T. (1993): "Intermediation in Search Markets," *Journal of Economics & Management Strategy*, 2, 97–120.

Gomes, R. (2014): "Optimal Auction Design in Two-Sided Markets," *Rand Journal of Economics*, 45, 248–272.

Hendel, I., A. Nevo, and F. Ortalo-Magné (2009): "The Relative Performance of Real Estate Marketing Platforms: MLS versus FSBOMadison.com," *American Economic Review*, 99(5), 1878 – 98.

Hsieh, C.-T., and E. Moretti (2003): "Can Free Entry Be Inefficient? Fixed Commissions and Social Waste in the Real Estate Industry," *Journal of Political Economy*, 111(5), 1076–1122.

Jullien, B. (2000): "Participation Constraints in Adverse Selection Models.," *Journal of Economic Theory*, 93(1), 1 – 47.

——— (2005): "Two-Sided Markets and Electronic Intermediaries," *CES-IFO Economic Studies*, 51(2/3), 233–260.

Krishna, V. (2002): *Auction Theory*. Elsevier Science, Academic Press.

Levitt, S. D., and C. Syverson (2008): "Market Distortions When Agents Are Better Informed: The Value of Information in Real Estate Transactions," *Review of Economics and Statistics*, 90(4), 599–611.

Loertscher, S. (2007): "Horizontally Differentiated Market Makers," *Journal of Economics & Management Strategy*, 16(4), 793–825.

Loertscher, S., and A. Niedermayer (2016): "Percentage Fees in Thin Markets: An Optimal Pricing Perspective," *Working Paper*.

Myerson, R. (1981): "Optimal auction design," *Mathematics of Operations Research*, 6(1), 58–73.

Myerson, R., and M. Satterthwaite (1983): "Efficient Mechanisms for Bilateral Trading," *Journal of Economic Theory*, 29(2), 265–281.

Neeman, Z., and N. Vulkan (2010): "Markets Versus Negotiations: The Predominance of Centralized Markets," *The B.E. Journal of Theoretical Economics: Advances*, 1(6).

Niedermayer, A., and A. Shneyerov (2014): "For-Profit Search Platforms," *International Economic Review*, 55(3), 765 – 789.

Riley, J. G., and W. F. Samuelson (1981): "Optimal Auctions.," *American Economic Review*, 71(3), 381 – 392.

Rochet, J.-C., and J. Tirole (2003): "Platform competition in Two-Sided markets," *Journal of the European Economic Association*, 1, 990–1029.

——— (2006): "Two-Sided Markets: A Progress Report," *RAND Journal of Economics*, 37(3), 645–667.

Rubinstein, A., and A. Wolinsky (1987): "Middlemen," *Quarterly Journal of Economics*, 102(3), 581–593.

Rust, J., and G. Hall (2003): "Middlemen versus Market Makers: A Theory of Competitive Exchange," *Journal of Political Economy*, 111(2), 353–403.

Rustichini, A., M. A. Satterthwaite, and S. R. Williams (1994): "Convergence to Efficiency in a Simple Market with Incomplete Information," *Econometrica*, 62(5), pp. 1041–1063.

Rutherford, R., T. Springer, and A. Yavas (2005): "Conflicts between principals and agents: evidence from residential brokerage," *Journal of Financial Economics*, 76, 627–65.

Satterthwaite, M., and A. Shneyerov (2007): "Dynamic Matching, Two-Sided Information, and Participation Costs: Existence and Convergence to Perfect Competition," *Econometrica*, 75(1), 155–200.

Satterthwaite, M., and A. Shneyerov (2008): "Convergence to Perfect Competition of a Dynamic Matching and Bargaining Market with Two-sided Incomplete Information and Exogenous Exit Rate.," *Games and Economic Behavior*, 63(2), 435–467.

Satterthwaite, M. A., and S. R. Williams (2002): "The Optimality of a Simple Market Mechanism.," *Econometrica*, 70(5), 1841 – 1863.

Shneyerov, A., and A. Wong (2010): "Bilateral Matching and Bargaining with Private Information.," *Games and Economic Behavior*, 62(2), 748–762.

Spulber, D. F. (1996): "Market Making by Price-Setting Firms," *Review of Economic Studies*, 63(4), 559–580.

Stahl, D. O. (1988): "Bertrand Competition for Inputs and Walrasian Outcomes," *American Economic Review*, pp. 189–201.

Tirole, J. (2016): "From Bottom of the Barrel to Cream of the Crop: Sequential Screening with Positive Selection," *Econometrica*, 84(4), 12911343.

Yavas, A. (1996): "Matching of Buyers and Sellers by Brokers: A Comparison of Alternative Commission Structures," *Real Estate Economics*, 24, 97–112.

Online Appendix

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A Proofs

Proof of Proposition 2. The proof becomes much simpler by first taking the intermediate step of deriving the optimal mechanism in the class of all incentive compatible, individually rational mechanisms. Once that is done, simply imposes the constraint that the intermediary cannot use arbitrary mechanisms, but only fee setting. Then one proceeds to show that with the fee ω^* described in the proposition, one can implement the optimal mechanism. Since ω^* is optimal in the class of arbitrary mechanisms, it is also optimal in the more restricted class of fee-setting mechanisms.

Consider the following bilateral mechanism design problem going back to Myerson and Satterthwaite (1983). There is one buyer whose distribution v is drawn from F with support $[0, 1]$ and one seller whose distribution c is drawn from G with support $[0, 1]$. (We will drop the tilde in $\tilde{F}$ and $\tilde{G}$ in the proof for notational ease.) A mechanism designer that organizes trade between the buyer and the seller and wants to maximize his profits.[34] Without loss of generality, one can consider direct truth-revealing mechanisms in which the mechanism designer asks the buyer and the seller to report their types. Bases on these reports, the seller gets the transfer $M_S(\hat{v}, \hat{c})$, the buyer gets the (negative) transfer $M_B(\hat{v}, \hat{c})$, and the good is traded with probability $Q(\hat{v}, \hat{c})$, where M_S and M_B are functions $[0, 1]^2 \to \mathbb{R}$, Q is $[0, 1]^2 \to [0, 1]$, and $\hat{v}$ and $\hat{c}$ are the reported types of the agents.

The mechanism designer designs a mechanism that maximizes his expected profits $E_{v,c}[M_B(v, c) - M_S(v, c)]$, subject to incentive compatibility constraints (both the buyer and the seller have an incentive to report their types truthfully) and individual rationality (both the buyer and the seller are willing to participate rather than choose the outside option).

