Marketmaking Middlemen*

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Abstract

This article develops a model in which market structure is determined endogenously by the choice of intermediation mode. There are two representative modes of intermediation that are widely used in real-life markets: one is a middleman mode where an intermediary purchases inventory from the wholesale market and resells to buyers; the other is a market-making mode where an intermediary offers a platform for buyers and sellers to meet and trade. We show that a *marketmaking middleman*, who adopts a mixture of these two intermediation modes, can emerge in a directed search equilibrium and discuss implications for the market structure.

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1 Introduction

This article develops a framework in which market structure is determined by the intermediation service offered to customers. There are two representative modes of intermediation that are widely used in real-life markets. In one mode, an intermediary acts as a *middleman*, who is specialized in buying and selling for his own account and typically has access to a superior inventory technology (e.g. supermarkets, traditional brick and mortar retailers, and dealers in financial and steel markets). In the other mode, an intermediary acts as a *marketmaker* who offers a platform where the participating buyers and sellers can meet and trade with each other and at least one side of the market pays a fee for using the platform (e.g. auction sites, brokers in goods or financial markets, and many real estate agencies).

The market-making mode became more popular as new advanced internet technology facilitated the use of online platforms in the late 1990s and early 2000s. In financial markets, an expanded platform sector is adopted in a specialist market, i.e., the New York Stock Exchange (NYSE), and even in a typical dealers' (i.e., middlemen's) market, i.e, the NASDAQ.[1] In goods and service markets, the electronic retailer Amazon.com and the online hotel/travel reservation agency Expedia.com started as a pure middleman but now also act as a marketmaker, by allowing other suppliers to participate on their platform as independent sellers. In housing markets, some entrepreneurs run a dealer company (developing and owning luxury apartments and residential towers) and a brokerage company simultaneously in the same market.

Common to all the above examples is that intermediaries operate both as a middleman and a marketmaker at the same time. This is what we call a *marketmaking middleman*. Hence, the first puzzle is to explain the emergence of marketmaking middlemen, i.e., why the middleman or the platform sector has not become the exclusive avenue of trade, despite the recent technological advancements.

We also observe considerable differences in the microstructure of trade in these markets. The

[1] In the finance literature, brokers are akin to our market-makers, and dealers are akin to our middlemen. The market-makers/specialists in financial markets quote prices to buy or sell assets as well as take market positions, so they correspond broadly to our market-making middlemen.

NASDAQ is still a more 'middlemen-based' market relative to the NYSE. Some intermediaries in housing markets are marketmaking middlemen whereas many intermediaries are brokers. Other online intermediaries, such as eBay and Booking.com, are pure platforms, who do not buy and sell on their own accounts, like Amazon.com and Expedia.com do. So the second puzzle is to explain what determines the position of an intermediary's optimal mode in the spectrum spanning from a pure platform mode to a pure middleman mode.

We consider a model in which the intermediary mode is determined endogenously as a result of the strategic choice of a monopolistic intermediary. In our model, there are two markets open to agents, one is operated by the intermediary and the other is a decentralized market where buyers and sellers meet and trade. The intermediated market combines two business modes: as a middleman, the intermediary is prepared to serve many buyers at a time making use of its advantageous access to wholesale supplies; as a marketmaker, the intermediary offers a platform to buyers and sellers and charges a fee for this service. The intermediary can choose how to allocate the attending buyers among these two business modes.[2]

We model the intermediated market as a directed search market in order to feature the intermediary's technology of spreading price and capacity information efficiently – using the search function offered in the NYSE Arca or Expedia/Amazon website or in the web-based platform for house hunters. For example, one can receive instantly all relevant information such as prices, the terms of trade and stocks of individual sellers. In this setting, each individual seller is subject to an inventory capacity of discrete units (normalized to one unit in the model), whereas the middleman has unlimited access to the wholesale market. Naturally, the middleman is more efficient in matching demand with supply. The decentralized market represents an individual seller's outside option that determines the lower bound of his market utility.

With this set up, we consider two situations, *single-market search* versus *multiple-market search*. Under single market search, agents have to choose which market to search in advance, either the

[2]Throughout the article, "marketmaker" and "platform" refer to the same intermediation mode, and we use them interchangeably.

decentralized market or the intermediated market. This implies that the intermediary needs to offer buyers at least their expected value in the decentralized market, but once they participate, the intermediated market operates without fear for outside competitive pressure. As is well known in the two-sided market literature, there exist belief-based multiple equilibria in the participation stage of buyers and sellers. Given that the middleman mode is more efficient in realizing transactions, we show that under mild refinements on beliefs, the intermediary uses the middleman-mode exclusively when agents search in a single market.

When agents are allowed to search in multiple markets, the option to also search in the decentralized market is an outside option that creates competitive pressure for the intermediary. This outside option caps the prices/fees that the intermediary can charge in the intermediated market. Moreover, an agent's value in the D market is affected by the intermediary mode. We call this *cross-market feedback.* To illustrate this, suppose buyers are relocated from the platform to the middleman. As middleman matching is frictionless, the overall trade at the intermediary increases. Thus, fewer buyers continue to search in the decentralized market, which lowers a seller's outside value. This constitutes a positive cross-market feedback because it allows the intermediary to charge a higher platform fee. However, another effect is that fewer sellers match on the platform now and those unmatched sellers will continue to try to find a trading partner in the decentralized market. Consequentially, buyers expect a higher success rate in the decentralized market and this puts competitive pressure on the price/fee that the intermediary can charge. This constitutes a negative cross-market feedback. Ultimately, it is the matching efficiency of the two modes, the positive and the negative cross-market effect that determines the middleman's scale and eventually the intermediation mode.

Single-market search captures the traditional search technology for local supermarkets or brick and mortar retailers. Over the course of a shopping trip, consumers usually have to search, buy and even transport the purchased products during a fixed amount of time. Given the time constraint, they visit a limited number of shops — typically one supermarket — and appreciate the proximity provided by its large inventory capacity. In contrast, multi-market search is more related to the advanced search technologies that are available in the digital economy. It allows the online-customers to search and compare various options easily. Multiple market search is also relevant in the market for durable goods such as housing or expensive items where customers are exposed to the market for a sufficiently long time to ponder multiple available options.

We show that a marketmaking middleman can emerge in a directed search equilibrium. The marketmaking middleman can outperform both of the extreme intermediation modes. Relative to a pure platform, its middleman sector can reduce the out-of-stock risk, whereas relative to a pure middleman its platform sector can better exploit the surplus of intermediated trade. It is this trade-off that answers the two puzzles above. Somewhat surprisingly, our result suggests that an improvement in search technologies induces the intermediary to generate inefficiencies to increase profits. This occurs because platform trade creates more profits but it is at the expense of more frictional matching.

Our article is related to the literature on middlemen developed by Rubinstein and Wolinsky(1987) who show that an intermediated market can be active under frictions because middlemen have an advantage in the meeting rate over the original suppliers.[3] Using a directed search approach, Watanabe (2010, 2018, 2020) provides a model of an intermediated market operated by middlemen with high inventory holdings. The middlemen's high selling-capacity enables them to serve many buyers at a time. Because of the lower likelihood of stock-out, it generates a retail premium of inventories. This mechanism is adopted by the middleman in our model. Hence, if the platform were not available, then our model would be a simplified version of Watanabe where we added an outside market. It is worth mentioning that in Watanabe (2010, 2018, 2020), the middleman's inventory is modeled as an indivisible unit, i.e., a positive integer, so that the middlemen face a non-degenerate distribution of their selling units as other sellers do. In contrast, here we consider unlimited inventory holdings of the middleman, assuming more flexible inventory technologies, so that the middleman faces a degenerate distribution of sales. This simplification allows us to characterize the middle-

[3] See also Biglaiser (1993), Li (1998), Shevchenko (2004), Masters (2007), Wright and Wong (2014), Nosal et al. (2015), Geromichalos and Jung (2018), Awaya et al. (forthcoming).

man's profit-maximizing choice of its scale — in Watanabe(2010, 2018) it is determined by aggregate demand-supply balancing, and in Watanabe (2020) it is treated as an exogenous parameter. More recently, Holzner and Watanabe (2020) study a labor market equilibrium using a directed search approach to model a job-brokering service offered by Public Employment Agencies, but the choice of intermediation mode is not the scope of their article.

Our article is also related to the two-sided market literature, see e.g. Caillaud and Jullien (2001, 2003), Rochet and Tirole (2003), Armstrong (2006), Hagiu (2006).[4] The critical feature of a platform is the presence of a cross-group externality, i.e., the participants' expected gains from a platform depend positively on the number of participants on the other side of it. Caillaud and Jullien (2003) show that even when agents have pessimistic beliefs on the intermediated market, the intermediary can make profits by using "divide-and-conquer" strategies, i.e., subsidizing one group of participants in order to attract another group and extract the ensuing externality benefit. Broadly speaking, if there were no middleman mode, our model would be a directed search version of Caillaud and Jullien (2003) in combination with a decentralized market. Moreover, our result that the intermediary sometimes induces agents to search more than they like is related to the idea of search diversion in Hagiu and Jullien (2011). They pursue this idea in a model of an information platform that has superior information about the match between consumers and stores and that could direct consumers first to their least preferred store.

Rust and Hall (2003) develop a search model which features the coexistence of different intermediation markets.[5] They consider two types of intermediaries, one is a "middleman" whose market requires costly search and the other is a monopolistic "market maker" who offers a frictionless market. They show that agents segment into different markets depending on heterogeneous production costs and consumption values, thus these two types of intermediaries can coexist in equilibrium. Their model is very different from ours in many respects. For instance, selling capability and in-

[4]Related articles from other aspects can be found in Baye and Morgan (2001), Rust and Hall (2003), Nocke et al. (2007), Galeotti and Moraga-González (2009), Loertscher and Niedermayer (2008), and Rhodes et al. (2021). Earlier contributions of this strand of literature are, e.g., Stahl (1988), Gehrig (1993), Yavaş (1994), Spulber (1996), and Fingleton (1997).

