TRADING WITH EXPERT DEALERS *

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Abstract

We jointly model investors' allocation of order flow among over-the-counter dealers and dealers' acquisition of expertise that increases their ability to take advantage of investors across transactions. Investors choose dealers based on their level of expertise and the liquidity they are expected to provide whereas dealers choose their level of expertise based on the number of transactions they expect to intermediate and the cost of acquiring expertise. Our model rationalizes why the most sought-after dealers often are those with the best data, technology, and skills, despite the significant adverse selection concerns triggered by their expertise.

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1 Introduction

A seminal insight from the literature on asymmetric information is that one should be wary of trading with a counterparty that possesses superior expertise (e.g., data, technology, and skills) (Akerlof 1970). Such counterparty is able to condition its trading decisions on superior information and take advantage of a less informed trader. Yet, in real financial markets, the dealers that intermediate most trades happen to be extremely sophisticated institutions. For example, Goldman Sachs remains the second most active over-the-counter (OTC) dealer of derivatives among US banks while spending $\$400M$ per year to acquire financial data from third-party sources and $\$400K$ per employee on average to attract, compensate, and retain the best and brightest.[1] Why do so many investors and traders flock to such dealers despite the obvious adverse selection concerns associated with their superior expertise? Why don't dealers try to develop a reputation for lacking the private information and skills used to take advantage of their counterparties, thereby minimizing adverse selection concerns?

In this paper, we jointly model dealers' expertise acquisition and investors' order-flow allocation in OTC markets. On one hand, dealers acquire expertise to improve their ability to value the assets investors want to trade with them — expertise allows dealers to take advantage of the less informed investors that send them their order flow. On the other hand, investors split their order flow based on the expertise each dealer is expected to use against them when trading.

An important and somewhat novel feature of our analysis consists of how we model dealers' expertise to capture the limited information spillovers across assets. When a dealer acquires private information about one particular asset being traded, it often has limited pricing implications for other assets and transactions. For example, the majority of corporate bonds trade less than twice a year (see Chaderina, Muermann, and Scheuch 2022) while differences in maturity, duration,

[1] See OCC (2021), Campbell (2018), and Goldman Sachs' 2021-Q4 earnings report for the specific numbers in the sentence. For evidence of concentration in OTC intermediation for various types of assets, see Cetorelli et al. (2007), Atkeson, Eisfeldt, and Weill (2014), Begenau, Piazzesi, and Schneider (2015), Di Maggio, Kermani, and Song (2017), Li and Schürhoff (2019), Siriwardane (2019), and Hendershott et al. (2020).

covenants, and collateral pledged render even bonds from the same issuer imperfect substitutes. Thus, if a dealer acquires an informational advantage about a specific corporate bond transaction, it does not guarantee that this dealer will also benefit from a similar advantage for its next transaction. In our model, we assume that a dealer's expertise level determines the number of transactions for which this dealer will have the resources needed to gain an informational advantage over its counterparties. By hiring smart traders, purchasing fast computers, and gaining access to various proprietary databases, a dealer ends up increasing its capacity or bandwidth to take advantage of multiple counterparties across transactions involving various types of assets within a short period of time. When investors are interested in trading different assets (e.g., corporate bonds, municipal bonds, and derivative products linked to different entities), a dealer's resources must be allocated to assessing the terms of trade of all the proposed transactions. Thus, as more order flow gets directed to this dealer, its resources are spread out more thinly across trades, thereby reducing the probability that this dealer gains an informational advantage when valuing the asset(s) and assessing the terms of trade associated with a given transaction.

Our model features a tension between investors' and dealers' preferences for dealers' expertise levels. Ceteris paribus, investors prefer to trade with dealers that possess low levels of expertise, as it reduces adverse selection concerns. Dealers, on the other hand, prefer to have access to high levels of expertise when trading with investors, as it allows them to extract a larger share of the surplus from trade. We show that in equilibrium trading is concentrated around one dealer that acquires a high level of expertise as long as the cost of expertise is sufficiently low. Investors are then indifferent between trading with this sophisticated dealer whose expertise is thinly spread among a large number of transactions and trading with a less sophisticated dealer whose scarcer resources can be used to gain informational advantages in a small number of transactions. Thus, paradoxically, in equilibrium order flow is concentrated around a dealer that employs smarter traders, owns faster computers, and has better data. This outcome arises because dealers' expertise levels are endogenous responses to investors' expected allocation of order flow. A dealer expecting to intermediate a lot of transaction volume cannot credibly commit to not acquiring the expertise needed to take advantage of these unsophisticated counterparties. An outcome where most order flow is concentrated around a less sophisticated intermediary cannot be sustained in equilibrium as the large number of investors expected to do business with this "central" intermediary renders expertise acquisition too profitable for this intermediary.

Our paper contributes to the literature that studies the allocation of order flow in OTC markets. Green (2007) analyzes dealers' incentives to take advantage of investors who cannot compare terms of trade across dealers without incurring high search costs. Unlike us, Green (2007) does not study the endogenous acquisition of expertise by dealers in response to the expected level of transaction volume or the liquidity externalities of order-flow concentration in light of adverse selection concerns. Chacko, Jurek, and Stafford (2008) and Sambalaibat (2018) highlight the execution-speed benefits of order-flow concentration without modeling dealers' optimal response in terms of expertise acquisition. Pagano (1989) and Chaderina and Green (2014) endogenize market participation in light of liquidity externalities, but do not consider the role played by dealers' endogenous expertise. We highlight how liquidity concentration benefits investors when trading with dealers with a given level of expertise bandwidth. Babus and Hu (2017) show the optimality of a star network when intermediaries keep track of their counterparties' past actions and discipline them in case of misbehavior.

Like us, Li and Song (2021) jointly model dealers' expertise acquisition and investors' order-flow allocation in OTC markets. However, in their model, a dealer's superior information is shared with its customers, who can then make better portfolio decisions thanks to the expertise of their selected dealer. Whereas informed dealers effectively act as brokers or advisors in Li and Song (2021), they act as trading counterparties in our model, meaning that they use their expertise to take advantage of the investors who choose to transact with them.

Our paper also relates to the literature that studies information acquisition in OTC markets. Glode, Green, and Lowery (2012) highlight OTC traders' incentives to overinvest in expertise prior to their trading interactions in order to take advantage of their counterparties, but assume an exogenous order-flow allocation. Glode and Opp (2020) show how predictable trading interactions can incentivize costly information acquisition by OTC traders. These papers are silent about the liquidity externalities of order-flow concentration in light of adverse selection concerns, which are the focus of our analysis.

2 Model

Our model has two stages. In the first stage, dealers acquire expertise while investors choose the dealers with whom they will trade. In the second stage, trade takes place between investors and dealers. Below, we will introduce the trading game and analyze agents' optimal trading behavior. Using these results, we will then solve for the optimal levels of expertise that dealers will acquire and the optimal allocations of order flow that investors will choose.

2.1 Trading Stage

Since the focus of our paper is on how dealers and investors behave in the first stage, we keep our model of the second stage simple. While our model makes formal assumptions on how trading occurs among agents, we will later emphasize the generic properties of trading games that our central insights rely on.

Consider a simple trading game between the prospective buyer and seller of an asset. This asset has an uncertain common value v, which can either be v_l or v_h with equal probabilities (based on public information). We denote $E(v) = \mu \equiv \frac{v_h+v_l}{2}$. In addition to this common value, the prospective buyer collects a private benefit $b > 0$ when acquiring and holding the asset. The existence of this private benefit b (a.k.a., the gains from trade) is public knowledge.

At the time of the transaction, the buyer believes that the seller has an informational advantage about v with probability λ. Specifically, with probability λ the seller is endowed with a private signal $s \in [v_l, v_h]$ about the asset's value v, such that $E(v|s) = s$. For tractability, we assume that $s \sim U[v_l, v_h]$.[2] While the seller's probability of having an informational advantage about the value of a specific asset is taken as given in this stage, we will later investigate dealers' incentives to invest in expertise (e.g., technology, human capital, and data) and boost their λ.

To avoid signaling and equilibrium multiplicity concerns, we assume that the buyer makes a take-it-or-leave-it offer to purchase the asset at a price P from the potentially privately-informed seller. As we show in the Appendix, however, the trading stage evolves in a symmetric manner when instead a prospective buyer is assumed to be informed with probability λ and an uninformed seller makes a take-it-or-leave-it offer. Yet, in order to simplify the exposition, we focus the baseline analysis on investors being on the buy-side and dealers being on the sell-side of each transaction.

When deciding which price P to offer in exchange for an asset, the prospective buyer faces the following tradeoff. Offering a higher price means that the buyer is more likely to get the asset and realize the gains to trade b. However, offering a higher price also means that conditional on getting the asset, the buyer shares more of its surplus with the seller.

For any $P \geq \mu$, the buyer receives an expected surplus of $\mu + b - P$ when the seller does not have an informational advantage about the value of the asset. When the seller has an informational advantage however, trade only takes place if the seller's signal is weakly below the offer price, that is, if $s \leq P$. Overall, the buyer's expected surplus from offering a price $P \in [v_l, v_h]$ is:

$$\Pi(\lambda, b, P) \equiv \begin{cases} (1-\lambda)(\mu + b - P) + \lambda \left(\frac{P - v_l}{v_h - v_l}\right)\left(b - \frac{P - v_l}{2}\right) & \text{if } P \geq \mu, \\ \lambda \left(\frac{P - v_l}{v_h - v_l}\right)\left(b - \frac{P - v_l}{2}\right) & \text{if } P < \mu. \end{cases} \tag{1}$$

A buyer never finds it optimal to offer either $P > v_h$ (which is dominated by offering $P = v_h$)

[2] One way to think about such a signal would be to recall that the prior probability of both high and low values of the asset is 0.5. When informed, the seller updates the probability of the high value of the asset to $p \in [0, 1]$. Then the conditional expected value of the asset is $s \equiv v_l + p(v_h - v_l)$, which is uniform on $[v_l, v_h]$ whenever $p \sim U[0, 1]$.

or $P < v_l$ (which is dominated by offering $P \to v_l^+$). We now characterize the buyer's optimal bidding strategy when facing a dealer with expertise λ.