Theorems 3 and 4 in Myerson and Satterthwaite (1983) show that a mechanism is optimal if and only if it satisfies the two following conditions: (i) the good is transferred if and only if the buyer's virtual valuation is larger than the seller's virtual cost (for-

[34] Myerson and Satterthwaite (1983) are almost exclusively cited for there impossibility result. However, that paper also contains results for an intermediary that maximizes profits, see Section 5 of that paper.

mally, $\Phi(v) \geq \Gamma(c)$), and (ii) if the utility of the least efficient traders is zero (formally, $E_c[vQ(v,c) - M_B(v,c)] = 0$ for $v = 0$ and $E_v[M_S(v,c) - cQ(v,c)] = 0$ for $c = 1$).

The fee ω^* satisfies these criteria for the following reasons. Notice that given the fee $\omega^*(p)$ in (9), the expected profit of a seller with cost c is

$$(p - \omega^*(p) - c)(1 - F(p)) = \int_p^1 \Gamma^{-1}(\Phi(v)) f(v) dv - c(1 - F(p)),$$

where the equality follows after plugging in the expression for $\omega^*(p)$. This is maximized at p such that $\Gamma^{-1}(\Phi(p)) = c$ because of the seller's first-order condition $-[\Gamma^{-1}(\Phi(p)) - c]f(p) = 0$. This is equivalent to $p = \Phi^{-1}(\Gamma(c))$. Since the buyer accepts the take-it-or-leave-it offer p if and only if $v \geq p$, it follows that this implements the allocation rule of the optimal mechanism and hence satisfies condition (i).

As for condition (ii), observe that both a seller with cost 1 and a buyer with valuation 0 trade with probability 0 and hence have zero expected payoffs. □

B Price Posting as an Optimal Mechanism

Consider a setup with N buyers and N sellers who draw their values and costs independently from distributions F and G with support $[0, 1]$. Assume that F and G are common knowledge but that each agent's realized type is his private information. Assume that agents can only trade via the mechanism designer's platform and that each agent's utility of the outside option of not trading is 0. A direct mechanism is a collection of functions $\langle Q, M\rangle$ with $Q : [0, 1]^{2N} \to [0, 1]^{2N}$ specifying, for all agents i, the probability Q_i that the agent trades and $M : [0, 1]^{2N} \to \mathbb{R}^{2N}$ specifying, for all agents i, the payment M_i makes to the mechanism. A mechanism is feasible if $\sum_{i\in\mathcal{B}} Q_i \leq \sum_{j\in\mathcal{S}} Q_j$, where $\mathcal{B}$ ($\mathcal{S}$) is the set of buyers (sellers). By the revelation principle (see e.g. Myerson, 1981), the focus on direct mechanisms is without loss of generality. A direct mechanism $\langle Q, M\rangle$ is (Bayes-Nash) incentive compatible if, knowing his own type and the functions $\langle Q, M\rangle$ and the distributions F and G, each agent's expected payoff is maximized when reporting his type truthfully, with expectations taken with respect to F and G, assuming all other agents report truthfully. The mechanism is individually rational when this expected payoff is not less than 0.

With a continuum of buyers and sellers each with mass one, the following result is true:

Proposition 4. *Consider an intermediary who faces a continuum of buyers and sellers who draw their types independently from distributions F and G. The optimal mech-*

anism for the intermediary that respects agents' incentive compatibility and individual rationality constraints is price posting with prices p_B^0 and p_S^0 satisfying (2) and (4).

Proof of Proposition 4. As is well known, the revenue equivalence theorem implies that up to additive constants payments and expected revenue are pinned down by the allocation rule of a mechanism (see e.g. Myerson, 1981; Riley and Samuelson, 1981; Krishna, 2002). With a profit-maximizing mechanism, the additive constants are pinned down by the agents' individual rationality constraints. The allocation of the optimal mechanism with N buyers and N sellers who draw their types $\boldsymbol{v} = (v_1, .., v_N)$ and $\boldsymbol{c} = (c_1, ..c_N)$ independently from the distributions F and G induces the q buyers with the highest values and the q sellers with the lowest costs to trade, where q is such that

$$\Phi(v_{(q)}) \geq \Gamma(c_{[q]}) \quad \text{and} \quad \Phi(v_{(q+1)}) < \Gamma(c_{[q+1]})$$

with $v_{(q)}$ denoting the qth highest element of $\boldsymbol{v}$ and $c_{[q]}$ denoting the qth lowest element of $\boldsymbol{c}$ (and with $c_{[0]} = 0 = v_{(N+1)}$ and $c_{[N+1]} = 1 = v_{(0)}$ to make sure q is well defined). This is a conceptually straightforward generalization of the broker-optimal mechanism derived by Myerson and Satterthwaite (1983) for the case $N = 1$.

In the dominant strategy implementation of the optimal mechanism, trading buyers pay $\max\{v_{(q+1)}, \Phi^{-1}(\Gamma(c_{[q]}))\}$ and trading sellers are paid $\min\{c_{[q+1]}, \Gamma^{-1}(\Phi(v_{(q)}))\}$.

We now show that as N goes to infinity, the buyers' payments converge to p_B^0 and the sellers' payments converge to p_S^0 and the quantity traded converges to q^*.

$$\operatorname*{plim}_{N\to\infty} v_{(q)} = \operatorname*{plim}_{N\to\infty} v_{(q+1)} = \operatorname*{plim}_{N\to\infty} \Phi^{-1}(\Gamma(c_{[q]})) =: p_B. \tag{12}$$

Similarly,

$$\operatorname*{plim}_{N\to\infty} c_{[q]} = \operatorname*{plim}_{N\to\infty} c_{[q+1]} = \operatorname*{plim}_{N\to\infty} \Gamma^{-1}(\Phi(v_{(q)})) =: p_S, \tag{13}$$

while the fraction of buyers and sellers who trade satisfy

$$\operatorname*{plim}_{N\to\infty} \frac{q}{N} = \operatorname*{plim}_{N\to\infty} \frac{\max\{i | v_{(i)} \geq p_B\}}{N} = 1 - F(p_B), \tag{14}$$

$$\operatorname*{plim}_{N\to\infty} \frac{q}{N} = \operatorname*{plim}_{N\to\infty} \frac{\max\{i | c_{[i]} \geq p_S\}}{N} = G(p_S). \tag{15}$$

(12), (13), (14), and (15) imply that the optimal mechanism converges to price posting with p_B and p_S that satisfy $\Phi(p_B) = \Gamma(p_S)$ and $(1 - F(p_B)) = G(p_S)$.

□

C Model with Binary Types

In this appendix, we provide a model with discrete – indeed, binary – types, the main purpose being that this specification more readily admits a dynamic extension than a model with a continuum of types. It also allows us to show that our main findings are robust with respect to type distributions and dynamics, and it demonstrates that, in contrast to the specifications with continuous types analyzed in the main body of the paper, equilibrium predation need not always be detrimental to social welfare.