[5]See Ju et al. (2010) who extend the Rust and Hall model by considering oligopolistic market makers.

ventory do not play any role in their formulation of a search rule, but it is the key ingredient in our model. As Rust and Hall (2003) state: "An important function of intermediaries is to hold inventory to provide a buffer stock that offers their customers liquidity at times when there is an imbalance between supply and demand. In the securities business, liquidity means being able to buy or sell a reasonable quantity of shares on short notice. In the steel market, liquidity is also associated with a demand for immediacy so that a customer can be guaranteed of receiving shipment of an order within a few days of placement. *Lacking inventories and stockouts, this model cannot be used to analyze the important role of intermediaries in providing liquidity* (page 401; emphasis added)." This is exactly what we emphasize in our model which incorporates Rust and Hall's observation. We show that intermediaries can pursue different types of intermediation modes even when faced with homogeneous agents.

The rest of the article is organized as follows. Section 2 presents our model of intermediation, and the benchmark case of single-market search. Section 3 extends the analysis to allow for multiple-market technologies and presents the key finding of our article. Section 5 concludes. All the proofs are in the Appendix.

2 Single-market search

Set-up

Consider a mass B of identical buyers, a unit mass of identical sellers, and one intermediary. Buyers and sellers want to trade with each other but can only meet in one of two markets: a *centralized/intermediated market* (C market) operated by the intermediary, or a *decentralized market* (D market). We consider two search technologies: *single-market search*, where buyers and sellers can only attend one out of the two markets, and *multi-market search* where buyers and sellers can attend both markets *sequentially*. This section spells out the details of single-market search, and the next section discusses multi-market search.

Buyers and sellers. Buyers have demand for one unit of a homogeneous indivisible good. The consumption value is 1. Sellers can produce the good at a constant marginal cost $c \in [0,1)$, but they have a limited capacity to accommodate visitors. For simplicity, a seller's capacity is normalized to *one* unit. That is, each seller is able to serve at most one buyer. The small capacity is a key feature that differentiates an individual seller from a large-scale middleman (to be introduced below). It can be caused by various reasons, such as a small number of service staff or insufficient storage space.

The D market. In the decetralized market, search is random and the surplus is split by bilateral generalized Nash bargaining. Denote the measure of buyers joining the D market by B^d and that of sellers by S^d. Search frictions are captured by a matching function $M^d(B^d, S^d)$, which has constant returns to scale, is strictly increasing and strictly concave in both arguments. Let $x^d \equiv \frac{B^d}{S^d}$ represent the buyer-seller ratio. Then the matching probability for a seller is $\lambda^s(x^d) \equiv \frac{M^d(B^d,S^d)}{S^d}$, and for a buyer it is $\lambda^b(x^d) = \frac{\lambda^s(x^d)}{x^d}$. We impose that $\lambda^b(x^d)$ is strictly convex, and satisfies $\lambda^b(\infty) = \lambda^s(0) = 0$, $\lambda^b(0) = \lambda^s(\infty) = 1$. Let $\beta \in (0,1]$ be the buyer's bargaining power parameter. Then the expected value for a buyer and a seller is respectively,

$$V^d = \lambda^b(x^d)\beta(1-c) \tag{1}$$

$$W^d = \lambda^s(x^d)(1-\beta)(1-c). \tag{2}$$

Throughout the article, we refer to a buyer's value as V^i, a seller's value as W^j, the buyer-seller ratio as x^j, and add a superscript $i \in \{m, p, d\}, j \in \{p, d\}$ for the trading venue, where m, p, d represent *m*iddleman, *p*latform and *D* market, respectively (middleman and platform are introduced below).

The C market. The centralized market is operated by a monopolistic intermediary who has the choice between two different modes: middleman and platform. As a *middleman*, it purchases the good from the wholesale market at price c and resells to buyers at price $p^m \in [c, 1]$. The middleman's inventory technology is more advanced than that of individual sellers. To feature this, we assume that the middleman has continuous access to the wholesale market.[6] Then, middleman matching is frictionless and a buyer's value from the middleman is

$$V^m = 1 - p^m. \tag{3}$$

As a *platform* (or a *market-maker*), the intermediary provides a venue for buyers and sellers to meet and trade. It charges $f \geq 0$ for each successful transaction. Without loss of generality, we assume that sellers pay f.[7] Search on the platform is directed, and consists of the following stages. First, participating sellers simultaneously post a price. Observing all posted prices, buyers simultaneously decide whether or not to participate and if they do, which seller to visit. This results in submarkets consisting of the sellers who post a price and the buyers visiting those sellers. Within a submarket, meetings between buyers and sellers are governed by a constant-returns-to scale matching function: $M^p(b,s)$, where b and s are the measures of buyers and sellers in the submarket, respectively. Finally, matched pairs trade at the posted price, and unmatched agents receive a payoff of zero.[8]

Although sellers are allowed to post any price and buyers are allowed to approach any seller, we show below that in equilibrium all sellers post the same price so buyers will randomise with equal probability over all sellers. Let B^p and S^p be the measures of buyers and sellers on the platform, respectively. We assume that $M^p(\cdot)$ has constant returns to scale, is strictly increasing and concave in both arguments, and satisfies $M^p(0,S^p) = M^p(B^p,0) = 0$ and $M^p(B^p,S^p) < \min\{B^p,S^p\}$. Denote the platform buyer-seller ratio by $x^p \equiv \frac{B^p}{S^p}$, and the equilibrium price on the platform by p^s. Then, a seller is matched with probability $\mu^s(x^p) \equiv M^p(x^p,1)$, and her expected value is

$$W^p = \mu^s(x^p)(p^s - f - c).$$

A buyer is matched with probability $\mu^b(x^p) = \frac{\mu^s(x^p)}{x^p}$, and her expected value is

$$V^p = \mu^b(x^p)(1 - p^s).$$

[6] The supply side of the wholesale market can be producers who are not in the retail process, or individual sellers who have limited inventory capacity but unrestricted production capacity.

[7] Allowing for participation fees/subsidies, which accrue irrespective of transactions in the C market, will not affect our main result.

[8] The approach adopted here is equivalent to the one where buyers post prices and sellers direct their search to them, as is common in the labor market.

Note that $\mu^{s\prime}(x^p) \in (0, \mu^b(x^p))$ for all positive x^p.[9] We further assume $\mu^{s\prime}(0) < 1$.[10]

Timing. The model has three stages.

1. *Announcement.* The intermediary announces a platform fee f and a middleman price p^m.
2. *Participation.* Buyers and sellers observe f and p^m and simultaneously decide which market (sector) to participate in.
3. *Trade.* Trade takes place in each market.

Comparing trade venues Matching is frictionless at the middleman whereas it is frictional in the other two venues. The D market has traditional search frictions (it takes time for buyers and sellers to meet) whereas on the platform there are coordination frictions (buyers do not know which sellers other buyers visit). The C market has price posting whereas in the D market prices are determined by bargaining. However, this is not essential, our main results also hold for other selling mechanisms and directed search in the D market.

Market equilibrium

For the moment, we take as given the intermediary's strategy $P = (p^m, f) \in \mathbb{P}$ where $\mathbb{P}$ denotes the set of all feasible price pairs such that the middleman price $p^m \in [c, 1]$ and the platform fee $f \in [0, 1-c]$.[11] In this section, we describe an equilibrium in the participation stage, referred to as *a market equilibrium*. For any given announced price pair P, a seller's strategy consists of a trading venue to participate in (either the D market or the platform in the C market), and if the platform is chosen what price to post. A buyer's strategy consists of a trading venue to participate in (either the D market, the middleman, or the platform), and if the platform is chosen which seller to visit. Just

[9]This is because $\frac{\partial M^p(B^p,S^p)}{\partial B^p} = \mu^{s\prime}(x^p) > 0$ and $\frac{\partial M^p(B^p,S^p)}{\partial S^p} = \mu^s(x^p) - x^p\mu^{s\prime}(x^p) > 0$.

[10]Naturally, we require all matching probabilities to be less or equal to 1. Matching functions such as the Cobb-Douglas would require additional restrictions. One matching function that is microfounded and fits all requirements is the urn-ball matching function, where a seller is matched with probability $1 - e^{-\gamma x}$, $\gamma \in (0, 1]$, where x the buyer-seller ratio.

[11]We could have included explicitly an action for the intermediary to shut down the platform or middleman mode, but this is redundant because a pure platform arises if the intermediary sets $p^m = 1$ and $f < 1 - c$, and a pure middleman arises if $p^m < 1$ and $f = 1 - c$.

as with subgame-perfection, we work backward and derive first a trade equilibrium on the platform assuming $B^p, S^p > 0$. Below, we follow the standard procedure in the directed search literature (see e.g., Wright et al., 2021).