Proposition 1. *In equilibrium, the buyer offers the price:*

$$P^* = \begin{cases} v_h & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ v_l + b - \frac{1-\lambda}{\lambda}(v_h - v_l) & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ \mu & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ v_l + b & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l), \end{cases} \tag{2}$$

where $\beta(\lambda) = \frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}$. *Moreover,* P^* *weakly increases in* b *and weakly increases in* λ *whenever* $b \neq \frac{1}{2}\beta(\lambda)(v_h - v_l)$.

Throughout the paper, proofs of our formal results are relegated to the Appendix. As Proposition 1 shows, the solution for P^* allows for four cases. Figure 1 plots the buyer's optimal bid as a function of the gains to trade b and highlights how the optimal bid P^* is weakly increasing in the private benefit b. Intuitively, the more private benefits the buyer gets from acquiring the asset, the more aggressive the buyer is in trying to secure the asset. By making a higher bid, the buyer increases the likelihood of acceptance, but it requires sharing more trading surplus with the seller.

When the private benefit from trade b is below $\frac{1}{2}\beta(\lambda)(v_h - v_l)$, the buyer offers $P^* < \mu$ which is not a high enough price to convince the current owner to sell the asset if uninformed about its value. However, by bidding conservatively the buyer is limiting the adverse selection associated with trading with an informed seller. In this region of b, an incremental increase in b pushes the buyer to make a marginally higher bid in order to make the trade more likely to occur.

When the private benefit from trade b is between $\frac{1}{2}\beta(\lambda)(v_h - v_l)$ and $\frac{2-\lambda}{2\lambda}(v_h - v_l)$, the buyer bids $P^* = \mu$ which is just enough to convince an uninformed owner to sell the asset. This higher price is then subjecting the buyer to a higher degree of adverse selection when the seller is informed, yet the private benefit of acquiring the asset is large enough to warrant making sure the uninformed seller is willing to participate in a trade. In this region of b, a small increase in b does not change which seller type the buyer targets: increasing the bid would attract more informed seller types but it would also expose the buyer to more adverse selection than wanted.

When the private benefit from trade b is between $\frac{2-\lambda}{2\lambda}(v_h - v_l)$ and $\frac{1}{\lambda}(v_h - v_l)$, the buyer finds it optimal to offer an even higher price in order to convince the informed seller to sell the asset with a higher probability. The optimal bid increases with the private benefit again as a larger benefit makes the buyer more willing to get exposed to adverse selection by offering a larger price. This price is capped by v_h which allows the buyer to secure complete participation by any seller type. At that point, once b gets above $\frac{1}{\lambda}(v_h - v_l)$, the buyer would be made worse off by further increasing the price offered since it is already accepted with probability 1.

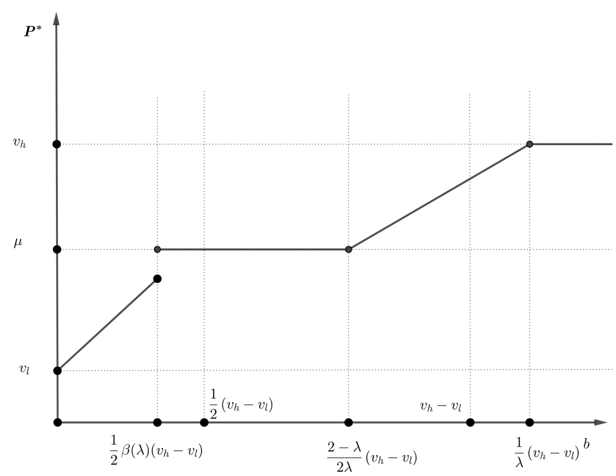


Figure 1

Buyer's Optimal Bidding Function. This graph illustrates the four cases of the buyer's optimal bidding function for $\lambda < 1$, as formalized by Proposition 1. The x-axis represents the private benefit of trade and the y-axis represents the price the buyer finds optimal to offer to the seller.

In a similar spirit, a buyer generally bids a weakly higher price when trading with a seller who is more likely to have an informational advantage. As the seller's λ increases, the buyer increases its bid to increase the likelihood of trade. In particular, for a given level of b, an increase in the seller's expertise decreases the two upper thresholds of the P^* cases, namely $\frac{2-\lambda}{2\lambda}$ and $\frac{1}{\lambda}$. So when λ increases, the buyer is more likely to find itself in the two highest cases of P^*. Moreover, for the range of parameter values where the buyer bids above μ but below v_h, the higher the λ, the higher is the bid $v_l + b - \frac{1-\lambda}{\lambda}(v_h - v_l)$. However, the threshold $\frac{1}{2}\beta(\lambda)$ also increases with λ. Thus, as the seller is more likely to be informed, the strategy of bidding μ becomes more susceptible to being adversely selected by the seller. So when λ is large enough, the buyer opts to bid below the unconditional value and P^* decreases from μ to $v_l + b$.

In what will become our region of interest where the buyer targets the uninformed seller type as well as some informed seller types, the optimal bid weakly increases with λ. The next corollary establishes that in this parameter region the buyer is made better off by being paired with a seller who is less likely to be informed about the asset being traded. That is, while investors increase their bids in response to higher dealer expertise, they are made worse off by an increase in dealer expertise because they end up giving away a larger share of their surplus.

Corollary 1. *If $\frac{1}{2}\beta(\lambda)(v_h - v_l) < b < \frac{1}{\lambda}(v_h - v_l)$, the buyer's expected surplus Π is decreasing in the probability λ that the seller is informed about the asset. If $b \geq \frac{1}{\lambda}(v_h - v_l)$, the buyer's expected surplus Π is unaffected by λ. If $b \leq \frac{1}{2}\beta(\lambda)(v_h - v_l)$, the buyer's expected surplus Π is increasing in λ.*

Corollary 1 shows that, in most cases, a buyer weakly prefers being matched to a seller that is less likely to have an informational advantage about the asset being traded. As Proposition 1 established, a buyer shares a larger share of its surplus when trading with a better informed seller. Hence, in those cases, the buyer is better off being matched with a less informed counterparty.

The only exception to this relationship is when the private benefits from trade are so small that the buyer finds it optimal to offer a price that is only accepted by an informed seller who has received a signal below the unconditional value. In this parameter region, the buyer benefits from a marginal increase in the likelihood that the dealer is informed since it means that the trade is marginally more likely to happen. Moreover, in this parameter range the buyer does not change its bid even if the seller is more informed. Therefore, as the seller becomes marginally more likely to be informed, the buyer is more likely to get the asset, while bidding exactly the same price, which implies that the buyer is made better off.

For the remainder of the paper, we impose a parametric restriction on b that allows our analysis to zoom in on the more natural case in which an investor strictly prefers to trade with a counterparty that is less likely to have an informational advantage:

Assumption 1. $\frac{1}{2}(v_h - v_l) \leq b < (v_h - v_l)$.

Imposing $\frac{1}{2}(v_h - v_l) \leq b$ guarantees that $\frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b$ since:

$$\beta(\lambda) = \frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1} \leq 1, \tag{3}$$

whenever $\lambda \leq 1$. As Figure 2 illustrates, Assumption 1 narrows down the relevant parameter range such that $\mu \leq P^* < v_h$. That is, it excludes the two extreme cases in which the buyer either bids below the unconditional value of the asset and trades only with seller types who have received sufficiently negative signals, or bids v_h as it is not concerned with adverse selection. Within the parameter range imposed by Assumption 1, the buyer ends up trading with both uninformed and informed seller types while remaining wary of the adverse selection resulting from the seller's potential informational advantage.

2.2 Expertise Acquisition and Order-Flow Allocation Stage

We now study how dealers choose the expertise level they acquire and how investors choose the dealer with which they will trade. To capture the idea that dealers' expertise is chosen in anticipation of investors' order-flow allocation and investors' order flow is allocated in anticipation of

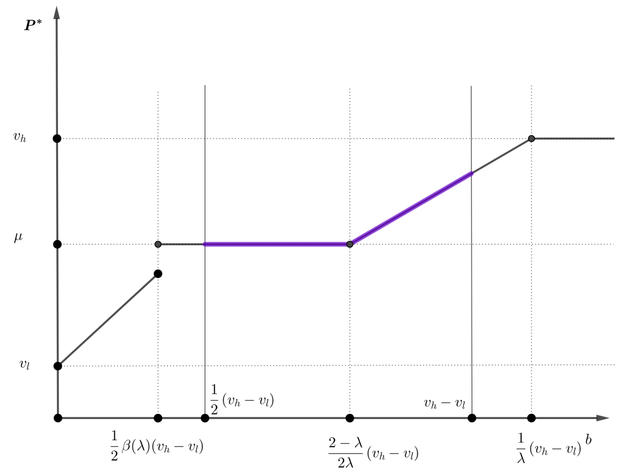


Figure 2

Buyer's Optimal Bidding Function in Parameter Range of Assumption 1. This graph illustrates the buyer's optimal bidding function for the subset of cases permitted by Assumption 1. The x-axis represents the private benefit of trade and the y-axis represents the price the buyer finds optimal to offer to the seller.

dealers' expertise levels, we solve for a Nash equilibrium when investors' and dealers' decisions are made simultaneously.

As discussed above, our model is designed to capture the notion that a dealer's investment in expertise improves its capacity to take advantage, within a short period of time, of multiple counterparties across different transactions involving various types of assets. A financial firm cannot value all possible assets and assess the terms of trade of all possible transactions simply by hiring one trader, buying one computer, or gaining access to one proprietary database. The more resources it invests to boost its expertise, the higher is the firm's bandwidth when assessing the profitability of a variety of potential transactions. To depict in a tractable manner this idea that more scalability requires additional investments, we assume that the market is fragmented in the sense that there are multiple investors each interested in trading a different asset (e.g., a specific corporate bond, municipal bond, or derivative product). Each dealer starts with enough expertise (e.g., data, human capital, computing power) to value assets and gain an informational advantage in at most $\underline{k}$ transactions. Each dealer j can, however, choose to further invest in expertise in order to have the resources and bandwidth needed to value $k_j > \underline{k}$ assets. We then refer to k_j as dealer

j's expertise level, which is assumed to cost $c \cdot (k_j - \underline{k})$ to acquire.