C.1 Setup

We now assume that the type sets are $\mathcal{V} = \{v_1, v_2\}$ for buyers and $\mathcal{C} = \{c_1, c_2\}$ for sellers, and we impose symmetry in the sense that $G(c_1) = h$ and $F(v_1) = 1 - h$, so that $1 - F(v_2) = h$ and $1 - G(c_2) = 1 - h$. We also assume $v_2 > v_1 \geq c_2 > c_1$, which implies that it is efficient for all sellers to produce and for all buyers to buy one unit.

While a binary type space is more tractable for some questions, the specification does come at a cost, since one can get results which are an artefact of the discrete type space: Demand functions are not strictly downward sloping and continuous anymore, supply functions are not strictly upward sloping and continuous. This can lead to multiple prices or multiple quantities being in equilibrium in several specifications. To avoid such issues we assume that the fraction of efficient buyers v_2 and the fraction of efficient sellers c_1 is both h.

Another way of getting rid of artefacts of a discrete type space would be to add small perturbations of the type space, so that buyers' valuation would be either in an ϵ-environment of v_1 or an ϵ-environment of v_2 and the same for the seller. However, this would lead to a considerably more tedious notation.

C.2 Equilibrium analysis

We now derive the equilibrium outcome for a given choice of mechanism by the market maker.

Price posting If the intermediary wants to induce the Walrasian traded quantity (full trade) using price posting, he optimally sets $p_B = v_1$ and $p_S = c_2$ and nets a profit of $\Pi_w = v_1 - c_2$, with w standing for Walrasian sets. If there is no random matching market, his profit when trading only with the most efficient set of traders (that is, v_2 and c_1) is the (restricted quantity) monopoly profit $\Pi_m = h(v_2 - c_1)$.

If $\Pi_w \geq \Pi_m$, a profit maximizing intermediary implements first-best. To make sure that there is a deadweight loss of monopoly, we assume $\Pi_w < \Pi_m$, which is equivalent to

$$h > \frac{v_1 - c_2}{v_2 - c_1} =: \mu, \tag{16}$$

where μ is the ratio of markups under full trade and under exclusive trade (i.e. with efficient buyer and seller types only). From here onwards, assume that (16) holds. Note that for the continuous type model studied in the main text, there is always a deadweight loss of monopoly. Consequently, assumption (16) should be seen as avoiding an artefact of a discrete type space.

Price posting with random matching market Let λ be the matching probability in the random matching market and assume that trade takes place at the expected price $(v_1 + c_2)/2$. This price can be due to any of the bargaining protocols mentioned in the main text, i.e. random proposal take-it-or-leave-it-offers, Nash bargaining, double auctions, or fixed-price bargaining.[35] For a buyer of type v_2 and a seller of type c_1, the expected payoffs of participating in the random matching market, denoted, respectively, as $V_B(v_2)$ and $V_S(c_1)$, are

$$V_B(v_2) = \lambda\left(v_2 - \frac{v_1 + c_2}{2}\right) \quad \text{and} \quad V_S(c_1) = \lambda\left(\frac{v_1 + c_2}{2} - c_1.\right).$$

The prices (p_B, p_S) the intermediary sets when trading with the efficient types only satisfy

$$v_2 - p_B = V_B(v_2) \quad \text{and} \quad p_S - c_1 = V_S(c_1),$$

or equivalently

$$p_B = (1-\lambda)v_2 + \lambda\frac{v_1 + c_2}{2} \quad \text{and} \quad p_S = (1-\lambda)c_1 + \lambda\frac{v_1 + c_2}{2}.$$

The intermediary's profit with an active random matching market (which occurs if he trades only with the efficient types) is therefore

$$\Pi_p = h(p_B - p_S) = h(1-\lambda)(v_2 - c_1) = (1-\lambda)\Pi_m.$$

Observe that Π_p goes to 0 as λ goes to 1. Notice also that Π_w approaches 0 as μ approaches 0. Therefore, there will be parameter constellations such that predatory fee-setting will be profitable if it leads to a positive profit.

[35] It does not matter for our results, which price in the interval $[c_2, v_1]$ is chosen, but it is convenient to have a price exactly in the middle of the interval. To get this, for random proposal take-it-or-leave-it-offers, the offer probability has to be $\alpha = 1/2$. For Nash bargaining, the bargaining weight has to be $\alpha = 1/2$. For double auctions and fixed-price bargaining, any price in the interval $[c_2, v_1]$ could be the transaction price, including $(v_1 + c_2)/2$.

Another relevant comparison is between Π_p and the Walrasian profit Π_w. One can show that

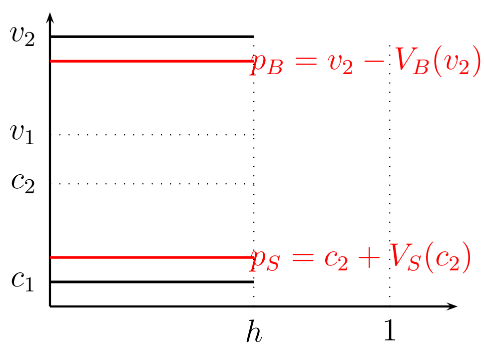
$$h(1-\lambda)(v_2-c_1) = \Pi_p > \Pi_w = v_1 - c_2$$

is equivalent to

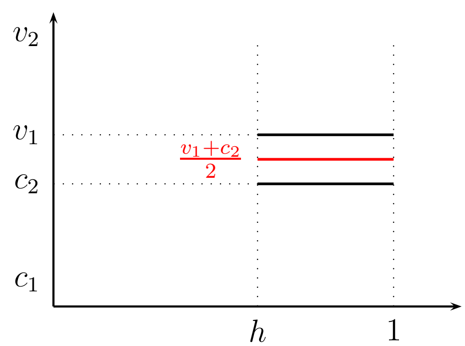
$$\lambda < 1 - \frac{\mu}{h} = \frac{h-\mu}{h} =: \lambda_w.$$

Note that for $\mu \to 0$ (which is equivalent to $v_1 \to c_2$), this condition is always satisfied. $\mu \to 0$ is reasonable to consider, given that it implies zero profits when implementing the Walrasian allocation, which always holds for a continuous type space.

The intermediated market and the bilateral exchange with price posting are illustrated in Fig. 4.



(a) Intermediated Market



(b) Bilateral Exchange

Figure 4: The intermediated and the bilateral market with price posting.