Let V^p denote the maximum value that a buyer can obtain on the platform, i.e., the market utility. Suppose that a potential deviant seller posts a price $p' \neq p^s$ that attracts an expected queue x' of buyers.[12] Given that we have a continuum of sellers, this deviation has measure zero and does not affect V^p. Then, as buyers must be indifferent between visiting any seller (including the deviating seller), they must receive V^p on and off the equilibrium path and this pins down the expected queue at a deviant:

$$\mu^b(x')\left(1 - p'\right) = V^p. \tag{4}$$

Because a buyer's matching probability $\mu^b(x)$ is strictly decreasing in x, this equation describes a downward sloping demand curve — when the seller raises her price p', the expected queue of buyers x' becomes shorter and this corresponds to a lower trading probability for the seller. The seller's problem is then $\max_{p'} \mu^s(x')\left(p' - f - c\right)$, taking (4) as a constraint. Essentially, the seller is the residual claimant and the buyer always obtains his market utility. Eliminating p' using (4), yields

$$W^p = \max_{x'}\{\mu^s(x')(1 - f - c) - x'V^p\}.$$

The necessary and sufficient first order condition is $\mu^{s\prime}(x')\left(1 - f - c\right) - V^p = 0$. This condition implies that all sellers choose the same x' and in equilibrium it must be equal to the platform buyer-seller ratio x^p. Evaluating the first order condition at $x' = x^p$ yields the buyers' expected value on the platform,

$$V^p = \mu^{s\prime}(x^p)(1 - f - c), \tag{5}$$

and the expected value of the sellers on the platform,

$$W^p = \left(\mu^s(x^p) - x^p\mu^{s\prime}(x^p)\right)\left(1 - f - c\right). \tag{6}$$

[12]Equivalent, x' is the buyer-seller ratio of the submarket where the deviant seller is in.

Thus, on the platform, the buyer and seller's expected values are equal to their marginal contribution to the joint surplus.

Given the trade equilibrium in each trading venue, buyers and sellers choose which of the trading venues to participate in. With single-market search, the measure of agents at each venue must sum up to the total population measures:

$$B^m + B^p + B^d = B, \tag{7}$$

$$S^p + S^d = 1. \tag{8}$$

where B^m is the measure of buyers visiting the middleman.

Definition 1 *Given the buyer's and the seller's values in the C market and the D market described by (1), (2), (3), (5) and (6), an allocation of agents described by a vector $N = (B^m, B^p, B^d, S^p, S^d)$ constitutes a market equilibrium for each given P if it satisfies (7) and (8), and if neither a buyer nor a seller can gain by deviating to another trading venue.*

Denote the set of equilibrium allocations for a given P by $\mathcal{N}(P)$. $\mathcal{N}(P)$ is in general not a singleton — a member of $\mathcal{N}(P)$ can be only one active trading venue, either the middleman, the platform, or the D market, or multiple active venues. However, note that having all three trading venues active in equilibrium is a "rare event" because with three active venues, buyers must be indifferent among all of them, $1 - p^m = \mu^{s\prime}(x^p)(1 - f - c) = \lambda^b(x^d)\beta(1 - c)$, and sellers must be indifferent between the platform and the D market, $(\mu^s(x^p) - x^p\mu^{s\prime}(x^p))(1 - f - c) = \lambda^s(x^d)(1 - \beta)(1 - c)$. From these equations and the fact that $M^d(\cdot)$ and $M^p(\cdot)$ exhibit constant returns to scale, the matching probabilities, $\lambda^s(\cdot), \lambda^b(\cdot)$ and $\mu^s(\cdot)$, depend only on the buyer-seller ratios, x^p and x^d. In addition, the payoff from middleman trade does not depend on any population parameter. Summing up, for each given P, we have three equations for only two unknowns x^p and x^d. This means that even if a market equilibrium exists with the three active venues for some P, it is not robust to variations in P. Therefore, with single-market search technologies, a market equilibrium with all the three trading venues active is a knife-edge case. As we will see later in the intermediary's problem, which determines a profit-maximizing P, this property will help us reduce significantly the possible deviations and the equilibrium configurations we have to examine.

Intermediation mode

We now examine the profit-maximizing intermediation mode via the choice of $P = (p^m, f)$. We call the intermediary *a pure platform* if $B^p, S^p > 0$ and $B^m = 0$, *a pure middleman* if $B^m > 0$ and $B^p = S^p = 0$, and *a hybrid (or a market-making middleman)* if $B^p, S^p, B^m > 0$.

The intermediary selects a price pair $P = (p^m, f)$ to maximize its profit, given by

$$B^p \mu^b(x^p) f + B^m(p^m - c),$$

where the first term is fee revenue and the second one is the middleman profit. To capture how an announced P determines B^p, x^p $(= \frac{B^p}{S^p})$ and B^m, we define a demand function for intermediary services as a mapping $N(P)$ that associates each P with a market equilibrium allocation given by Definition 1. That is, $N(P)$ selects an element from $\mathcal{N}(P)$ for all $P \in \mathbb{P}$. Each $N(\cdot)$ is supported by a belief system where each agent assigns probabilities on how other agents join different trading venues.

To see how beliefs matter for the intermediary's decision, suppose that agents hold *optimistic* beliefs on the number of visitors at the intermediary. Then, the intermediary can almost make a monopolist profit $B - \epsilon$ (with $\epsilon > 0$) in equilibrium by setting $p^m = 1 - \epsilon$ and $f = 1 - c$, where all buyers trade with the middleman and all sellers participate in the platform but do not trade.

Consider another example where agents hold *pessimistic* beliefs against the intermediary — everyone believes that others avoid the C market whenever possible. The platform will remain inactive because everyone believes that the platform is empty. The intermediary can only make a positive profit by setting p^m sufficiently low. The buyers' indifference condition between the middleman and the D market is: $1 - p^m = \lambda^b(B - B^m)\beta(1 - c)$. This gives a monotonic relationship between B^m and

p^m. In general, the intermediary's profit maximizing problem can be written as:

$$\max_{B^m \in [0,B]} B^m(1-\lambda^b(B-B^m)\beta)(1-c).$$

It is straightforward to show that the solution to this problem is characterized by a cutoff $\tilde{\beta}^s \equiv \frac{1}{1-B\lambda^{b\prime}(0)} \in (0,1)$ such that the intermediary chooses an interior $B^m \in (0,B)$ if and only if $\beta > \tilde{\beta}^s$, and a corner solution $B^m = B$ if and only if $\beta \leq \tilde{\beta}^s$.

In all of the examples above, the intermediary acts as a pure middleman. Indeed, the intermediary prefers allocating buyers to the middleman rather than to the platform because the former is more efficient than the latter, i.e., a mass of B' buyers results in B' trades in the middleman sector but only in $B'\mu^b(x^p) < B'$ trades on the platform for any $x^p \in (0,\infty)$. In addition, the middleman can charge a premium for its frictionless service, which can be seen by comparing (3) and (5) and observing that to attract buyers it is necessary for the frictional platform to set $f < p^m - c$.

We are interested in whether a pure middleman can occur more generally, that is, not just with the extreme beliefs in the above examples, but also for other beliefs. We should note however that, by manipulating beliefs, any intermediation mode can be sustained in equilibrium.[13] Thus, we impose two mild refinements to focus on reasonable beliefs. These refinements can be stated equivalently as restrictions on $N(\cdot)$. We add a hat to denote variables in equilibrium and use a prime for a deviation. In particular, $\hat{P} = (\hat{p}^m, \hat{f})$ denotes the price pair in a proposed equilibrium.

The first refinement on $N(\cdot)$ is called *local belief stability*. Consider a marginal deviation P' from $\hat{P}$. If an intermediary's mode is active under $\hat{P}$, and it remains to be active under P', then $N(\cdot)$ is locally belief stable. For example, if the intermediary acts as an hybrid in the proposed equilibrium, then under local belief stability it remains an hybrid following P'.

Formally, let $B_\delta(\hat{P})$ be an open ball around $\hat{P}$ with radius $\delta > 0$, and let $N' = (B^{m\prime}, B^{p\prime}, B^{d\prime}, S^{p\prime}, S^{d\prime})$ be a typical off-equilibrium-path allocation. Define $\mathcal{S}_1(P')$ as the set of market allocations such that

[13] For instance, consider demand $N(\cdot)$ such that for any deviation of the intermediary, all buyers and sellers switch to the D market whenever possible. Under this utmost pessimistic belief, a hybrid mode with a high middleman price can occur in equilibrium because the intermediary would make zero profit by deviating from the proposed equilibrium.

an intermediary sector remains active under deviation P':

$$\mathcal{S}_1(P') = \{N' \in \mathcal{N}(P') : B^{p\prime}, S^{p\prime} > 0 \text{ if } \hat{B}^p, \hat{S}^p > 0, \text{ and } B^{m\prime} > 0 \text{ if } \hat{B}^m > 0\}.$$

Refinement 1 (local belief stability) *$N(\cdot)$ is locally belief stable if there exists a $\delta > 0$ such that for all $P' \in B_\delta(\hat{P})\backslash\{\hat{P}\}$ and $\mathcal{S}_1(P')$ nonempty, we have $N(P') \in \mathcal{S}_1(P')$.*

We label the refinement "belief stability" because it aims to exclude demand mappings that can be derived from unstable beliefs. One such case is that, for a marginal change in P, agents suddenly become pessimistic about the intermediary, although they were not pessimistic on the equilibrium path. This type of coordination failure problem occurs in many other settings. In a model of bank runs (see Diamond and Dybvig, 1983), an unstable belief would be that agents expect that a bank run is more likely if the bank increases equity marginally. Under such (unreasonable) pessimistic beliefs, a marginal increase in equity will perversely lead to a bank run. Similarly, in the model of self-fulfilling debt crises (see Cole and Kehoe, 2000), an unstable belief would be that investors believe that a crisis is more likely if government debt is reduced marginally. In all these settings, this refinement makes sense.

The second refinement on $N(\cdot)$ is *monotonicity*. It requires that the number of buyers participating in the intermediated market, including the middleman and the platform, does not decrease following a deviation $P' \leq P$. Define $\mathcal{S}_2(P')$ as a subset of $\mathcal{N}(P')$ such that the measure of buyers visiting the intermediary is not lower under P':

$$\mathcal{S}_2(P') = \{N' \in \mathcal{N}(P') : B^{m\prime} + B^{p\prime} \geq \hat{B}^m + \hat{B}^p.\}$$

Then monotonicity is defined below.