Each dealer also starts with a loyal client base of measure $\underline{n}$. These are unsophisticated investors who always trade with the same (e.g., local) dealer (see also Green 2007). We refer to the N investors who are not loyal to a specific dealer and who optimize based on the expected terms of trade as independent investors. In the simultaneous-move game of this stage, each independent investor chooses which dealer to do business with and each dealer chooses how much expertise to acquire. Then trade occurs as described in subsection 2.1, taking these decisions as given.

When considering doing business with a dealer j, investor i forecasts the probability that the dealer will have an informational advantage about a specific asset as: $\lambda_j = \min\left(\frac{k_j}{n_j}, 1\right)$, where n_j is the number of investors who will be doing business with dealer j and k_j is the number of assets that dealer j has the bandwidth to value. That is, when $n_j > k_j$, a measure $n_j - k_j$ of dealer j's transactions happen without the dealer having an informational advantage. Dealers are allowed to be short or long any asset in their inventory (recall: the model behaves symmetrically whether the dealer is a buyer or a seller).

A dealer j's order flow n_j thus adds up the transaction volume from its loyal investors (i.e., $\underline{n}$) and from the independent investors who chose this dealer (i.e., n_j^*). As a result, the dealer's total expected profit is given by:

$$\Delta\left(k_j, n_j\right) \equiv n_j \left[(1-\lambda_j)(P^* - \mu) + \lambda_j \left(\frac{P^* - v_l}{v_h - v_l}\right)\left(P^* - \frac{P^* + v_l}{2}\right)\right] - c \cdot (k_j - \underline{k}), \qquad (4)$$

where $\lambda_j = \min\left(\frac{k_j}{n_j}, 1\right)$ and $P^* \geq \mu$ for the range of parameters consistent with Assumption 1.

Figure 3 identifies which of the four parameter regions in Proposition 1 applies for every λ and b pair. Imposing Assumption 1 restricts our attention within areas II and III. In these regions, we can establish a one-to-one relationship between our conditions on b and analogous conditions on λ. In particular, $\frac{1}{2}(v_h - v_l) \leq b < \min\left(\frac{2-\lambda}{2\lambda}, 1\right)$ can be expressed as $\underline{\lambda} \leq \lambda < \frac{1}{1+\frac{2b}{v_h - v_l}}$, where $\underline{\lambda} \equiv \frac{\underline{k}}{\underline{n}+N}$.

Substituting in the optimal bid P^* derived in Proposition 1, we can rewrite the dealer's expected

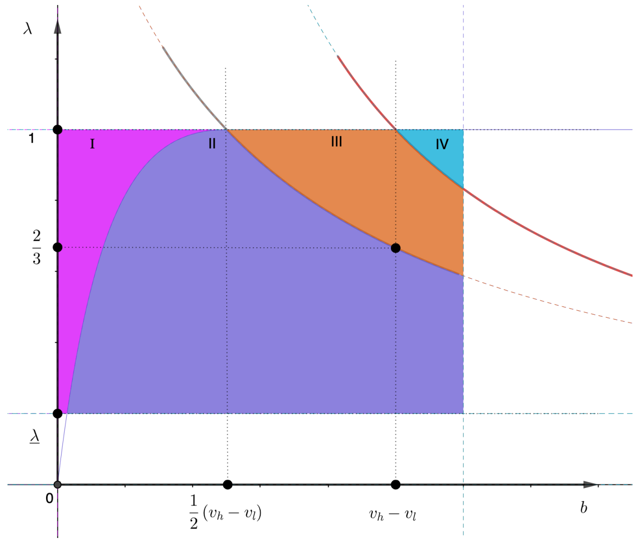


Figure 3

Conditions on b vs λ. This graph identifies which of the four parameter regions in Proposition 1 applies for every λ and b pair. Area I corresponds to $b < \frac{1}{2}\beta(\lambda)(v_h - v_l)$, area II corresponds to $\frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l)$, area III to $\left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l)$, and area IV to $b \geq \frac{1}{\lambda}(v_h - v_l)$.

profit as:

$$\Delta(k_j, n_j) = \begin{cases} n_j \left[\frac{\lambda_j b^2}{2(v_h - v_l)} - \left(\frac{1-\lambda_j}{2\lambda_j}\right)(v_h - v_l)\right] - c \cdot (k_j - \underline{k}) & \text{if } \frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*} \leq 1, \\ n_j \frac{\lambda_j}{8}(v_h - v_l) - c \cdot (k_j - \underline{k}) & \text{if } \underline{\lambda} \leq \lambda_{j^*} < \frac{2}{1+\frac{2b}{v_h - v_l}}. \end{cases} \quad (5)$$

The next lemma shows that, as long as the cost of expertise is small enough, a dealer increases its expected profit by maximizing the probability λ_j of having an informational advantage about the value of the assets being traded. That is, ceteris paribus, when expertise is cheap a dealer j is better off increasing k_j until $\lambda_j = 1$.

Lemma 1. *For a given n_j, $\frac{\partial \Delta(k_j, n_j)}{\partial k_j} > 0$ as long as $\lambda_j < 1$ and $c < \frac{1}{8}(v_h - v_l)$.*

There are two benefits to a dealer's expertise in our setting. A first benefit comes from making better decisions when responding to offers. This benefit is most evident in the range of $b < \min\left(\frac{2-\lambda_j}{2\lambda_j}, 1\right) \cdot (v_h - v_l)$ or, equivalently, $\underline{\lambda} \leq \lambda < \frac{2}{1+\frac{2b}{v_h - v_l}}$. With small gains to trade, investors only bid the unconditional value of the asset, μ, and if the dealer were to acquire slightly more expertise, investors would not adjust their bids. However, the dealer would be more likely to know the value of the asset and make a better decision, which is captured by the fact that $\frac{\partial\Delta(k_j,n_j)}{\partial k_j} = \frac{1}{8}(v_h - v_l) - c > 0$ when $P^* = \mu$. In Figure 4, this advantage of expertise is illustrated by the small positive slope in the relationship between a dealer' expected profit, gross of expertise costs, and its λ for low levels of λ.

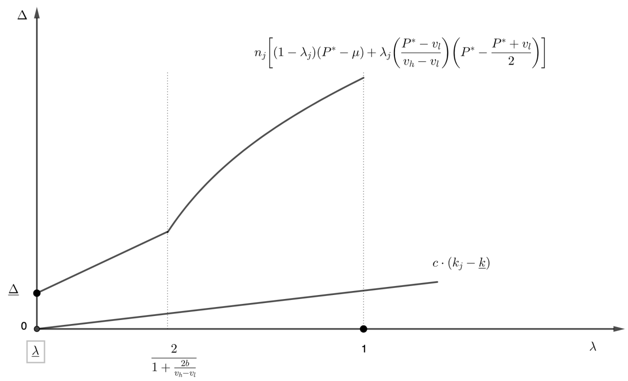


Figure 4

Costs and Benefits of Expertise Acquisition. This graph shows how increasing the likelihood of a dealer having an informational advantage affects its expected profit from trade and the cost of acquiring the required level of expertise. The x-axis represents λ, the likelihood of a dealer having an informational advantage. The y-axis represents the dealer's gross trading profit, $n_j\left[\frac{\lambda_j b^2}{2(v_h-v_l)} - \left(\frac{1-\lambda_j}{2\lambda_j}\right)(v_h - v_l)\right]$, and the costs of expertise acquisition, $c \cdot (k_j - \underline{k})$. The distance between these two lines is the dealer's net profit, Δ.

A second benefit of expertise is triggered by higher levels of gains to trade, or equivalently when $\frac{2}{1+\frac{2b}{v_h-v_l}} \leq \lambda_{j^*} \leq 1$. Figure 4 shows that the slope in the relationship between a dealer' expected profit, gross of expertise costs, and its λ is higher in this region. If the dealer becomes marginally more likely to be informed, then investors increase their bids accordingly. Thus, for higher level of gains to trade, a dealer benefits from acquiring expertise by both receiving better terms of trade from investors and making better decisions about when to agree to these proposed terms of trade.

While our model makes formal assumptions on how trading occurs among agents, the central insights we will highlight below mainly rely on the generic properties that, ceteris paribus, dealers appropriate larger economic rents from investors when acquiring more expertise and investors are worse off when trading with dealers that are more likely to have an informational advantage thanks to their higher expertise.

An equilibrium of the expertise acquisition and order-flow allocation stage is defined by dealers' expertise choices $k_j^* \geq \underline{k}$ and investors' dealer choices $Dealer_i$ such that:

- for any investor i that chooses to rout its trade to dealer j, i.e., $Dealer_i = j$, we have:

$$\Pi\left(\min\left(\frac{k_j^*}{n_j}, 1\right), b, P_j^*\right) \geq \Pi\left(\min\left(\frac{k_{j'}^*}{n_{j'}+1}, 1\right), b, P_{j'}^*\right) \qquad \forall j' \neq j, \tag{6}$$

  where P_j^* and $P_{j'}^*$ respectively denote the optimal price offers from investors when trading with dealer j and with dealer $j^{'}$ (see Proposition 1),

- for any dealer j that chooses k_j^* and expects to receive order flow n_j as a result of investors' dealer choices $Dealer_i$, we have:

$$\Delta\left(k_j^*, n_j\right) \geq \Delta\left(k_j', n_j\right) \qquad \forall k_j' \neq k_j^*. \tag{7}$$

As already stated, we model dealers' and investors' decisions as a simultaneous-move game. This timeline allows to capture the idea that expertise acquisition and order-flow allocation are endogenous to each other and none of these decisions unilaterally drives the other (as they would if these two decisions were modeled as sequential). While the default level of expertise as well as the loyal client base of each dealer are well-known to all market participants, we assume that investors cannot know for sure the future levels of expertise of dealers, whereas dealers cannot be certain of investors' future allocation of order flow. Our equilibrium definition imposes that there is no systematic deviation between conjectured and realized outcomes when agents make their decisions.

For the remainder of this section, we make the following assumptions about dealers and their loyal investors:

Assumption 2. *All dealers are identical ex-ante identical with respect to their minimum levels of expertise* $\underline{k}$ *and order flow from loyal investors* $\underline{n}$*. Moreover,* $\underline{k} \geq \underline{n} + 1$.

We now introduce the basic intuition for why concentrating order flow toward one dealer can be optimal for independent investors.