Fee-Setting Assume now that instead of posting prices, the intermediary employs a large number of brokers (with mass 1 or larger) and randomly matches buyers and sellers one-to-one across the brokers if the number of buyers and sellers joining the intermediated market is the same. (Otherwise, agents on the long side are rationed randomly). The fee-setting mechanism used by the brokers has the fee $\underline{\omega}$ for the low price $\underline{p}$ and the fee $\overline{\omega}$ upon the high price $\overline{p}$ (and appropriately chosen ω for any other price, which will be off equilibrium). We now derive the optimal structure of this fee-setting mechanism.

The intermediary wants the efficient seller to set $\underline{p}$, which will be accepted by both buyers, and the inefficient seller to set $\overline{p}$, which will only be accepted by the high type buyer. Accordingly, the incentive constraints for the sellers are

$$h(\overline{p} - \overline{\omega} - c_2) \geq \underline{p} - \underline{\omega} - c_2 \tag{17}$$

$$h(\overline{p} - \overline{\omega} - c_1) \leq \underline{p} - \underline{\omega} - c_1. \tag{18}$$

Inequalities (17) and (18) are equivalent to

$$h(\overline{p} - c_2) - \underline{p} + c_2 \geq h\overline{\omega} - \underline{\omega} \tag{19}$$

$$h(\overline{p} - c_1) - \underline{p} + c_1 \leq h\overline{\omega} - \underline{\omega}. \tag{20}$$

As $h(\overline{p} - c_2) - \underline{p} + c_2 \geq h(\overline{p} - c_1) - \underline{p} + c_1$ is equivalent to $c_2 \geq c_1$, which is assumed (with strict inequality), we know that there is a number $h\overline{\omega} - \underline{\omega}$ such that both incentive constraints are satisfied.

The individual rationality constraints for the sellers are

$$\overline{p} - \overline{w} - c_2 \geq 0 \tag{21}$$

$$\underline{p} - \underline{w} - c_1 \geq 0. \tag{22}$$

Making the individual rationality constraint for the inefficient seller type binding, we get $\overline{w} = \overline{p} - c_2$. Using this and making the incentive constraint for the efficient seller type bind, we get $\underline{\omega} = \underline{p} - c_1 - h(c_2 - c_1)$. It is easy (and routine) to verify that the individual rationality constraint for the efficient seller type and the incentive constraint for the inefficient seller type will be satisfied with slack. The intermediary's profit under predatory fee-setting is therefore

$$\Pi_f \quad = \quad h\underline{\omega} + h(1-h)\overline{\omega} = h(\underline{p} + \overline{p} - c_1 - c_2) - h^2(\overline{p} - c_1),$$

since with probability h, the seller is efficient and trades for sure (fee $\underline{\omega}$), and with probability $1-h$, the seller is inefficient and trades with probability h (fee $\overline{\omega}$). Of course, $\overline{p} = v_2$ and $\underline{p} = v_1$, so that

$$\underline{\omega} = v_1 - c_1 + h(c_2 - c_1) \quad \text{and} \quad \overline{\omega} = v_2 - c_2. \tag{23}$$

Plugging this into Π_f yields

$$\Pi_f = h(1-h)(v_2 - c_1) + h(v_1 - c_2) = h(v_2 - c_1)(1 - h + \mu) = (1 - h + \mu)\Pi_m,$$

which is less than Π_m under condition (16).

Equilibrium mechanisms If we assume that $\mu = 0$, we get

$$\Pi_f \quad = \quad h(1-h)(v_2 - c_1). \tag{24}$$

Therefore, under the assumption that $\mu = 0$, $\Pi_f > \Pi_p$ is equivalent to $\lambda > h$. Under this assumption, the fees simplify to $\overline{w} = v_2 - c_2$ and $\underline{w} = (1-h)(v_1 - c_1)$. In general, $\Pi_f > \Pi_p$ can be rearranged to

$$\lambda > \lambda^* := h - \mu$$

Note that $\lambda^* > 0$ by condition (16), which states that $h - \mu > 0$. Summarizing, we have established the following result.

Proposition 5. *Predatory fee-setting is profitable for the intermediary if and only if the competing exchange were otherwise sufficiently efficient, that is if and only if* $\lambda > h - \mu$*.*

A further comparison worthwhile making concerns fee setting and Walrasian price posting. We know that for λ sufficiently large, the intermediary prefers Walrasian price posting (v_1, c_2) to posting a large spread (v_2, c_1). One may wonder whether Walrasian price posting may be preferred to fee setting. This is, however, not the case for the following reason. Fee setting generates higher profits than Walrasian price posting if

$$h(v_2 - c_1)(1 - h + \mu) = \Pi_p > \Pi_w = v_1 - c_2,$$

which can be rearranged to $h > \mu$, which is satisfied by assumption. This means that fee setting is always preferred to Walrasian price posting.

Note further that whenever price posting with a large spread is preferred to fee setting ($\lambda < \lambda^*$), it is also preferred to Walrasian price posting, since $\lambda_w > \lambda^*$. (This actually also follows from the fact that fee setting is always preferred to Walrasian price posting.)

Fee setting is illustrated in Fig. 5.

C.3 Extensions

In this section, we show that our findings are robust with respect to various equilibrium selection criteria and that they extend to a model with dynamic random matching.

C.4 Dynamic random matching

Dynamic effects arise naturally in the context of intermediated trade because agents who are not matched or do not trade today have the option of trading tomorrow.[36] We now extend the static model to account for these effects.

[36] See, for example, Spulber (1996), Rust and Hall (2003) and Duffie, Garlenau, and Pedersen (2005).

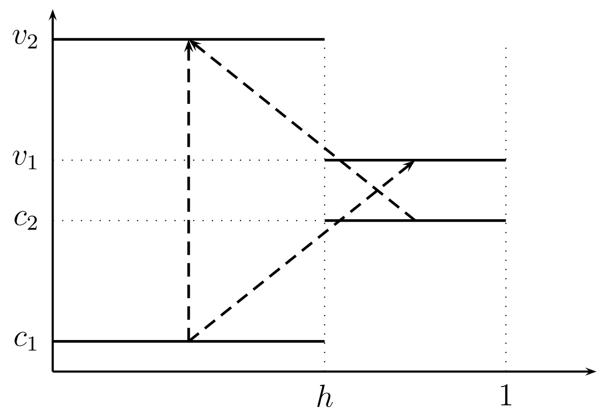


Figure 5: Trade in the intermediated market with fee setting.

Setup We consider the following dynamic random matching extension of our baseline model. There is an infinite horizon model with periods $t = 0, 1, 2, ...$ Initially both the intermediated and the direct market are empty. In each period mass 1 of buyers and mass 1 of sellers enter the market. If a trader trades, he leaves the market. If he does not trade, he stays in the market with the survival probability δ. With probability $1 - \delta$ a buyer or seller who does not trade drops out for exogenous reasons and gets utility 0. These assumptions are similar to those in Satterthwaite and Shneyerov (2008)) and Shneyerov and Wong (2010). The assumptions on the distribution of types are the same as in the static model, that is every buyer is of type v_2 with probability h and of type v_1 with probability $1 - h$ while every seller is of type c_1 with probability h and of type c_2 with probability $1 - h$, where $v_2 > v_1 \geq c_2 > c_1$.