Refinement 2 (monotonicity) *$N(\cdot)$ is monotonic if for $p^{m\prime} \leq \hat{p}^m$, $f' \leq \hat{f}$ and nonempty $\mathcal{S}_2(P')$, we have $N(P') \in \mathcal{S}_2(P')$.*

This refinement is similar to the ones used in the literature (see, for example, Caillaud and Jullien, 2003). We should note that this refinement is not so restrictive in the following sense. First, it is only about the number of buyers visiting the C market and it imposes no restriction on how sellers would behave. Second, it does not dictate how buyers are allocated between the two sectors of the intermediary. For example, it can be that following a deviation P', fewer buyers visit the middleman so long as the total number of buyers visiting the C market does not decrease.[14]

Given the market equilibrium $N(P)$ in Definition 1, we focus attention on a single-market search equilibrium consisting of the intermediary's profit-maximizing price pair $\hat{P} = (\hat{p}^m, \hat{f})$ with refinements 1 and 2. Below, we show that the intermediary will not activate the platform in any of such equilibria. The equilibria can be classified as follows. In one equilibrium, which we refer to as a *dominant-market equilibrium*, trade occurs only in the C market, and in the other equilibrium, which we refer to as a *segmented-market equilibrium*, trade occurs in both the C market and the D market.

Suppose, by contradiction that in a dominant-market equilibrium the intermediary is a pure platform, i.e., $\hat{B}^p = B$, $\hat{x}^p = \hat{B}^p$ and $\hat{B}^m = 0$ for some $\hat{P} = (\hat{p}^m, \hat{f})$, where buyers prefer the platform over the middleman: $\mu^{s\prime}(B)(1 - \hat{f} - c) > 1 - \hat{p}^m$. Then, there exists a profitable deviation by the intermediary. As mentioned above, the intermediary prefers relocating buyers to the middleman sector. This can be done profitably by deviating to a low enough middleman price such that all the buyers choose to participate in the middleman sector, but not too low so that the profit margin of the middleman is still higher than the platform (see the proof of Proposition 1 for details). Refinement 2 ensures that all buyers visit the C market because the deviation is a price decrease.

Suppose next that the intermediary is a hybrid. Note that the above logic can be used here only when the proposed equilibrium has a relatively small middleman sector. This is because when the middleman sector is already large, which could happen in a dominant-market equilibrium, lowering p^m is not a profitable way to relocate buyers from the platform to the middleman. We can instead consider a marginal increase in f in order to further expand the middleman sector. One concern here would be that this deviation might drive some or all buyers to the D market because this time,

[14] Monotonicity is also a restriction on beliefs. For instance, if some measure of buyers visit the intermediary at a given price, then we rule out beliefs that following a price decrease, fewer buyers visit the intermediary, which could happen if their beliefs became more optimistic towards trade in the D market.

refinement 2 does not apply. One scenario is that all three venues are active following the fee increase. However, this is is a knife-edge case as is discussed above and thus can be avoided by the intermediary almost costlessly to take up the entire D-market share profitably. Other possible scenarios include that, following the deviation, buyers and sellers suddenly turn pessimistic against the C market — they may either all switch to the D market or divide between the D market and the platform/middleman. However, these beliefs are ruled out by refinement 1. All in all, as before, we can focus on the path where the intermediary implements an empty D market following a deviation to a higher fee.

A similar procedure can be used to establish a pure middleman in a segmented-market equilibrium. Because the intermediary can deviate profitably from the knife-edge equilibrium of the three active venues, we can focus attention on the following two equilibrium candidates: an active D market with a pure middleman or with a pure platform. We have already seen that the former equilibrium exists for relatively high values of β. For the latter case, a profitable deviation is to lower p^m (similar as before) in order to establish an active middleman sector.

Proposition 1 (Pure middleman) *With single-market search and refinements 1 and 2, the intermediary will choose to operate as a pure middleman in any market equilibrium.*

3 Multi-market search

With multi-market search technologies, buyers and sellers can sequentially visit the C market and the D market. To simplify the presentation of our key idea, we assume that the C market opens prior to the D market. Apart from the fact that this appears to be the most natural setup in our economy, it can be motivated by the first mover advantage of the intermediary: its expected profit is higher if the C market opens before the D market. Hence, this sequence arises endogenously if the intermediary is allowed to select the timing of the market sequence. In a recent study without intermediation, Armstrong and Zhou (2015) show that a seller often makes it harder or more expensive to buy its product later than at the first opportunity. We maintain the same set-up of matching and price formation in both markets as in the previous section.

The timing is modified as follows. First, the intermediary announces the platform transaction fee f and the inventory price p^m. Then, buyers and sellers simultaneously decide whether or not to participate and trade in the C market. Those who have successfully traded leave the market, whereas the remaining agents from the C market participate in the D market and trade.

This new set-up brings several changes. First, *inducing participation in the C market becomes easier.* Joining the C market does not rule out the possibility of trading in the D market, thus the value of sequentially joining the C market and the D market is weakly larger than that of directly entering the D market. Thus, we do not need to deal with the belief–based multiplicity of equilibria that arose under single-market search.[15]

Second, *convincing participants to trade in the C market becomes more difficult.* The intermediary needs to ensure that the C market offers must be weakly better than the participants' expected utility in the D market. This imposes incentive constraints to the intermediary's profit maximizing problem. As we will see below, the incentive constraints play an important role in shaping the optimal intermediation mode.

Market equilibrium

Trade in the D market. We work backwards and start with the equilibrium value in the D market. Consider a candidate equilibrium where the offers in the C market make it weakly better to trade there for the buyers and sellers. Then the agents who ultimately join the D market are those who failed to trade in the C market. The population of sellers joining the D market equals $S^d = 1 - \mu^s(x^p)$, where $\mu^s(x^p)$ is the measure of the matched pairs on the platform of the C market. The measure of buyers joining the D market is given by $B^d = B - B^m - \mu^s(x^p)$, where B^m buyers trade with the middleman. The intermediary mode in the C market which is captured by B^m and x^p, determines the D-market buyer-seller ratio x^d, which in turn determines the buyers' value $V^d = \lambda^d(x^d)\beta(1-c)$,

[15]If the two markets opened at the same time, we would have to deal with the agents' beliefs about what other agents would choose when they turn out to be matched in both markets. This would give rise to multiple equilibria. In an infinite horizon model, one can construct a stationary equilibrium where the order of the markets does not matter (see Watanabe, 2020).

and the sellers' value $W^d = \lambda^s(x^d)(1-\beta)(1-c)$ in the D market.

Incentive constraints in the C market. For the platform to be active, the price/fee must satisfy the following incentive constraints:

$$1 - p^s \geq V^d, \tag{9}$$

$$p^s - f - c \geq W^d. \tag{10}$$

Condition (9) is the incentive constraint for buyers to trade on the platform. It states that the offered payoff $1 - p^s$ should weakly exceed the expected value that buyers can obtain in the D market. Condition (10) is the incentive constraint for sellers to trade in the C market, which states that the payoff in the C market $p^s - f - c$ should be no less than the expected payoff in the D market.

A similar incentive constraint must be satisfied in order for buyers to trade with the middleman:

$$1 - p^m \geq V^d. \tag{11}$$

Under conditions (9) to (11), agents are weakly better off trading in the C market. When there is a tie, we make the tie-breaking assumption that indifferent buyers/sellers trade in the C market.

Equilibrium prices on the platform. As before, consider a seller who deviates to a price $p' \neq p^s$ and attracts an expected queue $x' \neq x^p$ of buyers, subject to the market-utility condition:

$$V^p = \mu^b(x')\left(1 - p'\right) + \Big(1 - \mu^b(x')\Big) V^d, \tag{12}$$

where $\mu^b(x')$ is the probability that a buyer is served by this deviating seller. If not served, the buyer receives V^d. The seller's optimization problem is:

$$\max_{p',x'} \Big\{\mu^s(x')(p' - f - c) + (1 - \mu^s(x'))W^d\Big\}, \; s.t. \; (12).$$

The seller trades successfully on the platform with probability $\mu^s(x')$ and in that case he receives $p' - f - c$. Else, the seller has a chance to meet a buyer in the D market and obtains W^d. Following the same procedure as before, we can substitute out p' using (12), and the sufficient and necessary first-order condition is

$$\mu^{s\prime}(x')\,(v-f)-\left(V^p-V^d\right)=0, \tag{13}$$

where v denotes the total surplus on the platform net of the outside options:

$$v(x^d)\equiv\left(1-\lambda^b(x^d)\beta-\lambda^s(x^d)(1-\beta)\right)(1-c). \tag{14}$$

Note that v depends on the outside values of buyers and sellers and hence on the D market tightness. The first-order condition (13) yields

$$V^p=\mu^{s\prime}(x^p)\,(v-f)+V^d,$$

$$W^p=\left(\mu^s(x^p)-x^p\mu^{s\prime}(x^p)\right)(v-f)+W^d,$$

and the equilibrium price on the platform follows from

$$p^s-f-c=\left(1-\frac{x^p\mu^{s\prime}(x^p)}{\mu^s(x^p)}\right)(v-f)+W^d. \tag{15}$$

The equilibrium price p^s net of the fee f and cost c guarantees the seller a profit that equals the seller's outside option W^d plus a share $1-\frac{x^p\mu^{s\prime}(x^p)}{\mu^s(x^p)}$ of the net trade surplus, $v-f$, that the intermediary is willing to give to buyers and sellers. Using (15), we can simplify the incentive constraints (9) and (10) to

$$f\le v. \tag{16}$$

Intermediation mode

To write down the intermediary's problem, it is convenient to consider first the intermediary's profit with a hybrid mode. In equilibrium, buyers must be indifferent between visiting the middleman and the platform, i.e., $V^m=V^p$, which yields

$$p^m=1-\lambda^b(x^d)\beta(1-c)-\mu^{s\prime}(x^p)\,(v-f)\,,$$

where v is the net surplus defined in (14), $x^p=B-B^m$ and $x^d=\frac{B-B^m-\mu^s(B-B^m)}{1-\mu^s(B-B^m)}$, both of which are determined by B^m, Applying p^m, we can see that condition (11) is also reduced to (16). Now, the intermediary' problem can be written as:

$$\max_{f\geq 0, B^m\in[0,B]} \left\{ \mu^s(x^p) f + B^m \left((1-\lambda^b(x^d)\beta)(1-c) - \mu^{s\prime}(x^p)\,(v-f) \right) \right\}, \tag{17}$$

subject to (16). The first term is the platform fee revenue, and the second term is the middleman profit. In (17), the pure middleman mode ($B^m = B$) and the pure platform mode ($B^m = 0$) can be treated as special cases as we show formally in the proof of Lemma 1. Hence, the problem is well defined, and so an equilibrium exists. As a first pass to solve the problem, we have the following lemma.