Lemma 2. *If in equilibrium at least one transaction occurs without the dealer having an informational advantage (i.e., there is at least one dealer with* $\lambda_j < 1$*), then all independent investors' order flow is allocated to the same dealer and, as a result, other dealers only receive order flow from their loyal investors.*

Intuitively, this lemma shows that, by contradiction, if independent investors were expected to split their transaction volume among two or more separate dealers, then each independent investor would benefit from re-routing its transaction to a different dealer. By reallocating its order flow to a dealer, the deviating investor would decrease the odds that this dealer is informed when trading with a given investor (i.e., this dealer's λ_j). Therefore, it would be in the best interest of every independent investor to allocate their order flow to a single dealer in order to stretch its expertise capacity and minimize the probability that this dealer takes advantage of each investor. The existence of one dealer whose $\lambda_j < 1$ ensures that there is at least one dealer with order flow that already exceeds its expertise capacity and therefore, an additional independent investor switching to dealer j would further decrease its λ_j.

Lemma 2 shows how liquidity externalities can incentivize independent investors to concentrate their order flow with one dealer. Each investor prefers to trade with a dealer that is attracting a lot of other independent investors, because this dealer is less likely to use its expertise to take advantage of this particular investor. However, as we will show in the next proposition, dealers take the allocation of order flow into account when choosing how much expertise to acquire. But before deriving this result, we need to rule out extreme outcomes by imposing a few restrictions on the aggregate distribution of dealers and investors.

Assumption 3. *The market is populated with L dealers and N independent investors, such that $\frac{\underline{k}}{\underline{n}+\frac{N}{L}} < 1$ and $\underline{\lambda} \equiv \frac{\underline{k}}{\underline{n}+N} \leq \frac{2}{3}$.*

These restrictions limit how much expertise dealers start with based on two possible cases. For the case where aggregate order flow is split evenly across all dealers, dealers' initial level of expertise $\underline{k}$ is not sufficient to allow them to enjoy an informational advantage in all the transactions in which they are involved. Without expertise acquisition, some dealers would end up being uninformed about some assets. For the case where all independent investors choose to do business with a single dealer, its initial level of expertise $\underline{k}$ leaves this central dealer without an informational advantage in at least 1/3 of the transactions. The restriction that $\underline{\lambda} \leq \frac{2}{3}$ is equivalent to $\frac{2-\underline{\lambda}}{2\underline{\lambda}} \geq 1$, which guarantees that investors would offer only the relatively lower price $P^* = \mu$ to a central dealer that did not acquire additional expertise (see P^* in Proposition 1). Altogether, these restrictions will ensure that a central dealer acquires expertise in equilibrium.

In the next proposition we combine the insights of Lemmas 1 and 2 with Assumption 3 and pin down the equilibrium allocation of order flow and the equilibrium levels of dealer expertise.

Proposition 2. *When $c < \frac{1}{8}(v_h - v_l)$, in equilibrium one dealer, say j^*, acquires an expertise level $k_{j^*} = \underline{n} + N$ and receives all the order flow from independent investors, whereas all other dealers do not acquire expertise above the initial level $\underline{k}$.*

Proposition 2 establishes that in equilibrium trade is concentrated around a central dealer, creating a pool of liquidity. However, when $c < \frac{1}{8}(v_h - v_l)$, the central dealer has the highest level of expertise among all dealers.

In fact, all dealers enjoy an informational advantage in all the transactions they execute in equilibrium, yet order flow is concentrated as first hinted in Lemma 2. While investors would prefer to trade with a dealer that is less likely to be informed, alternative dealers that acquired less expertise than the central dealer also have fewer assets to value. From Lemma 1, we know that for a small enough c a dealer benefits from increasing its expertise until it anticipates to always be informed given its expected order flow. Thus, the central dealer optimally reaches its expertise capacity given the equilibrium order flow, while alternative dealers have some unused expertise and are in position to use their limited resources to take advantage of any investor who trades with them. As a result, independent investors are indifferent between doing business with the expert dealer j^* that receives all independent investors' order flow and doing business with a dealer with minimal levels of expertise and order flow.

Overall, we can think of this equilibrium as featuring a sophisticated (i.e., expert) dealer attracting the transaction volume of attentive (i.e., independent) investors and multiple less sophisticated dealers benefitting from the lack of attentiveness of their loyal investor clientele. Yet, in this particular region of c, investors are indifferent about which dealer they trade with in equilibrium because all dealers have $\lambda_j = 1$.

Proposition 2 highlights that in equilibrium the large investments in expertise made by the central dealer do not deter independent investors from sending their order flow its way. The analysis focused on the dealer's incentives to acquire expertise when its cost is sufficiently low, and how this expertise affects the anticipated order flow from independent investors. We now analyze how the costs associated with expertise acquisition more generally affect the central dealer's level of expertise, while taking into account the endogeneity of order flow. As discussed above, a dealer benefits from acquiring expertise through the better terms of trade investors offer and through the ability to make better decisions in response to these offers. In order to decide how much expertise to acquire, a dealer must then compare these benefits with the cost of expertise.

Proposition 3. *In equilibrium, the probability that the central dealer has an informational advantage in a given trade is weakly decreasing in the cost of expertise acquisition. In particular, if* $b \geq \alpha(\underline{\lambda})(v_h - v_l)$*, the central dealer is informed with probability:*

$$\lambda^* = \begin{cases} 1 & \textit{if} \quad c \leq \zeta_1, \\ \sqrt{\frac{(v_h - v_l)^2}{2c(v_h - v_l) - b^2}} & \textit{if} \quad \zeta_1 < c \leq \min(\zeta_3, \zeta_4), \\ \underline{\lambda} & \textit{if} \quad c > \min(\zeta_3, \zeta_4). \end{cases} \tag{8}$$

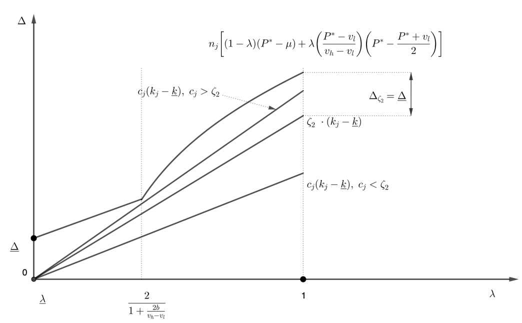
If instead $b < \alpha(\underline{\lambda})(v_h - v_l)$*, the central dealer is informed with probability:*

$$\lambda^* = \begin{cases} 1 & \textit{if} \quad c \leq \zeta_2, \\ \underline{\lambda} & \textit{if} \quad c > \zeta_2. \end{cases} \tag{9}$$

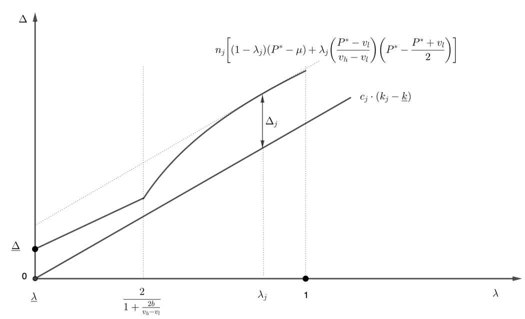
The quantity $\alpha(\underline{\lambda})$ *and all the thresholds* ζ *are defined in the proof to the proposition.*

This proposition shows that the equilibrium level of expertise is weakly decreasing in the cost of expertise acquisition. This prediction may seem natural, but requires that we account for how the dealer's choice of expertise is complicated by investors' optimal bidding response. If investors expect their dealer to have a moderate level of expertise, they bid a price equal to the unconditional value of the asset. Acquiring a marginally higher level of expertise solely benefits the dealer by allowing for better decisions regarding these fixed terms of trade. Acquiring substantially more expertise might, however, trigger more generous terms of trade that benefit the dealer. At that point, the benefits to higher expertise consist of not only making smarter acceptance and rejection decisions but also receiving more generous bids from investors. Whether investors offer a price $P^* = \mu$ or $P^* = v_l + b - \frac{1-\lambda}{\lambda}(v_h - v_l)$ dictates the benefits of expertise and determines the bounds on c that define the optimal expertise level of the central dealer.

Proposition 3 shows how the magnitude of the benefits from trade changes how the cost of expertise affects the equilibrium level of expertise that the central dealer acquires. When the private benefits from trade are small and the cost c is low, as featured in Proposition 2, the central dealer acquires enough expertise to gain an informational advantage in all transactions it intermediates. Since the benefits from trade are small, however, expertise acquisition fails to be profitable whenever investors offer a price $P^* = \mu$. As a result, the dealer never finds it optimal to acquire an intermediate level of expertise. Either the dealer acquires enough expertise to set $\lambda^* = 1$ when c is lower than a cutoff ζ_2, or it acquires no additional expertise, resulting in $\lambda^* = \underline{\lambda}$ when c is higher than this same cutoff. Panel (a) in Figure 5 illustrates these two possible equilibrium outcomes. The bottom straight line corresponds to the cost of expertise in the case where $c < \zeta_2$; the difference between the benefit and cost of expertise is maximized at $\lambda = 1$. The middle straight line corresponds to the case $c = \zeta_2$ and the dealer's net profit is also maximized at $\lambda = 1$. Thus, when $c \leq \zeta_2$, the dealer has an informational advantage in every transaction it intermediates. The top straight line, which is steeper, represents the case where $c > \zeta_2$; the optimal level of expertise that maximizes the distance between the dealer's gross profit from trade and the cost expertise acquisition is given by $\lambda^* = \underline{\lambda}$. When the cost of expertise is high, the benefits do not justify the costs and the central dealer sticks with the minimal (i.e., default) level of expertise.



(a) $b < \alpha(\underline{\lambda})(v_h - v_l)$



(b) $b \geq \alpha(\underline{\lambda})(v_h - v_l)$

Figure 5

Benefits and Costs of Expertise Acquisition. Panel (a) compares the dealer's gross profit from trade to the cost of expertise acquisition for three different levels of c and $b < \alpha(\underline{\lambda})(v_h - v_l)$. Panel (b) compares the dealer's gross profit from trade to the cost of expertise acquisition for an intermediate level of c and $b \geq \alpha(\underline{\lambda})(v_h - v_l)$.