Before we solve the dynamic random matching model, we briefly discuss the rationale for these assumptions. The literature on dynamic random matching typically uses one of the following three modeling assumptions to model impatience of participants in a market: (i) fixed search costs per period of participation, (ii) discounting, (iii) random drop-out of traders in every period. The third modeling assumption has several advantages in our setup. First, it is a parsimonious way of having both something similar to discounting (as in (ii)) and making sure that no traders stay in the market forever (as in (i)). The assumption also has the effect that the intermediary is also impatient: if a trader does not trade in a certain period, he may drop out in the next, which means a potentially foregone opportunity to extract rents for the intermediary. Another advantage is that a model with drop-out nests the static model we discussed before: if the probability of dropping out after a period without trade is 1, we are essentially in the static setup (repeated indefinitely). A further advantage is that the intermediary can simply focus on the stationary equilibrium of the market.[37] With discounting, one would have to consider both profits in the stationary (limiting) equilibrium and profits on the transition path to this equilibrium. An intermediary whose impatience stems only from drop-outs can ignore the transition path.

One can also think of a larger model, in which all three sources of impatience exists, but search costs converge to zero and the discount factor converges to 1.

Price posting In the intermediated market, buyers with v_2 and sellers with $\underline{c}$ enter and trade immediately.[38] In the non-intermediated market, buyers with v_1 and sellers with c_2 enter. Their per period probability of trade is λ. If they do not trade, they stay in the market with probability δ and may trade in any of the subsequent periods, provided they do not drop out. Hence, the ultimate probability of trade is

$$\hat{\lambda} = \lambda + (1-\lambda)\delta\lambda + (1-\lambda)^2\delta^2\lambda + (1-\lambda)^3\delta^3\lambda + ... = \frac{\lambda}{1-\delta(1-\lambda)}$$

It is easy to see that for $\delta \to 0$, $\hat{\lambda} \to \lambda$, and for $\delta \to 1$, $\hat{\lambda} \to 1$.

Since only λ is replaced by $\hat{\lambda}$ and everything else remains the same, the intermediary's per period profits are

$$\Pi_p = h(1-\hat{\lambda})(v_2 - c_1).$$

Note that the usual subtleties due to per period vs per cohort profits do not occur here, since traders joining the intermediary's platform trade immediately, so that per period and per cohort profits are the same.

Fee-setting mechanisms Next, consider fee setting mechanisms. We will consider the same type of equilibrium as in the static setup: all traders join the intermediary's platform, sellers with low costs c_1 set a low price $\underline{p}$, sellers with high costs c_2 set a high price $\overline{p}$. In equilibrium, high valuation buyers accept both the high and the low price, low valuation buyer only accept the low price.

The dynamic random matching model differs from the static setup in two ways. First, the distribution of types in the market differ from the entrant population as less efficient traders spend more time in the market. Second, traders have an option value of delaying trade and trading with a potentially more attractive future trading partner. Note that

[37]One has to be careful, when analyzing the stationary equilibrium though, since one has to look at per entering cohort profits rather than per period profits. We will discuss this later on.

[38]For $\lambda = 0$, It can be shown that this is the optimal mechanism, irrespective of δ, see e.g. Niedermayer and Shneyerov (2014), even if one allows for non-stationary, non-anonymous mechanisms.

by assuming that all impatience stems from the drop-out probability, we can focus on per cohort profits in the steady state equilibrium rather than on the complicated transition path to the steady state.

Because of symmetry of the buyer and seller probabilities of being efficient, it is sufficient to analyze efficient vs. inefficient traders. The analysis then applies to both the buyer and the seller side. Note that efficient traders (v_2 and c_1) trade immediately, so the mass of efficient traders in the market is equal to the mass of efficient entering traders, h. Denote the mass of inefficient traders in the market as m and the fraction of efficient traders in the market as $\tilde{h}$. The following has to hold:

$$\frac{m}{m+h} = 1 - \tilde{h},$$

which is equivalent to

$$m = h\frac{1-\tilde{h}}{\tilde{h}}.$$

In a stationary equilibrium, the inflow and the outflow of a certain type of agents has to be equal. For the efficient types, this clearly holds, since they trade with probability 1. For the inefficient agents, the inflow has mass $1-h$. The outflow is given by the mass m of agents in the market and the probability of not staying in the market. The probability of staying in the market is given by the probability of not trading $1-\tilde{h}$ and the probability of not dropping out δ. The inflow-outflow equilibrium equation is hence

$$1 - h = m(1 - (1 - \tilde{h})\delta)$$

Plugging in the expression for m yields a quadratic equation in $\tilde{h}$. Rearranging and solving for $\tilde{h}$ gives the solution[39]

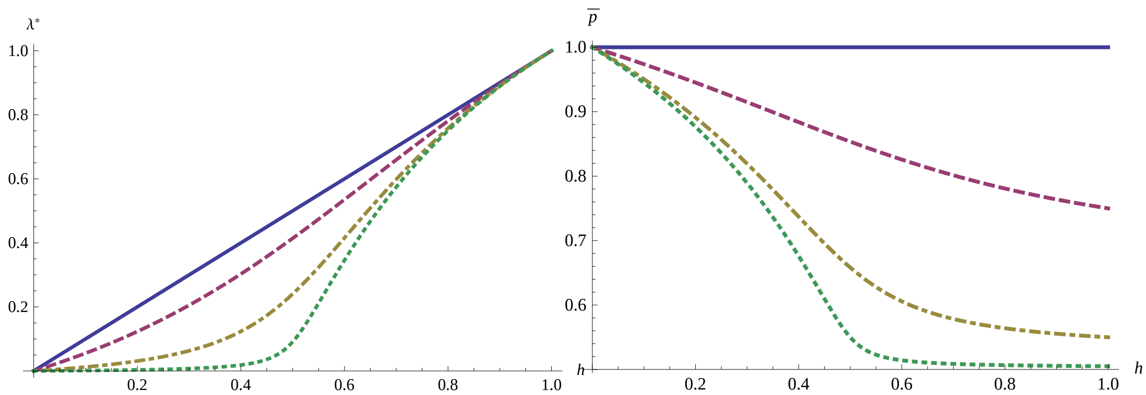
$$\tilde{h} = \frac{2\delta h - 1 + \sqrt{(2\delta h - 1)^2 + 4\delta(1-\delta)h^2}}{2\delta h}$$