Lemma 1 *The intermediary extracts the entire intermediation surplus v by setting $f = v$ for an active platform.*

The profit maximization problem boils down to

$$\max_{B^m\in[0,B]} \left\{ B^m(1-\lambda^b(x^d)\beta) + \mu^s(B-B^m) \left(1-\lambda^b(x^d)\beta - \lambda^s(x^d)(1-\beta) \right) \right\} (1-c). \tag{18}$$

Given that x^d is determined by B^m, hereafter, with a slight abuse of notation, we write $\lambda^b(B^m)$ and $\lambda^s(B^m)$ to clarify the dependence of these functions on B^m. We assume that for all $B^m \in (0, B)$, the following condition holds for some constant $L > 0$:

$$\left(B^m + \mu^s(B-B^m)\right)\beta\lambda^{b\prime\prime}(B^m) + \mu^s(B-B^m)(1-\beta)\lambda^{s\prime\prime}(B^m) > -L, \tag{19}$$

where $\lambda^{b\prime\prime}(B^m)$ and $\lambda^{s\prime\prime}(B^m)$ are the second order derivatives with respect B^m. This is a technical condition that is sufficient for the profit function to be concave (see Figure 1 for an example of matching functions that satisfy this condition). We will impose this condition in the rest of the analysis.[16]

The first-order derivative of the objective function (18) yields the marginal profit (where we omit-

[16]With further assumptions, condition (19) can be more concise. For example, if λ^b is convex in B^m, then a sufficient condition for a unique global maximum is: $\beta\lambda^{b''}(B^m) + (1-\beta)\lambda^{s''}(B^m) > -C/m(B)$. Or, if λ^b is convex in B^m and β is sufficiently large, (19) is also satisfied.

ted the term $1-c$):

$$\underbrace{1-\lambda^b(B^m)\beta-\mu^{s\prime}(B-B^m)\left(1-\lambda^b(B^m)\beta-\lambda^s(B^m)(1-\beta)\right)}_{\text{matching efficiency effect}}$$

$$+\underbrace{\left[-\left(B^m+\mu^s(B-B^m)\right)\lambda^{b\prime}(B^m)\beta\right]}_{\text{negative cross-market feedback}}+\underbrace{\left[-\mu^s(B-B^m)\lambda^{s\prime}(B^m)(1-\beta)\right]}_{\text{positive cross-market feedback}}. \tag{20}$$

Note that $\lambda^{b\prime}(B^m)>0$, and $\lambda^{s\prime}(B^m)<0$ because x^d is strictly decreasing in B^m (when more buyers are served by the middleman, fewer will visit the D market). The first line of (20) is the gain in *match efficiency* for a marginal increase in B^m — the middleman transactions increase by 1, and accordingly, its profits increase by $1-\lambda^b\beta$, whereas the platform transactions decrease by $\mu^{s\prime}$, and the profits decrease by $\mu^{s\prime}(\cdot)(1-\lambda^b\beta-\lambda^s(1-\beta))$. The matching efficiency effect, which is always positive, suggests that a higher B^m is always preferred. The second line of (20) reflects the gain/loss of intermediation rent in the form of p^m and/or f. This occurs due to *cross-market feedback*, i.e., a change in the D market tightness caused by a change in B^m will feedback to the C market via a change in the buyers' and sellers' outside values. An increase in B^m lowers the D-market buyer-seller ratio x^d. Thus, it improves the buyers' outside value V^d, and it deteriorates the sellers outside value W^d. The overall feedback effect can be positive or negative, depending on the relative contribution of changes in buyers' versus sellers' outside values.

To determine the profit-maximizing intermediation mode, we need to check which of the two effects described above is stronger or whether there exists an interior B^m that balances them. Consider first a special case $\beta=0$ so a buyer's outside value is zero. In this case, the feedback effect is positive, i.e. $-\mu^s(B-B^m)\lambda^{s\prime}(B^m)>0$. Hence, (20) implies that the marginal profit is strictly positive for all $B^m\in[0,B]$, and so the intermediary will choose $B^m=B$, i.e., a pure middleman mode, when $\beta=0$. Consider next another special case $\beta=1$ which, for a given D-market tightness x^d, maximizes the D-market value for buyers. In this case, the feedback effect is negative, i.e. $-\left(B^m+\mu^s(B-B^m)\right)\lambda^{b\prime}(B^m)<0$. That is, with a larger scale of the middleman sector B^m (or equivalently, a smaller scale of the platform), buyers are *more* likely to be matched whereas sellers are *less* likely to be matched in the C market. As those who fail to trade in the C market participate in the D market, this implies that an increase in B^m will decrease the D market buyer-seller ratio, leading to a higher value of buyers in the D market, and a lower inventory price and platform fee.

The negative cross-market feedback creates a possibility of an active platform in equilibrium. That is, if the matching effect, which is always positive, is relatively small, then the intermediary may choose a pure platform or a hybrid mode. The negative cross-market feedback is stronger with a higher β. This is formalized in the following proposition.

Proposition 2 (Multi-Market search) *With multi-market search and when condition (19) holds, there exists a unique equilibrium with active intermediation. The intermediary acts as a pure middleman for $\beta \leq \tilde{\beta}_1$, and a hybrid or a pure platform for $\beta > \tilde{\beta}_1$, with some $\tilde{\beta}_1 \in (0, 1)$. Further, if the profit-maximizing mode is hybrid, then an increase in β leads to a smaller middleman sector and a larger platform.*

The proposition shows that an active platform occurs with multi-market search for high values of β. Under single-market search, this never occurs.

Next, we determine the intermediation mode in the region where an active platform is involved. The key is again the negative feedback effect. We can capture it by considering the case $\beta = 1$ where as shown above the negative feedback effect is strongest. Note also that in this case, the feedback on f and p^m is equal because $f = p^m - c = (1 - \lambda^b(B^m))(1 - c)$. Then, we can define the elasticity of the fee/price with respect to the intermediated trade volume denoted by $Q(B^m) \equiv B^m + \mu^s(B - B^m)$:

$$z(B^m) \equiv -\frac{\partial(p^m - c)/\partial Q(B^m)}{(p^m - c)/Q(B^m)}.$$

$z(B^m)$ evaluated at the pure platform ($B^m = 0$) captures the strength of the negative feedback effect. If $z(0) > 1$, then for a 1% increase in intermediated trade (caused by a marginal increase in B^m), the price/fee decreases more than 1%, creating a relatively strong negative feedback effect. Using $z(0)$, the next proposition offers a necessary and sufficient condition for a pure platform or a hybrid (i.e. market-making middleman) to be optimal.

Proposition 3 (Hybrid versus Pure Platform) *With multi-market search and when condition (19) holds, consider the region where an active platform is chosen, i.e.,* $\beta > \tilde{\beta}_1$*. There exists a* $\tilde{\beta}_2 \in (\tilde{\beta}_1, 1)$ *such that the profit-maximizing mode is a pure platform if the fee/price is elastic, i.e.,* $z(0) > 1$*, and* $\beta \geq \tilde{\beta}_2$*, and a hybrid otherwise.*

Figure 1 plots the relative size of the middleman sector, $\frac{B^m}{B}$, as a function of β and B , where a darker color implies a lower middleman share. For given values of B, the higher the value of β, the stronger the negative feedback effect is and the smaller the middleman becomes. The figure illustrates the case with an elastic fee/price, i.e., $z(0) > 1$, a pure platform can dominate the hybrid mode in the darkest region.

Insert Figure 1 here.

Discussion. As shown above, the advantage of the hybrid intermediation mode relative to a pure middleman mode is a higher middleman price and a positive platform fee revenue. Which benefit is more crucial for the emergence of market-making middlemen? To answer this question, consider an extension of the model with entry costs $c_E > 0$ for each seller to operate on the platform.[17]

Our insight remains valid in such a setting. Now, the intermediary must also decide whether or not to subsidize sellers upon entry, e.g., via a negative participation fee. With single-market search, this is irrelevant because the pure middleman mode remains profit maximizing. With multiple-market search, as for all $\beta > \tilde{\beta}_1$, a hybrid or a pure platform is more profitable than a pure middleman, there exists a positive c_E that is smaller than the profit difference between the optimal mode and the pure middleman mode, such that Proposition 2 still holds. Other conclusions of multi-market search with regard to the hybrid mode versus the pure platform also remain to be valid.

[17]For example, online sellers find it important to display their product's image and keep it ready for delivery before actual transactions occur. A similar issue arises when asset holders are required to commit to their portfolio before trading with their brokers.