If, on the other hand, the benefits from trade are large, acquiring expertise becomes relatively more attractive and is then justified for a wider range of c. In this scenario, the dealer sometimes finds it optimal to acquire an intermediate level of expertise, which is decreasing in c and equalizes the marginal benefit of expertise when being offered $P^* = v_l + b - \frac{1-\lambda}{\lambda}(v_h - v_l)$ with the cost of expertise acquisition. In Panel (b) of Figure 5, the straight line plots the cost of expertise in such a case, where the optimum is interior, i.e. $\underline{\lambda} < \lambda^* < 1$. At this level of expertise, the marginal benefit from an extra unit of expertise is exactly offset by the cost of acquiring it.

Overall, a central dealer finds it optimal to acquire expertise because it allows to make better decisions and might even result in better terms of trade being offered by investors. The dealer compares the resulting higher trade payoff with the cost of acquiring expertise. In equilibrium, the dealer acquires a level of expertise that does not discourage order flow from independent investors, who recognize that other (less popular) dealers would also take advantage of them by using their lower level of expertise (some of which is unused). In all cases, the equilibrium can still be thought of featuring a sophisticated (i.e., expert) dealer transacting with the large pool of attentive investors and multiple less sophisticated dealers only attracting their loyal clienteles. However, in cases where the cost of expertise is high, independent investors are getting better terms of trade from their central, more sophisticated dealer than loyal investors are getting from their peripheral, less sophisticated dealers.

3 Extensions and Model Implications

We now extend our baseline analysis to enrich the cross-sectional and time-series implications of our model.

3.1 Ex Ante Dealer Heterogeneity

In the baseline analysis, we showed that the equilibrium allocation of order flow disproportionately favors one dealer when dealers are homogeneous ex ante. When the cost of expertise is small enough, this dealer finds it optimal to acquire more expertise than its rivals. This prediction rationalizes why investors tend to (paradoxically) allocate their order flow to the most sophisticated dealers, despite standard adverse selection concerns. A natural limitation of our equilibrium predictions so far is that any of the ex-ante identical dealers can be selected by investors to become the market leader – our analysis has been silent about how independent investors may coordinate on picking a single dealer and how this chosen dealer knows to expect more order flow when deciding how much expertise to acquire. To shed light on how the ex-ante characteristics of the dealer that turns out ex post to be the central one impact investor welfare, we now allow for ex-ante heterogeneity in the per-unit cost of expertise acquisition and rank possible equilibria in terms of investors' welfare. We denote by c_j the cost of acquiring expertise for dealer j.

Proposition 4. *Independent investors weakly prefer an equilibrium in which the dealer with the highest cost of expertise acquisition c_j is the central one.*

From Proposition 1 we know that the level of expertise of the central dealer is weakly decreasing in c, while investors prefer to trade with dealers with a lower λ_j (see Corollary 1). It is therefore intuitively clear that independent investors are better off when the central dealer is the one facing the highest cost of expertise.

3.2 Increasing Accessibility of OTC Markets

In the baseline analysis, we have considered a market populated by many independent investors. In particular, we focused on the homogenous case where $\underline{k} < \underline{n} + \frac{N}{L}$, meaning that there were many more investors and corresponding total order flow (i.e., $L\underline{n} + N$) than all dealers' capacity to have an informational advantage without any investments in expertise (i.e., $L\underline{k}$). We now relax this restriction to shed light on the implications of decreasing the number of independent investors or increasing the baseline level of dealer expertise.

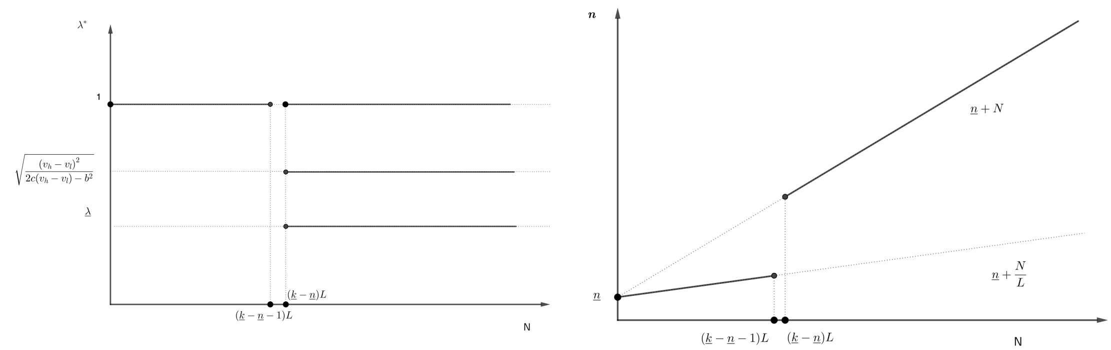
In what follows, we analyze an equilibrium for the case with ex-ante homogenous dealers and $\underline{k} > \underline{n} + \frac{N}{L} + 1$. When this condition holds, dealers would acquire enough resources to gain an informational advantage in all transactions they intermediate if independent investors were to allocate their trades evenly among dealers. The following proposition demonstrates that an even allocation of order flow can now be observed in equilibrium.

Proposition 5. *If $\underline{k} > \underline{n} + \frac{N}{L} + 1$, there exists an equilibrium in which all independent investors allocate their trades evenly among dealers while no dealer acquires any additional expertise.*

Proposition 5 describes a market outcome in sharp contrast to the one we discussed in the previous section: we now have an even allocation of order flow among all dealers. Independent investors know that all dealers will have an informational advantage when trading with them, yet since such business model is prevalent, investors have no incentives to switch dealers.

Unlike when Assumption 3 holds, here none of the dealers expects to receive enough order flow to warrant acquiring further expertise. Dispersed allocation of order flow in this equilibrium does not, however, benefit independent investors. That is, they are always trading with an informed dealer and bidding accordingly.

Figure 6 illustrates how the informational advantage and order-flow allocation of a central dealer change when the number of independent investors crosses the threshold $(\underline{k} - \underline{n} - 1)L$. When the number of independent investors is small, an even allocation of order flow across all dealers is sustainable in equilibrium. Panel (a) shows that $\lambda^* = 1$ for small N, while Panel (b) shows that each dealer's order flow is $\underline{n} + \frac{N}{L}$. As the number of independent investors increases beyond the threshold $(\underline{k} - \underline{n} - 1)L$, this equilibrium is no longer sustainable. The order flow concentrates around a central dealer, which receives a total order flow $\underline{n} + N$ and either acquires enough expertise to remain informed about all the transactions (i.e., $\lambda^* = 1$), only some (i.e., $\underline{\lambda} < \lambda^* < 1$), or does not acquire any extra expertise (i.e., $\lambda^* = \underline{\lambda}$), depending on the cost of expertise.



(a) Informational advantage of central dealer

(b) Order flow of central dealer

Figure 6

Equilibrium Impact of Increasing the Number of Independent Investors. Panel (a) plots the likelihood that a central dealer has an informational advantage as a function of the number of independent investors, for three levels of expertise cost. Panel (b) plots the transaction volume allocated to a central dealer as a function of the number of independent investors.

This extension can thus shed light on the consequences of the recent liberalization of OTC markets. Our results suggest that a disproportionally faster growth in the number of investors relative to the baseline expertise capacity of dealers (e.g., N growing faster than $\underline{k}$) could have led to increased concentration of order flow around one central dealer. Moreover, this inflow of participants may have increased this central dealer's incentives to acquire expertise above and beyond what is or was standard in the industry. Yet, since the dispersed equilibrium described in Proposition 5 has $\lambda_j = 1$ for all dealers whereas the concentrated equilibrium from Proposition 3 may feature $\lambda_{j^*} \leq 1$ for some levels of expertise acquisition costs, independent investors may or may not have benefited from this liberalization. We formalize this result in the corollary that follows.

Corollary 2. *An increase in the number of independent investors from* $N < (\underline{k} - \underline{n} - 1)L$ *to* $N > (\underline{k} - \underline{n})L$ *benefits independent investors if and only if either* $b \geq \alpha(\underline{\lambda})(v_h - v_l)$ *and* $c > \zeta_1$ *or* $b < \alpha(\underline{\lambda})(v_h - v_l)$ *and* $c > \zeta_2$.

While new investors might greatly benefit from the liberalization of OTC markets, our analysis in Corollary 2 shows that incumbent investors are better off only when dealers' costs of expertise acquisition are sufficiently high. In particular, with high enough costs, a central dealer is unwilling to pay the price required in order to gain informational advantages about the entire order flow of transactions following an increase in accessibility. Yet, our analysis also shows that potential advancements in technology, and the associated decreases in the cost of expertise dealers face, may have allowed a central dealer to extract a large fraction of the social surplus created by providing investors with easier access to OTC markets.

4 Conclusion

We jointly model investors' allocation of order flow among dealers and dealers' acquisition of expertise in OTC markets. An important and somewhat novel feature of our analysis consists of how we model dealers' expertise: a dealer's level of expertise determines the number of transactions for which this dealer will have the resources needed to gain an informational advantage over its counterparties. We show that, under intuitive conditions, the equilibrium allocation of order flow is concentrated towards one dealer that invests significant resources to boost its expertise and gain informational advantages when trading with investors. Despite the adverse selection concerns associated with these investments, investors prefer to funnel their transactions to this expert dealer rather than trading with less popular dealers that potentially have unused expertise capacity that can be used against their counterparties. Our analysis sheds light on the drivers behind the concentration of OTC intermediation as well as on the welfare implications of increased access to OTC markets.

Appendix

A Proofs Omitted from the Text

Proof of Proposition 1: The first-order condition from the buyer's surplus optimization problem is:

$$\frac{\partial \Pi(\lambda, b, P)}{\partial P} = \begin{cases} -(1-\lambda) + \frac{\lambda}{v_h - v_l}\left(v_l + b - P\right) = 0 & \text{if } P \in [\mu, v_h], \\ \frac{\lambda}{v_h - v_l}(v_l + b - P) = 0 & \text{if } P \in [v_l, \mu). \end{cases} \tag{A1}$$

The second-order condition for either of these cases is satisfied since:

$$\frac{\partial^2 \Pi(\lambda, b, P)}{\partial P^2} = -\frac{\lambda}{v_h - v_l} < 0. \tag{A2}$$

The first-order condition identifies the optimal price to offer within the respective regions $P \in [\mu, v_h]$ and $P \in [v_l, \mu)$. Yet, since the objective function has a discontinuity at $P = \mu$, we need to account for the possibility that the solution to the first-order condition in Equation (A1) for $P < \mu$ is dominated by $P = \mu$. In particular, we need to derive conditions under which the optimal bidding strategy is $P^* = v_l + b$ rather than $P = \mu$, and vice-versa.