It is easy to check th at for $\delta \to 0$, $\tilde{h} \to h$ and for $\delta \to 1$, $\tilde{h} \to 2 - 1/h$. The latter implies that the system is stable for $\delta \to 1$ if $h \in (1/2, 1)$. It is also easy to check that for $h \to 0$, $\tilde{h} \to 0$ and for $h \to 1$, $\tilde{h} \to 1$. From here onwards, we therefore assume

$$\max\{1/2, \mu\} < h < 1$$

Though $\tilde{h}$ is the probability that a trader meets an efficient potential trading partner in a given period, what matters for the decisions of traders is the ultimate probability of

[39]The two candidates to the quadratic equation are $\tilde{h}_{1,2} = \frac{2\delta h - 1 \pm \sqrt{(2\delta h-1)^2 + 4\delta(1-\delta)h^2}}{2\delta h}$. Since the square root is greater than $2\delta h - 1$, the solution with a minus sign would yield a negative value, contradicting that it is a probability. Therefore, the solution is given by the expression with the plus sign.



(a) λ^* as a function of h for $\delta = 0$ (solid), $\delta = 0.5$ (dashed), $\delta = 0.9$ (dash-dotted), and $\delta = 0.99$ (dotted).

(b) $\overline{p}$ as a function of h for $\delta = 0$ (solid), $\delta = 0.5$ (dashed), $\delta = 0.9$ (dash-dotted), and $\delta = 0.99$ (dotted).

Figure 6: λ^* and $\overline{p}$.

meeting an efficient type. This probability is given as

$$\hat{h} = \tilde{h} + \delta(1-\tilde{h})\tilde{h} + \delta^2(1-\tilde{h})^2\tilde{h} + \delta^3(1-\tilde{h})^3\tilde{h} + ... = \frac{\tilde{h}}{1-\delta(1-\tilde{h})}$$

Plugging in $\tilde{h}$ yields

$$\hat{h} = \frac{2h}{1+\sqrt{1-4(1-h)h\delta}}$$

Observe that for $h \geq 1/2$, $4(1-h)h\delta \leq 1$. Therefore, the square root is always real.

Next, we can derive the incentive compatibility and individual rationality constraints of traders. Note that since the setup is stationary, we only need to check whether a high cost seller has the incentive to set a high price in every period rather than a low price in every period, since the trade-off is the same in every period. Similarly, we only need to check that a low cost seller has the incentive to set a low price in every period rather than a high price in every period. Further, one can simply replace h with $\hat{h}$ for most of the analysis. This yields the incentive compatibility constraints for the sellers

$$\hat{h}(\overline{p} - \overline{w} - c_2) \geq \underline{p} - \underline{w} - c_2 \tag{25}$$

$$\hat{h}(\overline{p} - \overline{w} - c_1) \leq \underline{p} - \underline{w} - c_1 \tag{26}$$

The individual rationality constraints can be written analogously. By the same logic as for the static setup, we get the fees

$$\overline{w} = \overline{p} - c_2, \tag{27}$$

$$\underline{w} = \underline{p} - c_1 - \hat{h}(c_2 - c_1). \tag{28}$$

For the inefficient buyer, the option value of future trade is 0 as he will never get an offer below $\underline{p}$ no matter how long he waits. Hence, by the same logic as before, incentive compatibility and individual rationality constraints imply that $\underline{p} = v_1$.

For the efficient buyer, the situation is somewhat more complicated than in the static setup: an efficient buyer getting a high price offer $\overline{p}$ has the option of delaying trade and potentially getting a low offer $\underline{p}$ in the future. Hence, the efficient buyer's incentive compatibility constraint is

$$v_2 - \overline{p} \geq \delta\hat{h}(v_2 - \underline{p}),$$

where the left-hand side is the utility from accepting a high offer immediately and the right-hand side is the value of waiting a period and then staying in the market until getting a low offer. Again, stationarity makes sure that this condition is sufficient since rejecting a high offer in the current period and accepting a high offer some time in the future cannot be optimal. Rearranging yields

$$\overline{p} = (1 - \delta\hat{h})v_2 + \delta\hat{h}v_1.$$

This allows us to write per cohort profits. Note that considering per cohort profits is the right measure, since the mass of entering traders per period is exogenously given. The mass of efficient sellers entering per period is h, each trading immediately and generating profits $\underline{w}$. The mass of inefficient sellers entering per period is $1 - h$, each generating profit $\overline{w}$ with the ultimate probability $\hat{h}$. Hence, profits are

$$\Pi_f = h\underline{w} + (1-h)\hat{h}\overline{w} = h(\underline{p} - c_1) + \hat{h}((1-h)\overline{p} - (c_2 - hc_1)). \tag{29}$$

Predation We now compare profits for price posting and fee setting. Note that Π_p decreases in $\hat{\lambda}$ and $\hat{\lambda}$ increases with λ, whereas Π_f is independent of $\hat{\lambda}$ (and λ). Therefore, if $\Pi_p = \Pi_f$ for some λ^*, then $\Pi_p < \Pi_f$ for all $\lambda > \lambda^*$. One can show that λ^* exists and is unique, since for $\lambda = 1$, $\Pi_p = 0 < \Pi_f$, for $\lambda = 0$ we know that the optimal mechanism is price posting, and Π_p is continuous and strictly decreasing in λ.

We can get λ^* by solving $\Pi_p = \Pi_f$ in closed form:

$$\lambda^* = \frac{2(h-\mu)(1-\delta)}{1 - 2\delta(h-\mu) + \sqrt{1 - 4(1-h)h\delta}}.$$

or

$$\lambda^* = \frac{2(h-\mu)(1-\delta)}{2\delta\mu + \sqrt{(2\delta h - 1)^2 + 4\delta(1-\delta)h^2} - (2\delta h - 1)}.$$

With some algebra, it can be shown that $\lambda^* \in (0,1)$ if $h > \mu$. This also implies that $\Pi_f > 0$, since for $\lambda = 1$, $\Pi_p = 0$.