Interestingly, we also find that a platform can be activated even when the net profit obtained from the platform business is negative. To illustrate, suppose $\beta = 1$ and let the middleman sector profit be $\pi^m(B^m) = B^m(1 - \lambda^b(B^m))(1 - c)$. As β is large, simple calculus shows that $\pi^m(B^m)$ is maximized at some interior $B^{m*} < B$. Note that B^{m*} does not refer to the optimal mode because it does not taken into the platform profits. Denote the platform revenue by $r^p(B^{m*}) = \mu^s(B - B^{m*})(1 - \lambda^b(B^m))(1 - c)$, and let $c_E = r^p(B^{m*}) + \varepsilon$ for some small $\varepsilon > 0$ so that the platform operates with a negative profit $-\varepsilon$. Yet, the activation of platform increases the overall intermediary profits: $\pi^m(B^{m*}) + r^p(B^{m*}) - c_E = \pi^m(B^{m*}) - \varepsilon > \pi^m(B)$.

The key message is clear: The benefit of enjoying a higher price in the middleman sector will be the major source of profits for market-making middlemen even when the platform-entry costs are so high that the net profit from the platform business is negative.

4 Examples

Our analysis shows that a marketmaking middleman is more likely to emerge under multi-market search technologies than under single-market technologies. In this section, we offer some real market examples.

Online retailers. The electronic commerce company Amazon.com is traditionally an online retailer, who mainly aims at selling its inventories to customers. In the late 1990s, Amazon was facing fierce competition from local brick and mortar rivals, as well as chain stores such as Walmart, Sears, etc., and especially from eBay. According to the book, *The Everything Store: Jeff Bezos and the Age of Amazon*, Jeff Bezos worried that eBay may become the leading online retailer who attracts the majority of customers. In the summer of 1998, he invited eBay's management team and suggested the possibility of a joint venture or even of buying out their business. This is known to be Amazon's first attempt to set up an online marketplace. In the end, this trial failed. After several more trials and errors, however, Amazon finally launched their own marketplace in the early 2000s.

Amazon's launch of the platform business influenced significantly the book industry. On the one hand, Amazon attracts many of its competitors to join their platform. Indeed, Amazon drove physical book and record stores out of business, and many bookstore owners re-launched their business on the Amazon-website platform. On the other hand, Amazon lowers the chance of buyers to trade outside. As local bookstores disappeared, it became the habit for most book buyers to start their everyday online-shopping using Amazon as the prime site. Overall, these observed phenomena are in line with our theory.[18] Not surprisingly, Amazon promoted this shopping pattern to customers in other product categories. Since 2016, third-party sales has accounted for more than half of Amazon's revenue and the share has been steadily growing.

An alternative (complementary) to our theory would be a product selection story where Amazon uses the platform for third-party sellers to add new products with the demands too small for Amazon to offer. Once a product is "tested" to be popular enough, Amazon starts to also offer it through the middleman sector. This would be certainly a valid explanation but by far not the exclusive one. First, if this explanation were correct, we should eventually observe that most popular products are listed by Amazon, and most not-so-popular products are listed by independent sellers. In reality, however, many high-demand products are listed by both Amazon and third-party sellers at the same time, and importantly, they are competing with each other. This competition goes against the proposed explanation, but is more in line with our theory. In fact, Amazon could avoid fierce competition with strong third-party sellers — those who have private brands and own the "buy-box" —by giving up dealing with such a product in the middleman sector, which should in turn increase their fee revenue.

The general picture of the online travel agency industry is similar. Before the rise of Internet, most intermediaries in this industry acted as a pure middleman. In the middleman mode, hotels sell rooms to a middleman in bulk at discounted prices. The middleman then sells them to customers at a markup price. With the online reservation system, a market-making mode became popular, wherein hotels pay a market maker (e.g. Booking.com) commission fees upon successful reservations. The

[18] According to a recent survey, 66% of the U.S. consumers who shop online start their search on Amazon and continue with alternative channels including Walmart.com and BestBuy.com. In another survey on Amazon sellers, more than 75% sell through multiple channels. These features are consistent with our multi-market search set-up. Relevant reports are available on *https://www.junglescout.com/* (visited on Nov 15, 2021).

hotels post their services and prices on the platform. Expedia used to be a pure middleman but is nowadays a representative market-making middleman who employs both of these intermediation modes.

Specialist markets. The New York Stock Exchange (NYSE) is a specialist market, which is defined as a hybrid market that includes an auction component (e.g., a floor auction or a limit order book) together with one or more specialists (also called designated market makers). The specialists have some responsibility for the market: as brokers, they pair executable customer orders; and as dealers, they post quotes with reasonable depth (Conroy and Winkler, 1986).

As for their role as dealers in the exchanges, our model suggests that, at least for less active securities (represented by a lower outside option), the specialists' market can provide 'predictable immediacy' and increase the trading volume and liquidity. This is consistent with the trend to adopt hybrid markets in derivative exchanges and stock markets around the world, especially for thinly-traded securities. For example, several European stock exchanges implemented a program which gives less active stocks an option of accompanying a designated dealer in the auction market. These initiatives were effective not only in enhancing the creation of hybrid specialist markets, but also in increasing trade volumes and reducing liquidity risks (Nimalendran and Petrella, 2003, Anand et al., 2009, Menkveld and Wang, 2013, and Venkataraman and Waisburd, 2007.)

Another prediction from our analysis is related to the changing competitive environment faced by securities exchanges. As a broader implication, our result that the increased outside pressure goes hand in hand with more decentralized trades, captures the background trend in general: the market for NYSE-listed stocks was highly centralized in 2007 with the NYSE executing 79% of volume in its listings; in 2009, this share dropped to 25% (Securities and Exchange Commission, 2010); today, the order-flow in NYSE-listed stocks is divided among many trading venues – 11 exchanges, more than 40 alternative trading systems, and more than 250 broker-dealers in the U.S. (Tuttle, 2014). As a more specific implication, we show that the increased pressure from outside markets will scale up the platform component. This is indeed the case. Starting from 2006, the NYSE adopted the new hybrid trading system featuring an expanded platform sector "NYSE Arca", which allows investors to choose whether to trade electronically or by using traditional floor brokers and specialists. The new system is further supplemented by several dark pools, akin to platforms, owned by the NYSE. These strategies are also adopted by NASDAQ which has been thought of as a typical dealers' market.

Real estate agencies. Although intermediaries in housing markets are mostly thought of as brokers (the market maker in our model), the business mode employed by the Trump family is a market-making middleman. The Trump Organization holds several hundred thousand square feet of prime Manhattan real estate in New York City (NYC) and some more in other big cities. Besides developing and owning residential real estate, the Trump family operates a brokerage company that deals with luxury apartments, the Trump International Realty. Both of these companies target the same market in NYC. Indeed, the Trump's business mode is a marketmaking middleman – both owning his own residential towers, and offering broker services. Another example is a large-scale real estate company called Thor Equities. This firm owns and redevelops retail properties in Soho, Madison Avenue, and Fifth Avenue, and also runs brokerage agencies.

Although it is genuinely difficult for real estate agencies to operate a middleman sector, top real estate firms in many big cities attempt to expand their business by engaging in many new joint projects with developers. Mapped into our model, these efforts are aimed at increasing their inventory. For example, Nest Seekers, a real estate brokerage and marketing firm in NYC, works tightly with constructors on new developments, from the very early stage of layout design and fund raising (in some cases Nest Seekers offers their own capital) to the later marketing stage, and is eventually in charge of the entire marketing process. Strictly speaking, Nest Seekers does not own properties, but becomes the exclusive agent of projects. This co-development business is one step beyond the middleman mode formulated in our theory, and can be considered as an alternative way to secure their inventory.[19] This business mode is widely adopted by many top real-estate companies in NYC,

[19] A report titled "Inside the fight for Manhattan's most valuable new development exclusives" gives more detailed infor-

such as Douglas Elliman, Stribling, and Corcora, etc.

Finally note that some intermediaries do not only help to promote new developments, but also manage apartment complexes, which constitutes another source of "inventory". For example, Brown Harris Stevens, an American real estate company headquartered in New York City, is known for its cooperative apartment management service. These cooperative apartments usually contain hundreds of units in one building, and Brown Harris Stevens is then in charge of listing these properties when they are for rent or on sale.

5 Conclusion

This article developed a model in which market structure is determined endogenously by the choice of intermediation mode. We considered two representative business modes of intermediation that are widely used in real-life markets: a market-making mode and a middleman mode. We derived conditions for a mixture of the two modes, a *marketmaking middleman* to emerge.

One implication of our theory is that intermediaries can use a platform to reduce competition with sellers in the decentralized market. However, this is done by inducing consumers to search excessively and so generates inefficiencies. For future research, it would be interesting to examine this from the viewpoint of a regulator.

mation on how brokers cooperate with developers, available at *http://therealdeal.com/2016/03/15/inside-the-fight-for-manhattans-most-valuable-new-development-exclusives/* (visited on Nov 15, 2021).

Appendix

Proof of Proposition 1 We consider dominant-market equilibria first, and then segmented-market equilibria. A dominant-market equilibrium falls in one of the following scenarios: *(a) agents all join the C market; (b) buyers all join the C market, and sellers divide between the C and the D markets; (c) buyers all join the C market and sellers all join the D market.* The last scenario certainly indicates a pure middleman. *In scenario (b),* because sellers are indifferent between the two markets, and they receive a value of zero in the D market, their expected value on the platform is zero, suggesting $f = 1 - c$. Then buyers receive zero on the platform as well. But given $S^d > 0$ and $B^d = 0$, buyers' D-market value is $\beta(1-c) > 0$. Yet all buyers join the C market, which is only possible if they trade with the middleman. Thus, a pure middleman emerges in an equilibrium of scenario (b). The rest of the proof focuses on scenario (a).