The buyer's optimal bidding strategy is $P^* = v_l + b$ whenever $\Pi(\lambda, b, v_l + b) > \Pi(\lambda, b, \mu)$ and $v_l + b < \mu$. Define:

$$\begin{aligned} J(\lambda, b) \equiv \Pi(\lambda, b, v_l + b) - \Pi(\lambda, b, \mu) &= \frac{\lambda}{2}\frac{b^2}{v_h - v_l} - (1-\lambda)b - \frac{\lambda}{2}\left(b - \frac{1}{4}(v_h - v_l)\right) \\ &= \frac{\lambda}{2(v_h - v_l)}\left[b^2 - \left(\frac{2}{\lambda} - 1\right)(v_h - v_l)b + \frac{1}{4}(v_h - v_l)^2\right]. \end{aligned} \tag{A3}$$

$J(\lambda, b)$ measures the difference in the buyer's surplus between bidding below the unconditional expected value of the asset and bidding the unconditional expected value. While paying a lower price for the asset is best conditional on trading occurring at that price, the advantage of bidding μ is that it convinces uninformed seller to sell the asset. When the seller is never uninformed, however, offering $P = v_l + b$ weakly dominates offering $P = \mu$, that is, $J(1, b) = \frac{1}{2}\frac{1}{v_h - v_l}\left(b - \frac{v_h - v_l}{2}\right)^2 \geq 0$. Moreover:

$$\frac{\partial J(\lambda, b)}{\partial \lambda} = \frac{b^2}{2(v_h - v_l)} + \frac{b}{2} + \frac{1}{8}(v_h - v_l) > 0. \tag{A4}$$

Therefore, we know that for $0 < \lambda < 1$ the equation $J(\lambda, b) = 0$ has two roots in b, which we denote by b_1 and b_2, such that $b_1 < b_2$. The fact that $\frac{\partial^2 J(\lambda, b)}{\partial b^2} = \frac{\lambda}{v_h - v_l} > 0$ implies that the function J is convex in b for any $\lambda \in (0, 1)$. Hence, $J(\lambda, b) > 0$ for $b < b_1$ and for $b > b_2$. We can now use the standard formula for the roots of a quadratic equation and identify:

$$b_1 = \frac{1}{2}\left(\frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}\right)(v_h - v_l) \equiv \frac{1}{2}\beta(\lambda)(v_h - v_l), \tag{A5}$$

$$b_2 = \frac{1}{2}\left(\frac{2}{\lambda} - 1 + \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}\right)(v_h - v_l). \tag{A6}$$

Hence, $J(\lambda, b) > 0$ for $b < b_1$ and for $b > b_2$. Yet, $b_2 > \frac{1}{2}(v_h - v_l)$, which means that the b values in the interval $b > b_2$ are inconsistent with the bidding strategy $P = v_l + b$ being optimal since the latter is only valid for $v_l + b < \mu$, i.e., for $b < \frac{1}{2}(v_h - v_l)$. Hence, only $b < b_1$ is a relevant set of b values for which $J(\lambda, b) > 0$ and, therefore, $P^* = v_l + b$ is the optimal bidding strategy.

The following properties of $\beta(\lambda)$ are useful to keep in mind for the rest of the analysis. First, $\lim_{\lambda \to 0^+} \beta(\lambda) = 0$ and $\beta(1) = 1$. Moreover,

$$\frac{\partial \beta(\lambda)}{\partial \lambda} = -\frac{2}{\lambda}\left(1 - \frac{\frac{2}{\lambda} - 1}{\sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}}\right) > 0. \tag{A7}$$

Hence, $0 < \beta(\lambda) \leq 1$ for $0 < \lambda \leq 1$ and $\beta(\lambda)$ is monotonically increasing in λ.

As a result, the buyer's optimal bidding strategy can be written as:

$$P^* = \begin{cases} v_h & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ v_l + b - \frac{1-\lambda}{\lambda}(v_h - v_l) & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ \mu & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ v_l + b & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l). \end{cases} \tag{A8}$$

Moreover, the equilibrium bidding strategy satisfies the following properties:

$$\frac{\partial P^*}{\partial \lambda} = \begin{cases} 0 & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ \frac{1}{\lambda^2}(v_h - v_l) & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ 0 & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) < b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ 0 & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l), \end{cases} \tag{A9}$$

and the two upper thresholds decrease in λ, i.e. $\frac{\partial \frac{2-\lambda}{2\lambda}}{\partial \lambda} < 0$ and $\frac{\partial \frac{1}{\lambda}}{\partial \lambda} < 0$.

However, note that $\frac{\partial \beta(\lambda)}{\partial \lambda} > 0$ and $\mu = P^*_{b=\frac{1}{2}\beta(\lambda)(v_h - v_l)} > P^*_{b<\frac{1}{2}\beta(\lambda)(v_h - v_l)} = v_l + b$. Hence, for $b = \frac{1}{2}\beta(\lambda)(v_h - v_l)$, as λ increases by $\epsilon \to 0^+$, P^* discretely decreases from μ to $v_l + b$.

$$\frac{\partial P^*}{\partial b} = \begin{cases} 0 & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ 1 & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ 0 & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ 1 & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l). \end{cases} \tag{A10}$$

□

Proof of Corollary 1: We first write:

$$\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} = \frac{\partial\Pi(\lambda,b,P)}{\partial\lambda}|_{P=P^*} + \frac{\partial\Pi(\lambda,b,P)}{\partial P}|_{P=P^*} \cdot \frac{\partial P^*(\lambda)}{\partial\lambda}. \tag{A11}$$

From the proof of Proposition 1, we know that the price P^* is chosen to satisfy the buyer's first-order condition: $\frac{\partial\Pi(\lambda,b,P)}{\partial P}|_{P=P^*} = 0\ \forall b \neq \frac{1}{2}\beta(\lambda)(v_h - v_l)$. Thus, $\forall b \neq \frac{1}{2}\beta(\lambda)(v_h - v_l)$:

$$\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} = \frac{\partial\Pi(\lambda,b,P)}{\partial\lambda}|_{P=P^*}. \tag{A12}$$

As a result, Equation (1) can be used to derive that $\forall b \neq \frac{1}{2}\beta(\lambda)(v_h - v_l)$:

$$\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} = \begin{cases} -\frac{v_h-P^*}{2} - \left(\frac{v_h-P^*}{v_h-v_l}\right)\left(b - \frac{P^*-v_l}{2}\right) & \text{if } P^* \geq \mu, \\ \left(\frac{P^*-v_l}{v_h-v_l}\right)\left(b - \frac{P^*-v_l}{2}\right) & \text{if } P^* < \mu. \end{cases} \tag{A13}$$

From Proposition 1, $P^* \leq v_h$ for any value of b and as a result, $\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} = 0$ if $b \geq \frac{1}{\lambda}(v_h - v_l)$, $\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} < 0$ if $\frac{1}{2}\beta(\lambda)(v_h - v_l) < b < \frac{1}{\lambda}(v_h - v_l)$ and $\frac{\partial\Pi(\lambda,b,P^*(\lambda))}{\partial\lambda} > 0$ if $b < \frac{1}{2}\beta(\lambda)(v_h - v_l)$.

For $b = \frac{1}{2}\beta(\lambda)(v_h - v_l)$, as λ increases by $\epsilon \to 0^+$, P^* discretely decreases from μ to $v_l + b$. At $b = \frac{1}{2}\beta(\lambda)(v_h - v_l)$, $\Pi(\lambda, b, v_l + b) = \Pi(\lambda, b, \mu)$. Hence, there is only the direct effect of an increase in λ that matters and not the indirect through P^*. $\frac{\partial\Pi(\lambda,b,P)}{\partial\lambda} > 0$ for $P^* < \mu$. Hence, for as λ increases by $\epsilon \to 0^+$, we expect the buyer's surplus to increase for $b = \frac{1}{2}\beta(\lambda)(v_h - v_l)$. □

Proof of Lemma 1: Using Equation (5), we can show that when $\lambda_j = \min\left(\frac{k_j}{n_j}, 1\right) < 1$:

$$\frac{\partial\Delta(k_j,n_j)}{\partial k_j} = \begin{cases} \frac{b^2}{2(v_h-v_l)} + \frac{1}{2\lambda_j^2}(v_h - v_l) - c & \text{if } \min\left(\frac{2-\lambda_j}{2\lambda_j}, 1\right)\cdot(v_h - v_l) \leq b < (v_h - v_l), \\ \frac{1}{8}(v_h - v_l) - c & \text{if } \frac{1}{2}(v_h - v_l) \leq b < \min\left(\frac{2-\lambda_j}{2\lambda_j}, 1\right)\cdot(v_h - v_l). \end{cases} \tag{A14}$$

Thus, in all cases that satisfy Assumption 1, $\Delta(k_j, n_j)$ is strictly increasing in k_j as long as $\lambda_j < 1$ and $c < \min\left(\frac{b^2}{2(v_h-v_l)} + \frac{1}{2\lambda_j^2}(v_h - v_l), \frac{1}{8}(v_h - v_l)\right) = \frac{1}{8}(v_h - v_l)$. □

Proof of Lemma 2: Suppose, by contradiction, that given all dealers' choices of expertise, independent investors allocate their order flow among at least two dealers, i.e., there exist dealers j' and j'' such that $n^*_{j'} > 0$ and $n^*_{j''} > 0$. Then, if $\lambda_{j'} < \lambda_{j''}$, it is optimal for an independent investor who was planning to do business with dealer j'' to switch to dealer j' because of the lower probability that dealer j' has an informational advantage about the value of the asset this investor wants to trade, following Corollary 1 and Assumption 1. Thus, this allocation of order flow cannot be part of an equilibrium. If instead $\lambda_{j'} > \lambda_{j''}$, the reverse is true, and similarly this order-flow allocation cannot be part of an equilibrium.