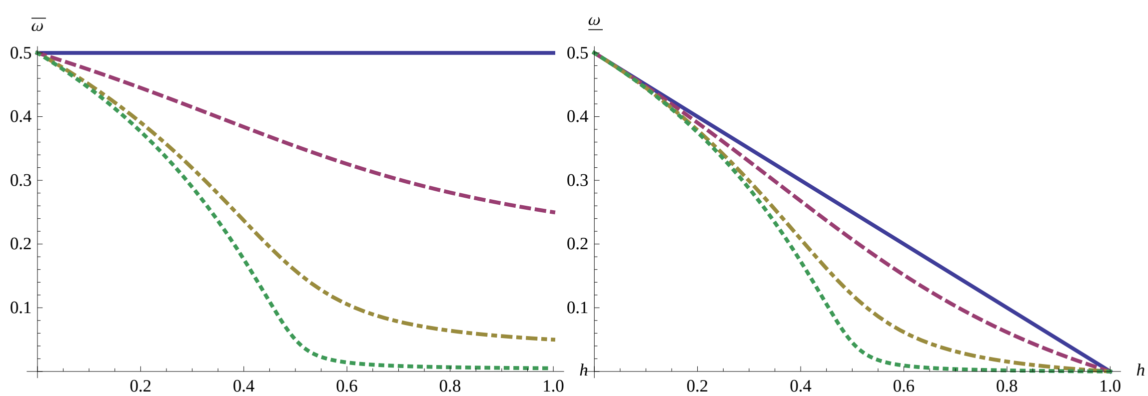
One can also show that fee setting is always preferred to Walrasian price posting, just as for the static setup. Note that for Walrasian price posting, profits are the same as in the static setup since traders trade immediately. That is, profits are $v_1 - c_2$. Again, it can be shown that $h > \mu$ implies $\Pi_f > v_1 - c_2$.

For the special case $v_1 = c_2$ (or, equivalently, $\mu = 0$), this further simplifies to

$$\lambda^* = \frac{2h(1-\delta)}{1 - 2h\delta + \sqrt{1 - 4(1-h)h\delta}}$$

We can plot λ^* as a function of h for different values of δ as depicted in Figure 6. For $\delta = 0$ we are back in the static setup and $\lambda^* = h$ as before. The figure illustrates that as δ increases, λ^* becomes lower, that is as the market becomes more dynamic (or as frictions become smaller), it is more likely that fee setting is preferred by the intermediary. This can be shown to hold in general, that is, $\partial\lambda^*/\partial\delta < 0$ holds under the assumption that $h > \mu$.

Additionally, one may wonder how prices and fees change as δ changes (this might belong to the previous subsection or somewhere else). To provide some numerical examples, set $v_2 = 1$, $c_1 = 0$ and $v_1 = c_2 = 1/2$. The high price $\overline{p}$ as a function of h is plotted in panel (b) of Figure 6 for the same values of δ as in panel (a). Note that $\underline{p} = v_1$ for any δ and h. $\overline{w}$ and $\underline{w}$ are plotted in panels (a) and (b) of Figure



(a) $\overline{w}$ as a function of h for $\delta = 0$ (solid), $\delta = 0.5$ (dashed), $\delta = 0.9$ (dash-dotted), and $\delta = 0.99$ (dotted).

(b) $\underline{w}$ as a function of h for $\delta = 0$ (solid), $\delta = 0.5$ (dashed), $\delta = 0.9$ (dash-dotted), and $\delta = 0.99$ (dotted).

Figure 7: $\overline{\omega}$ and $\underline{\omega}$.

C.5 Welfare

We now turn to the analysis of the effects of predatory fee-setting on social welfare and on consumer surplus, and we provide a brief assessment of the quantitative effects of predatory fee-setting in our model. We conclude the section with a discussion of policy implications of our simple model. Throughout this section, we confine attention to the basic (that is, static) model.

C.5.1 Effects of Fee-Setting on Welfare and Consumer Surplus

When the intermediary posts the prices $p_B = (1-\lambda)v_2 + \lambda\frac{v_1+c_2}{2}$ and $p_S = (1-\lambda)c_1 + \lambda\frac{v_1+c_2}{2}$, welfare W_p under price posting is

$$W_p = h(v_2 - c_1) + \lambda(1-h)(v_1 - c_2) = (v_2 - c_1)[h + \lambda(1-h)\mu], \tag{30}$$

where the subscript $PP.s$ stands for "selective price posting". Under selective price posting, consumer surplus, defined broadly as the sum of surplus grasped by buyers and sellers and denoted CS_p, is

$$CS_p = \lambda(v_2 - c_1)h + \lambda(1-h)(v_1 - c_2) = \lambda(v_2 - c_1)(h + (1-h)\mu). \tag{31}$$

Welfare W_f under fee-setting, on the other hand, is

$$W_f = h[hv_2 + (1-h)v_1 - c_1] + (1-h)h[v_2 - c_2] = h(v_2 - c_1) + h(1-h)(v_1 - c_2) \tag{32}$$

$$= (v_2 - c_1)[h + h(1-h)\mu]. \tag{33}$$

The first equality in (32) follows because the fraction h of the sellers have low costs and trade with all buyers, thereby generating a surplus of $hv_2 + (1-h)v_1 - c_1$ while the remaining sellers have high costs and only trade if matched to a buyer with a high valuation. The second equality follows after rearranging terms. Consumer surplus under fee-setting, denoted CS_f and defined in the same inclusive sense as under price posting, is

$$CS_f = h[hv_2 + (1-h)v_1 - c_1 - \underline{\omega}] + (1-h)h[v_2 - c_1 - \overline{\omega}] = h^2(v_2 - v_1 + c_2 - c_1) \tag{34}$$

$$= h^2(v_2 - c_1)(1-\mu), \tag{35}$$

where the second line follows after plugging in the value for $\underline{\omega}$ and $\overline{\omega}$ given in (23) and simplifying.

Observe that for $\mu = 0$, we have $W_p = W_f$. For $\mu > 0$, W_p increases in λ while W_f is independent of λ. At $\lambda = h$, we have $W_p = W_f$ and $W_p > W_f$ for any $\lambda > h$, assuming $v_1 > c_2$.[40] Since the condition for fee-setting to be profitable is $\lambda > h - \mu$, this means that (i) fee-setting is profitable whenever it reduces welfare but also, and somewhat surprisingly, (ii) that profitable and welfare enhancing fee-setting is possible, the latter occurring when $h - \mu < \lambda < h$. The intuition seems to be that if h is large relative to λ, the intermediary under fee-setting is a better match maker than is the random matching market.[41]

Notice also that CS_f is independent of λ while CS_p increases in λ. Since at $\lambda = h$, $CS_p > CS_f$, it follows that fee-setting decreases consumer surplus whenever it decreases total welfare. Because CS_p is continuous in λ, it follows also that the parameter space for which fee-setting is detrimental to consumer surplus is larger than the parameter space for which it is detrimental to welfare. This reflects a theme from Loertscher and Niedermayer (2016), where fee-setting emerges as a tool to extract rents from buyers and sellers.