Suppose the intermediary is not a pure middleman. Then, it is either a pure platform (case 1) or a hybrid (case 2). For each case, we propose a profitable deviation P' for all the possible market equilibrium allocations $N(P')$ satisfying refinements 1 and 2. We denote the equilibrium outcomes by using variables with a hat, i.e., the intermediary profits by $\hat{\pi}$, the buyer-seller ratios by $\hat{x}^j, j \in \{p, d\}$ and the measure of buyers and sellers in each trading venue by $\hat{B}^i$ and $\hat{S}^j, i \in \{m, p, d\}$.

⊙ **Case 1: Pure platform.** In the proposed equilibrium, it must hold that $\mu^{s\prime}(B)(1-\hat{f}-c) \geq 1 - \hat{p}^m$, and $\hat{\pi} = \mu^s(B)\hat{f}$. Consider a deviation to $p^{m\prime}$ ($< \hat{p}^m$) such that $1 - \hat{f} - c > 1 - p^{m\prime} > \mu^{s\prime}(B)(1-\hat{f}-c)$ and maintaining $\hat{f}$. Any allocation with an active D market violates refinement 2 as we are considering a price decrease. The allocation with only the platform active is not sustainable because buyers are better off by visiting the middleman: $1 - p^{m\prime} > \mu^{s\prime}(B)(1-\hat{f}-c)$. Then, the only remaining possibility is where the deviation accompanies an active middleman, which is clearly profitable because $\pi' = \mu^s(B - B^{m\prime})\hat{f} + B^{m\prime}(p^{m\prime} - c) > \mu^s(B - B^{m\prime})\hat{f} + B^{m\prime}\hat{f} > \mu^s(B)\hat{f} = \hat{\pi}$, where the first inequality is because $p^{m\prime} - c > \hat{f}$ and the second inequality is because platform matching is frictional.

⊙ **Case 2: Hybrid intermediary.** In the proposed equilibrium, buyers must be indifferent between visiting the middleman and the platform, $1 - \hat{p}^m = \mu^{s\prime}(\hat{x}^p)(1 - \hat{f} - c)$, with $\hat{x}^p > 0$. Suppose the buyers' value is zero ($\hat{p}^m = 1, \hat{f} = 1 - c$), and consider lowering $\hat{p}^m$ marginally while keeping $\hat{f}$ unchanged. By refinement 2, all buyers visit the C market where they obtain a positive value by trading with the middleman and zero by trading on the platform, irrespective of x^p. Thus, $\mathcal{S}_1(P')$ is empty and so refinement 1 does not apply here. Hence, the intermediary should become a pure middleman. Clearly, this deviation is profitable, $\pi' \approx B(1 - c) > (\hat{B}^m + \mu^s(B - \hat{B}^m))(1 - c) = \hat{\pi}$.

When the buyer's value is positive, the above logic does not apply because the demand to the middleman sector is determined by a smooth function of $p^m \neq \hat{p}^m$, i.e., the indifference condition of buyers between the middleman and the platform, so a marginal decrease in $\hat{p}^m$ is not sufficient to attract all the buyers on the platform. We therefore consider increasing $\hat{f}$ marginally while keeping $\hat{p}^m$ unchanged. This time, $\mathcal{S}_1(P')$ is non-empty because we can find an allocation $x^p > 0$ that satisfies the buyers' indifference condition. Therefore, by refinement 1, both the middleman and the platform should be active following the deviation. Because the allocation with the three active trading venues is a knife-edge case, the fee increase will merely change the composition of demand within the C market, leaving more buyers to the middleman and fewer buyers to the platform. This is a profitable deviation.

Turn to the Segmented-market equilibrium. We show that there exists a profitable deviation from a segmented-market equilibrium with an active pure platform and an active D market. The proof is an extension to that of dominant market equilibrium with additional considerations on an active D market. In the proposed equilibrium, the intermediary's profit is $\hat{\pi}(\hat{S}^p) = \hat{S}^p \mu^s(\hat{x}^p)\hat{f}$, and the following indifference conditions should hold: $\mu^{s\prime}(\hat{x}^p)(1 - \hat{f} - c) = \lambda^b(\hat{x}^d)\beta(1 - c) \geq 1 - \hat{p}^m$; $(\mu^s(\hat{x}^p) - \hat{x}^p\mu^{s\prime}(\hat{x}^p))(1 - \hat{f} - c) = \lambda^s(\hat{x}^d)(1 - \beta)(1 - c)$.

Consider a deviation to $P' = (p^{m\prime}, \hat{f})$ such that $p^{m\prime} < p^m$ and $1 - \hat{f} - c > 1 - p^{m\prime} > \max\{\mu^{s\prime}(\hat{x}^p), \mu^{s\prime}(B)\}(1 - \hat{f} - c)$. Note that the first inequality implies a higher profit margin of the middleman, $p^{m\prime} - c > \hat{f}$. The second inequality ensures that the middleman price is attractive to buyers, compared to the buyers' value on the platform off the equilibrium path — $\mu^{s\prime}(B)(1 - \hat{f} - c)$ if the platform is the only active venue and $\mu^{s\prime}(\hat{x}^p)(1-\hat{f}-c)$ if both the platform and the D market are active.

Suppose $N(P')$ involves only *one active venue.* By refinement 2 and with the deviation we consider, the only possibility is a pure middleman. Here, this deviation is profitable because $\pi' = B(p^{m\prime}-c) > B\hat{f} > \hat{B}^p\mu^b(\hat{x}^p)\hat{f} = \hat{\pi}$, where the first inequality is due to $p^{m\prime}-c > \hat{f}$ and the second inequality is because the platform matching is frictional.

Suppose $N(P')$ involves *two active venues.* Any allocation with a pure platform is not sustainable, because buyers are better off by trading with the middleman at price $p^{m\prime}$. If $N(P')$ involves a pure middleman and an active D market, then the deviation is profitable because $\pi' = B^{m\prime}(p^{m\prime}-c) > \hat{S}^p\hat{x}^p(p^{m\prime}-c) > \hat{S}^p\hat{x}^p\hat{f} > \hat{S}^p\mu^s(\hat{x}^p)\hat{f} = \hat{\pi}$, where in the first inequality we use $B^{m\prime} > \hat{S}^p\hat{x}^p$ (as is implied by refinement 2). If $N(P')$ involves a hybrid with an inactive D market, then the deviation is profitable because $\pi' = \mu^s(x^{p\prime})\hat{f} + B^{m\prime}(p^{m\prime}-c) > (\mu^s(x^{p\prime}) + B^{m\prime})\hat{f} > M^p(B,1)\hat{f} \geq M^p(\hat{B}^p,\hat{S}^p\hat{x}^p)\hat{f} = \hat{\pi}(\hat{S}^p)$, where the first inequality is by $p^{m\prime}-c > \hat{f}$, the second equality by the frictional platform matching, and the last inequality is because the intermediary attracts all the agents from the D market.

Finally, any $N(P')$ involving *three active venues* is a knife-edge case, which cannot be a candidate outcome of a profitable deviation. ■

Proof of Lemma 1 If the intermediary acts as a pure middleman ($B^m = B$), then all sellers are available in the D market. The middleman must set $p^m \leq 1-\beta(1-c)$, hence the profits are $B(1-\beta)(1-c)$. If the intermediary acts as a pure platform ($B^m = 0$), then the platform buyer-seller ratio $x^p = B$. The intermediary's problem becomes $\max_{f\in[0,1-c]} \mu^s(B)\,f,\ s.t.$ (16). The optimal solution features a binding incentive constraint, $f = v$ where v is a function of the buyer-seller ratio in the D market which takes the value $\frac{B-\mu^s(B)}{1-\mu^s(B)}$.

If the intermedairy acts as a hybrid, then it maximizes

$$\Pi(B^m, f) = \mu^s(x^p)f + B^m(p^m - c),$$

subject to $0 \leq f \leq v$, $0 < B^m < B$, with

$$v = \left(1 - \lambda^b(x^d)\beta - \lambda^s(x^d)(1-\beta)\right)(1-c),$$
$$p^m = 1 - \lambda^b(x^d)\beta(1-c) - \mu^{s\prime}(x^p)\,(v - f)\,.$$

Observe that $\lim_{B^m \to B} \Pi(B^m, f) = B(1-\beta)(1-c)$ and $\lim_{B^m \to 0} \Pi(B^m, f) = \mu^s\,(B)\,f$ with the same constraint $f \leq v$. Hence, we can compactify the constraint set and set up a general problem of (17).