Now if $\lambda_{j'} = \lambda_{j''} < 1$, an independent investor who was planning to do business with either dealer is strictly better off switching because $\frac{k_{j'}}{n_{j'}+1} < \frac{k_{j''}}{n_{j''}-1}$ and $\frac{k_{j'}}{n_{j'}-1} > \frac{k_{j''}}{n_{j''}+1}$. Finally, if $\lambda_{j'} = \lambda_{j''} = 1$, then an independent investor is better off switching to the dealer(s) whose $\lambda_j < 1$ (which exist(s) given the statement of the lemma). Hence, no matter what the dealers' expertise levels are, it is always optimal for a subset of independent investors to reallocate their order flow as long as the order flow of independent investors is allocated among two or more dealers and at least one dealer in the economy has $\lambda_j < 1$. $\square$

Proof of Proposition 2: To show that the stated equilibrium is indeed an equilibrium, we first rule out that a dealer $j \neq j^*$ would acquire $k_j > \underline{k}$ of expertise. When $\underline{k} \geq \underline{n} + 1$, this dealer's λ_j is already equal to 1, which means that this dealer enjoys an informational advantage in all the trades done with its loyal investors (remember: dealers $j \neq j^*$ do not attract any order flow from independent investors). Thus, there would be no benefit to acquiring more expertise.

We next rule out that an independent investor would leave dealer j^* and allocate order flow to a different dealer. If that was the case, this investor would go from trading with a dealer with $\lambda_{j^*} = 1$ to trading with a dealer with $\lambda_j = \min\left(\frac{\underline{k}}{\underline{n}+1}, 1\right) = 1$. Thus, there would be no benefit to switching dealers.

Moreover, when $c < \frac{1}{8}(v_h - v_l)$, dealer j^* finds it optimal to increase its expertise level until $\lambda_{j^*} = 1$ (see Lemma 1). Once dealer j^* reaches an expertise level of $k_{j^*} = \underline{n} + N$, the probability of being informed for every trade it participates to becomes 1. At that point, there would be no benefit to acquiring more expertise. Thus, the outcome described in the proposition is indeed an equilibrium.

Next, we show that an outcome where two dealers acquire expertise above $\underline{k}$ such that $\frac{k_j}{n_j} = \frac{k_j^*}{n_j^*} = 1$ cannot be an equilibrium. That is, we cannot have multiple dealers receiving order flow from independent investors and acquiring enough expertise to take full advantage of their order flow. In such a situation, similar to the logic in Lemma 2, independent investors would have an incentive to go from dealer j to j^* or the other way around. By switching from dealer j to j^*, investors would increase the order flow going to dealer j^* above this dealer's expertise capacity, thereby improving the odds that dealer j^* remains uninformed about a particular asset, i.e., $\frac{k_j}{n_j - 1} > 1 > \frac{k_j^*}{n_j^* + 1}$.

Finally, Assumption 3 rules out as an equilibrium a situation where independent investors allocate their order flow equally among dealers that all have excess expertise capacity despite not making any investment, i.e., $\frac{k_j}{n_j} > 1$ for all j. □

Proof of Proposition 3: Denote by $n_{j^*} = \underline{n} + N$ the total order flow that the dealer selected by independent investors, say j^*, expects to receive. Recall from Equation (4) that the dealer's profit is:

$$\Delta\left(k_{j^*}, n_{j^*}\right) = n_{j^*}\left[(1-\lambda_{j^*})(P^* - \mu) + \frac{\lambda_{j^*}}{2}\frac{(P^* - v_l)^2}{v_h - v_l}\right] - c \cdot (k_{j^*} - \underline{k}), \tag{A15}$$

where P^* is an investor's optimal bidding strategy, given by Proposition 1. For the range of b specified in Assumption 1, we can rewrite the optimal bidding strategy as:

$$P^* = \begin{cases} v_l + b - \frac{1-\lambda_{j^*}}{\lambda_{j^*}}(v_h - v_l) & \text{if } \frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*} \leq 1, \\ \mu & \text{if } \underline{\lambda} \leq \lambda_{j^*} < \frac{2}{1+\frac{2b}{v_h - v_l}}. \end{cases} \tag{A16}$$

Hence, $\Delta\left(k_{j^*}, n_{j^*}\right)$ is a continuous function of k_{j^*} with a kink at $k_{j^*} = n_{j^*} \cdot \frac{2}{1+\frac{2b}{v_h - v_l}}$. Intuitively, the two segments of the dealer's profit function capture the two bidding behaviors that investors might adopt, which depend on the dealer's expertise through the equilibrium λ_{j^*}. When they expect the dealer to be uninformed with a high probability, investors bid the unconditional value of the asset μ. When they expect the dealer to be informed with a high probability, investors start increasing their bids with the expertise of the dealer.

The cost parameter c determines the λ_{j^*} that the central dealer aims to achieve in equilibrium, for a given level of order flow. In particular, this dealer's marginal benefit from acquiring more expertise is given by $\frac{\partial \Delta(k_{j^*}, n_{j^*})}{\partial k_{j^*}}$. If $k_{j^*} \leq n_{j^*}$ (thus: $\lambda_{j^*} \leq 1$), this marginal benefit can be written as:

$$\frac{\partial \Delta\left(k_{j^*}, n_{j^*}\right)}{\partial k_{j^*}} = \begin{cases} \frac{b^2}{2(v_h - v_l)} + \frac{1}{2\lambda_{j^*}^2}(v_h - v_l) - c & \text{if } \frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*} \leq 1, \\ \frac{1}{8}(v_h - v_l) - c & \text{if } \underline{\lambda} \leq \lambda_{j^*} < \frac{2}{1+\frac{2b}{v_h - v_l}}. \end{cases} \tag{A17}$$

If, however, $k_{j^*} > n_{j^*}$, the marginal benefit reduces to:

$$\frac{\partial \Delta\left(k_{j^*}, n_{j^*}\right)}{\partial k_{j^*}} = -c. \tag{A18}$$

Hence, given the anticipated order flow of n_{j^*}, the optimal choice of $k_{j^*} \in [\underline{k}, n_{j^*}]$. In order to find the optimal k_{j^*} we need to find the local maximum associated with each of two segments and then identify the global maximum among these two for a given level of c.

Lemma 1 already states that for $c < \frac{1}{8}(v_h - v_l)$ the optimal acquisition of expertise leads to $\lambda_{j^*} = 1$. The same holds true for $c = \frac{1}{8}(v_h - v_l)$ since the dealer's profit is weakly increasing in k_{j^*}.

We now investigate what happens when $c > \frac{1}{8}(v_h - v_l)$. We first characterize the optimal level of expertise within the low-expertise segment where:

$$\frac{\partial \Delta\left(k_{j^*}, n_{j^*}\right)}{\partial k_{j^*}} = \frac{1}{8}(v_h - v_l) - c \quad \text{if } \underline{\lambda} \leq \lambda_{j^*} < \frac{2}{1+\frac{2b}{v_h - v_l}}. \tag{A19}$$

Since $c > \frac{1}{8}(v_h - v_l)$, the local optimum in this segment has $\lambda_{j^*} = \underline{\lambda}$. We denote the resulting dealer's profit as $\underline{\Delta}$:

$$\underline{\Delta} \equiv \Delta\left(k_{j^*} = \underline{k}, n_{j^*}\right) = n_{j^*}\frac{\underline{\lambda}}{8}(v_h - v_l) = \frac{\underline{k}}{8}(v_h - v_l). \tag{A20}$$

We next analyze the second segment where $\frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*} \leq 1$. Define as ζ_1 the level of c that sets:

$$\left.\frac{\partial \Delta\left(k_{j^*}, n_{j^*}\right)}{\partial k_{j^*}}\right|_{k_{j^*} = n_{j^*}} = 0. \tag{A21}$$

Utilizing Equation (A17), we can solve for ζ_1 as:

$$\zeta_1 = \frac{b^2}{2(v_h - v_l)} + \frac{1}{2}(v_h - v_l). \tag{A22}$$

Acquiring enough expertise to be informed about the entire order flow (i.e., $k_{j^*} = n_{j^*}$ and $\lambda_{j^*} = 1$) is the locally-optimal strategy for the central dealer when $c \leq \zeta_1$. The dealer's profit at $\lambda_{j^*} = 1$ is:

$$\Delta\left(k_{j^*} = n_{j^*}, n_{j^*}\right) = n_{j^*}\frac{b^2}{2(v_h - v_l)} - c(n_{j^*} - \underline{k}). \tag{A23}$$

We now compare the two local maximums for $\frac{1}{8}(v_h - v_l) < c \leq \zeta_1$. Define as ζ_2 the level of c such that two strategies with $\lambda_{j^*} = 1$ and $\lambda_{j^*} = \underline{\lambda}$ produce the same expected profits:

$$\zeta_2 = \frac{1}{1-\underline{\lambda}}\frac{b^2}{2(v_h - v_l)} - \frac{\underline{\lambda}}{1-\underline{\lambda}}\frac{v_h - v_l}{8}. \tag{A24}$$

Note that $\zeta_2 < \zeta_1$ if and only if:

$$b < \alpha(\underline{\lambda})(v_h - v_l), \tag{A25}$$

where $\alpha(\underline{\lambda}) = \sqrt{\frac{1}{4} + \frac{1-\underline{\lambda}}{\underline{\lambda}}}$.

Therefore, if $b < \alpha(\underline{\lambda})(v_h - v_l)$ then for $c \leq \zeta_2$ the global maximum is at $\lambda_{j^*} = 1$, while for $c > \zeta_2$ the global maximum is at $\lambda_{j^*} = \underline{\lambda}$.[3]

[3] When $b < \alpha(\underline{\lambda})(v_h - v_l)$ we can rule out $\underline{\lambda} < \lambda^* < 1$ as a possible global max for $c > \zeta_1$. This is because the

If $b \geq \alpha(\underline{\lambda})(v_h - v_l)$, the dealer's profit reaches its global maximum for $c \leq \zeta_1$ with $\lambda_{j^*} = 1$. Whenever $c > \zeta_1$, however, the cost of acquiring expertise is binding and the dealer limits its expertise by acquiring $k_{j^*} < n_{j^*}$. We must now revisit the first-order condition using Equation (A17) and set the marginal benefit in the high-expertise region to zero, which implies that $\lambda_{j^*} < 1$. We then get:

$$\lambda^* = \sqrt{\frac{(v_h - v_l)^2}{2c(v_h - v_l) - b^2}}. \tag{A26}$$

For the associated level of expertise to be part of an equilibrium, we need investors to bid aggressively above μ when facing a dealer with this specific λ_{j^*}. That is, we need $\lambda_{j^*} = \sqrt{\frac{(v_h - v_l)^2}{2c(v_h - v_l) - b^2}}$ to satisfy $\frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*}$, which requires that $c \leq \zeta_3 = \frac{b^2}{(v_h - v_l)} + \frac{1}{8}(v_h - v_l) + \frac{b}{2}$. We can also see that, if $c \leq \frac{b^2}{2(v_h - v_l)} + \frac{1}{2\underline{\lambda}^2}(v_h - v_l)$, then the k_{j^*} choice associated with this λ_{j^*} is no less than $\underline{k}$. However, we can show that $\zeta_3 \leq \frac{b^2}{2(v_h - v_l)} + \frac{1}{2\underline{\lambda}^2}(v_h - v_l)$ for the relevant parameter range. Thus, $\lambda_{j^*} = \sqrt{\frac{(v_h - v_l)^2}{2c(v_h - v_l) - b^2}}$ is a local maximum when $\zeta_1 < c \leq \zeta_3$.