Somewhat tedious algebra reveals that $CS_f = CS_p$ at $\lambda = \lambda_{CS}$ with

$$\lambda_{CS} := h^2 \frac{1-\mu}{h + (1-h)\mu}. \tag{36}$$

Since $\lambda^* = h - \mu < \lambda_{CS}$, predation is profitable and increases consumer surplus for $\lambda \in \left(h - \mu, h^2 \frac{1-\mu}{h+(1-h)\mu}\right)$. Summarizing, we have established the following two propositions, where the comparisons are made with welfare and, respectively, consumer surplus under (selective) price posting.

Proposition 6.

1. *("Bad price-posting equilibrium outcome") If $\lambda < h - \mu$, fee-setting achieves higher welfare than price posting, but a profit maximizing intermediary will choose price posting.*

2. *("Good fee-setting equilibrium outcome") If $\lambda \in [h - \mu, h]$, fee-setting achieves higher welfare and a profit maximizing intermediary will choose fee setting.*

3. *("Predatory fee-setting equilibrium outcome") If $\lambda > h$, price posting achieves higher welfare, but a profit maximizing intermediary will choose fee-setting.*

The possibility of positive equilibrium effects on welfare and consumer surplus of predation are reminiscent of Cabral and Riordan (1994, 1997), who show that in the

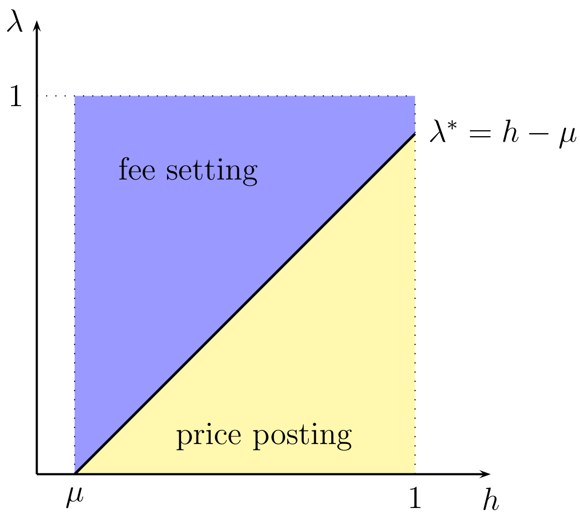
[40] At $v_1 = c_2$ welfare is the same with fee-setting and price posting because both mechanisms always induce trade by the efficient agents.

[41] Conditional on being an inefficient type, an agent's probability of trade in the matching market under price posting is λ while his probability of trading at the market maker with fee-setting is h. Since the efficient types trade with probability 1 regardless of the mechanism used by the intermediary, the result follows.

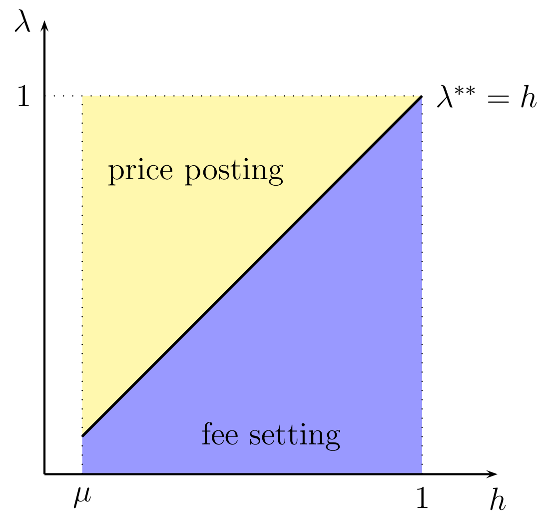
presence of a learning curve these effects can go either way. Note, however, that in continuous type space model, the profit generated by choosing the Walrasian quantity is zero, which corresponds to a μ close to 0 in our setup. For μ close to zero, the middle case ("good fee setting equilibrium outcome") vanishes.

Proposition 7. *For* $\lambda \in \left(h - \mu, h^2 \frac{1-\mu}{h+(1-h)\mu}\right)$*, predatory fee-setting increases consumer surplus while for* $\lambda > h^2 \frac{1-\mu}{h+(1-h)\mu}$ *it decreases consumer surplus.*

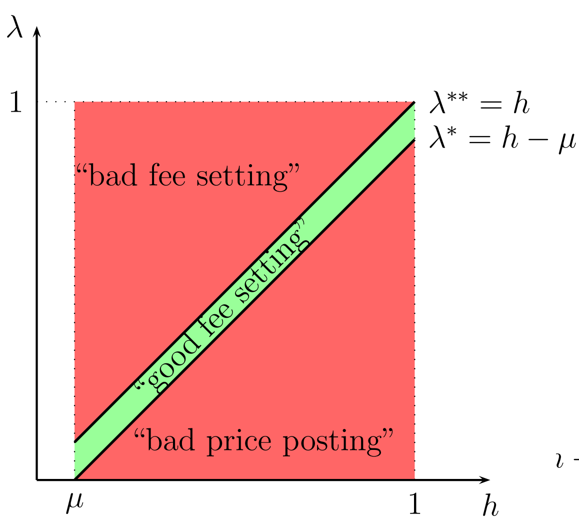
Note again that for $\mu \to 0$, both λ^* and λ_{CS} go to h, which means that consumer surplus always decreases when the intermediary prefers fee setting.



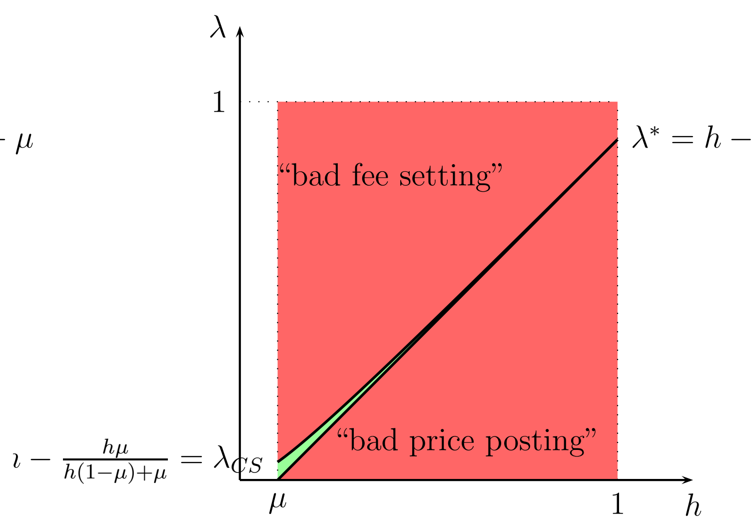
(a) Profits



(b) Welfare



(c) Profits vs Welfare



(d) Profits vs Consumer Surplus

Figure 8: The optimal mechanism in term of profits and welfare (Subfigures 8a and 8b); comparison of profits vs welfare and profits vs consumer surplus (Subfigures 8c and 8d).