We use the following Lagrangian:

$$\mathcal{L} = \Pi(B^m, f) + \theta_{b0} B^m + \theta_b (B - B^m) + \theta_v (v - f) + \theta_{f0} f,$$

where $\theta_{b0}, \theta_b, \theta_v, \theta_{f0} > 0$ are Lagrange multipliers. The first order condition with respect to f is

$$\frac{\partial \mathcal{L}}{\partial f} = \mu^s(x^p) + B^m \mu^{s\prime}(x^p) - \theta_v + \theta_{f0} = 0.$$

Hence, $\theta_v = \mu^s(x^p) + B^m \mu^{s\prime}(x^p) + \theta_{f0} > 0$, which implies that the intermediary will choose $f = v$. ■

Proof of Proposition 2 Throughout the proof, we use the marginal profit given by (20) to characterize the profit-maximizing intermediation mode:

$$\begin{aligned}\phi(B^m, \beta) \equiv & 1 - \lambda^b(B^m)\beta - \mu^{s\prime}(B - B^m)\left(1 - \lambda^b(B^m)\beta - \lambda^s(B^m)(1-\beta)\right) \\ & - \left(B^m + \mu^s(B - B^m)\right)\lambda^{b\prime}(B^m)\beta - \mu^s(B - B^m)\lambda^{s\prime}(B^m)(1-\beta).\end{aligned}$$

Observe that: (i) $\phi(B^m, 0) = 1 - \mu^{s\prime}(B - B^m)\,(1 - \lambda^s(B^m)) - \mu^s(B - B^m)\lambda^{s\prime}(B^m) > 0$ for all $B^m \in [0, B]$; (ii) $\phi(B, 1) = -B\lambda^{b\prime}(B) < 0$; (iii) $\frac{\partial \phi(B^m,\beta)}{\partial \beta} < 0$; (iv) $\frac{\partial \phi(B^m,\beta)}{\partial B^m} < 0$ (given condition (19) which is to be shown below). (i) implies that a pure middleman mode is profit-maximizing at $\beta = 0$. (ii)–(iv) imply that there exists a unique $\tilde{\beta}_1 \in (0, 1)$, given by $\phi(B, \tilde{\beta}_1) = 0$, such that $\phi(B^m, \beta) > 0$ for all $\beta \leq \tilde{\beta}_1$ and $B^m < B$, and $\phi(B, \beta) < 0$ for all $\beta > \tilde{\beta}_1$. The former implies that the profit-maximizing mode is a pure middleman for all $\beta \leq \tilde{\beta}_1$, whereas the latter implies that the profit-maximizing mode must involve an active platform — either a pure platform or a hybrid. The comparative statics of the possible hybrid mode (given by $\phi(B^m, \beta) = 0$ for $B^m \in (0, B)$ and $\beta > \tilde{\beta}_1$) is immediate from (iii) and (iv).

Finally, we give a sufficient condition that ensures the objective function is strictly concave, which guarantees the uniqueness of the equilibrium. Observe that

$$\begin{aligned}\frac{\partial\phi(B^m,\beta)}{\partial B^m} =&\mu^{s\prime\prime}(B-B^m)\left(1-\lambda^b(B^m)\beta-\lambda^s(B^m)(1-\beta)\right)\\&+2(1-\mu^{s\prime}(B-B^m))(-\lambda^{b\prime}(B^m)\beta)+2\mu^{s\prime}(B-B^m)\lambda^{s\prime}(B^m)(1-\beta)\\&+\left(B^m+\mu^s(B-B^m)\right)\left(-\lambda^{b\prime\prime}(B^m)\beta\right)+\mu^s(B-B^m)(-\lambda^{s\prime\prime}(B^m))(1-\beta).\end{aligned}$$

As $\mu^s(\cdot)$ is concave, the first term is negative. Because $\lambda^{b\prime}(B^m)>0$, and $\lambda^{s\prime}(B^m)<0$, the second line is also negative. Denote the first two lines by $\psi(B^m)\equiv\mu^{s\prime\prime}\left(1-\lambda^b(B^m)\beta-\lambda^s(B^m)(1-\beta)\right)+2(1-\mu^{s\prime})(-\lambda^{b\prime}(B^m)\beta)+2\mu^{s\prime}(B-B^m)\lambda^{s\prime}(B^m)(1-\beta)$ and let $L=-\sup_{B^m\in(0,B)}\{\psi(B^m)\}>0$. We require the two terms in the last line to be sufficiently small. Namely, for all $B^m\in(0,B)$, it is sufficient to assume that $\left(B^m+\mu^s(B-B^m)\right)\left(-\lambda^{b\prime\prime}(B^m)\beta\right)+\mu^s(B-B^m)(-\lambda^{s\prime\prime}(B^m))(1-\beta)<L$. ■

Proof of Proposition 3 The proof of Proposition 2 shows that $\phi(B,\beta)<0$ for all $\beta>\tilde{\beta}_1$. To determine the exact intermediation mode in this region, we need to know whether there exists an interior $B^m\in(0,B)$ that satisfies $\phi(B^m,\beta)=0$, leading to a hybrid mode, or that $\phi(B^m,\beta)<0$ for all $B^m\in[0,B]$, leading to a pure platform. For this, as $\phi(B^m,\beta)$ is strictly decreasing in B^m (see the proof of Proposition 2), it is sufficient to determine whether $\phi(0,\beta)>0$ or $\phi(0,\beta)\leq 0$ for given values of $\beta>\tilde{\beta}_1$.

There are two cases.

- Case (i): If $\phi(0,1)>0$, then as $\phi(0,\beta)>0$ for all $\beta>\tilde{\beta}_1$, there exists an interior $B^m\in(0,B)$ that satisfies $\phi(B^m,\beta)=0$ and so the intermediary will choose a hybrid mode for all $\beta>\tilde{\beta}_1$.

- Case (ii): If $\phi(0,1)<0$, then there exists a unique $\tilde{\beta}_2\in(\tilde{\beta}_1,1)$ that satisfies $\phi(0,\tilde{\beta}_2)=0$, because $\phi(B,\tilde{\beta}_1)=\phi(0,\tilde{\beta}_2)=0>\phi(B,\tilde{\beta}_2)$, implying $\tilde{\beta}_2>\tilde{\beta}_1$. For $\beta\in[\tilde{\beta}_2,1]$, it holds that $\phi(0,\tilde{\beta}_2)=0\geq\phi(0,\beta)\geq\phi(B^m,\beta)$ for all $B^m\in[0,B]$, and so the intermediary will choose a pure platform. For $\beta\in(\tilde{\beta}_1,\tilde{\beta}_2)$, as $\phi(0,\beta)>\phi(0,\tilde{\beta}_2)=0$ and $\phi(B,\beta)<\phi(B,\tilde{\beta}_1)=0$, there exists an interior $B^m\in(0,B)$ that satisfies $\phi(B^m,\beta)=0$, and so the intermediary will choose a hybrid mode.

Finally, simple manipulation shows that $\phi(0,1) < 0$ is equivalent to $z(0) \equiv -\frac{\partial(p^m - c)/\partial Q(B^m)}{(p^m - c)/Q(B^m)}|_{B^m=0} > 1$ where $p^m - c = (1 - \lambda^b(B^m))(1 - c)$ and $Q(B^m) \equiv B^m + \mu^s(B - B^m)$. ■

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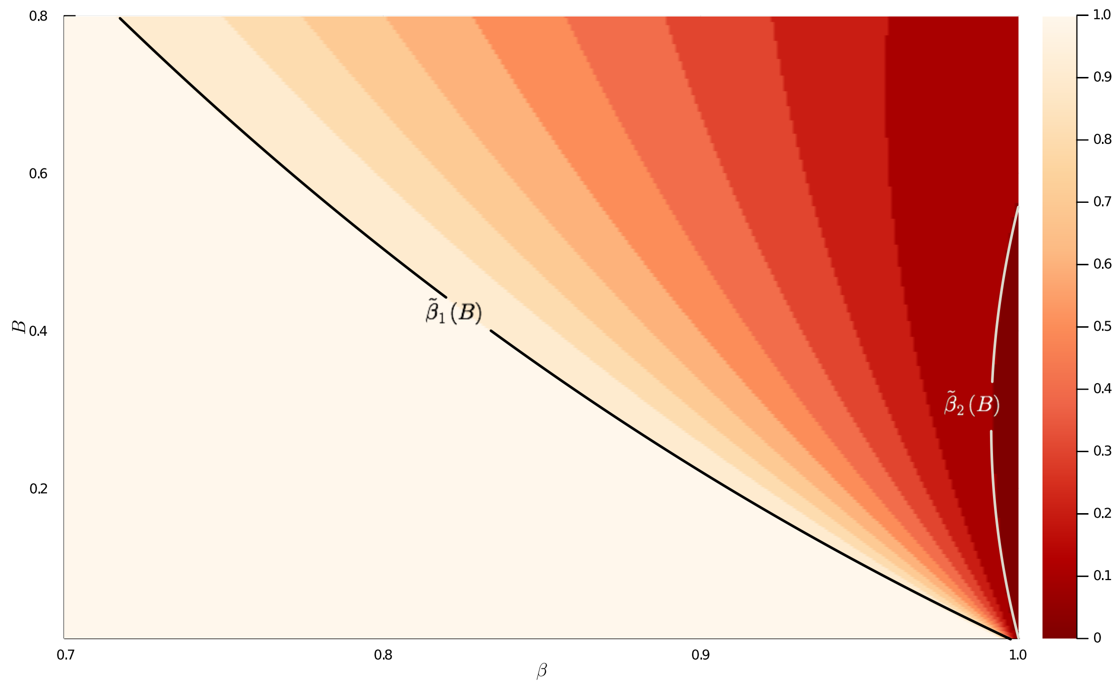

Figure 1: Relative scale of the middleman, captured by $\frac{B^m}{B}$ in the space spanned by $B \in [0.001, 0.8]$ and $\beta \in [0.7, 1]$. The value of $\frac{B^m}{B}$ is indicated by the color bar, where the darkest color indicates a pure platform and the lightest color indicates a pure middleman. The matching functions of the platform and the D market are $\mu^s(x^p) = 1 - e^{-\gamma x^p}$, with $\gamma = 0.55$, and $\lambda^b(x^d) = \frac{1-e^{-x^d}}{x^d}$, respectively. These probability functions satisfy the conditions in Proposition 2. With this parameter space, $z(0) > 1$ for $B < 0.58$. A pure middleman emerges in equilibrium in the parameter space to the left of the curve $\tilde{\beta}_1(B)$, and a pure platform emerges in equilibrium in the parameter space to the right of the curve $\tilde{\beta}_2(B)$, and in between the intermediary operates as a market-making middleman.