Hence, we have two conjectured outcomes that feature different pricing strategies by investors for $\zeta_1 < c \leq \zeta_3$. If the dealer does not acquire extra expertise (i.e., $k_{j^*} = \underline{k}$), all investors bid on the assets conservatively at μ, expecting the dealer to be informed only for a fraction of transactions. If instead the dealer acquires extra expertise so that $k_{j^*} = \lambda_{j^*}(\underline{n} + N) \geq \underline{k}$, investors expect the dealer to be informed more often and bid above μ to increase the likelihood of getting an asset. Which one is more profitable for the dealer depends on the level of the expertise costs. In particular, define ζ_4 the level of expertise costs such that $\Delta(k_{j^*} = n_{j^*}\lambda^*(\zeta_4), n_{j^*}) = \underline{\Delta}$ as solution in to the following implicit equation:

$$\zeta_4 = \frac{1}{\lambda^*(\zeta_4) - \underline{\lambda}}\left(\frac{\lambda^*(\zeta_4)}{2}\frac{b^2}{v_h - v_l} - \frac{1}{2\lambda^*(\zeta_4)}(v_h - v_l) + \frac{1}{2}(v_h - v_l) - \frac{\underline{\lambda}}{8}(v_h - v_l)\right) \tag{A27}$$

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dealer's profit is decreasing in c for $\frac{2}{1+\frac{2b}{v_h - v_l}} \leq \lambda_{j^*} \leq 1$ by the Envelope theorem, $\frac{\partial \Delta(k^*_{j^*}, n_{j^*})}{\partial c} < 0$. Therefore, for $\zeta_2 < \zeta_1$, it must be the case that:

$$\underline{\Delta} \geq \Delta(k^*_{j^*} = n_{j^*}, n_{j^*})_{c=\zeta_2} > \Delta(k^*_{j^*} = n_{j^*}, n_{j^*})_{\zeta_2 < c \leq \zeta_1} > \Delta(k^*_{j^*} < n_{j^*}, n_{j^*})_{c > \zeta_1}.$$

where $\lambda^* = \sqrt{\frac{(v_h - v_l)^2}{2\zeta_4(v_h - v_l) - b^2}}$. For $c < \zeta_4$ the strategy to build expertise dominates the default option of maintaining the initial expertise level.

Altogether, the equilibrium features the following probability of the central dealer being informed for a given transaction. If the benefits from trade are substantially large, i.e. $b \geq \alpha(\underline{\lambda})(v_h - v_l)$, then:

$$\lambda^* = \begin{cases} 1 & \text{if} \quad c \leq \zeta_1, \\ \sqrt{\frac{(v_h - v_l)^2}{2c(v_h - v_l) - b^2}} & \text{if} \quad \zeta_1 < c \leq \min(\zeta_3, \zeta_4), \\ \underline{\lambda} & \text{if} \quad c > \min(\zeta_3, \zeta_4). \end{cases} \tag{A28}$$

Otherwise, when the benefits from trade are small relative to the potential adverse selection, i.e. $b < \alpha(\underline{\lambda})(v_h - v_l)$, then:

$$\lambda^* = \begin{cases} 1 & \text{if} \quad c \leq \zeta_2, \\ \underline{\lambda} & \text{if} \quad c > \zeta_2. \end{cases} \tag{A29}$$

□

Proof of Proposition 4: From Corollary 1 we know that independent investors prefer to trade with a dealer with the smallest λ_{j^*}, thereby maximizing the likelihood of trading with an uninformed dealer. Since λ_{j^*} is weakly decreasing in c_{j^*} according to Proposition 3, the higher the cost of acquiring expertise is for the dealer, the lower is the equilibrium level of informativeness of the central dealer. Hence, independent investors are better off if the central dealer is the dealer j with the highest c_j. □

Proof of Proposition 5: Consider a dealer j that receives $\frac{N}{L}$ trades from independent investors and does not acquire additional expertise, i.e., $k_j = \underline{k}$. Then:

$$\lambda_j = \min\left(\frac{\underline{k}}{\underline{n} + \frac{N}{L}}, 1\right) = 1. \tag{A30}$$

Moreover, $\lambda_i = 1$ for all dealers. Hence, if an independent investor were to switch from dealer j to dealer j', dealer j''s probability of being informed would be:

$$\lambda_{j'} = \min\left(\frac{\underline{k}}{\underline{n} + \frac{N}{L} + 1}, 1\right). \tag{A31}$$

Hence, there is no incentive for any of the independent investors to deviate away from the current choice of dealers. Therefore, $k_j = \underline{k}$ for all j and independent investors allocating evenly their order flow among dealers is an equilibrium. □

Proof of Corollary 2: Before the increase in N, the equilibrium was consistent with Proposition 5, which means that all investors were trading with a fully informed dealer, i.e., $\lambda_j = 1$ for all j. After the increase in N, Proposition 3 states that for a central dealer j^* that receives all independent investors' order flow, we have $\lambda_{j^*} < 1$ as long as either $b \geq \alpha(\underline{\lambda})(v_h - v_l)$ and $c > \zeta_1$ or $b < \alpha(\underline{\lambda})(v_h - v_l)$ and $c > \zeta_2$. Hence, independent investors benefit from a liberalization of OTC that reduces their dealer's probability of being informed. Otherwise, we still have that $\lambda_{j^*} = 1$ for the central dealer and $\lambda_j = \min\left(\frac{\underline{k}}{\underline{n}}, 1\right) = 1$ for all other dealers, thus none of the incumbent investors is made better off. □

B Analysis of Trading Stage when Roles are Reversed

In this Appendix, we show that the trading stage evolves in a symmetric manner when a prospective buyer is assumed to be informed with probability λ and an uninformed seller makes a take-it-or-leave-it offer instead of what we assume in the baseline analysis.

New, when quoting a price P, the seller believes that the buyer has an informational advantage about v with probability λ. Specifically, with probability λ the buyer is endowed with a private signal $s \in [v_l, v_h]$ about the asset's value v, such that $E(v|s) = s$ and $s \sim U[v_l, v_h]$.

When deciding which price P to quote, the prospective seller faces the following tradeoff.

Quoting a lower price means that the seller is more likely to sell the asset and realize the gains to trade b. However, quoting a lower price means that conditional on selling the asset, the seller shares more of its surplus with the buyer.

For any $P \leq \mu$, the seller receives a surplus of $P - \mu + b$ when the buyer does not have an informational advantage about the value of the asset. When the buyer has an informational advantage, however, trade only takes place if the buyer's signal is weakly above the quoted price, i.e., if $s \geq P$. Overall, the seller's expected surplus from quoting a price $P \in [v_l, v_h]$ is:

$$\Pi(\lambda, b, P) \equiv \begin{cases} (1-\lambda)\left(P - \mu + b\right) + \lambda\left(\frac{v_h - P}{v_h - v_l}\right)\left(b - \frac{v_h - P}{2}\right) & \text{if } P \leq \mu, \\ \lambda\left(\frac{v_h - P}{v_h - v_l}\right)\left(b - \frac{v_h - P}{2}\right) & \text{if } P > \mu. \end{cases} \tag{B1}$$

A seller never finds it optimal to quote either $P < v_l$ (which is dominated by quoting $P = v_l$) or $P > v_h$ (which is dominated by quoting $P \to v_h^-$). We can now characterize the seller's optimal quoting strategy when facing a dealer with expertise λ.

Proposition 6. *In equilibrium, the seller quotes the price:*

$$P^* = \begin{cases} v_l & \textit{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ v_h - b + \frac{1-\lambda}{\lambda}(v_h - v_l) & \textit{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ \mu & \textit{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ v_h - b & \textit{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l), \end{cases} \tag{B2}$$

where $\beta(\lambda) = \frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}$. *Moreover,* $\frac{\partial P^*}{\partial \lambda} \leq 0$ *and* $\frac{\partial P^*}{\partial b} \leq 0$.

Proof. The first-order condition from the seller's surplus optimization problem is:

$$\frac{\partial \Pi(\lambda, b, P)}{\partial P} = \begin{cases} (1-\lambda) + \frac{\lambda}{v_h - v_l}(v_h - P - b) = 0 & \text{if } P \in [v_l, \mu], \\ \frac{\lambda}{v_h - v_l}(v_h - P - b) = 0 & \text{if } P \in (\mu, v_h]. \end{cases} \tag{B3}$$

The second-order condition for either of these cases is satisfied since:

$$\frac{\partial^2 \Pi(\lambda, b, P)}{\partial P^2} = -\frac{\lambda}{v_h - v_l} < 0. \tag{B4}$$

The first-order condition identifies the optimal price to quote within the respective regions $P \in (\mu, v_h]$ and $P \in [v_l, \mu]$. Yet, since the objective function has a discontinuity at $P = \mu$, we need to account for the possibility that the solution to the first-order condition in Equation (B3) for $P > \mu$ is dominated by $P = \mu$. We show below that when $b < \frac{1}{2}\beta(\lambda)(v_h - v_l)$ where $\beta(\lambda) = \frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}$, the strategy to quote $P = v_h - b$ dominates quoting $P = \mu$.

As a result, the seller's optimal price-quoting strategy can be written as:

$$P^* = \begin{cases} v_l & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ v_h - b + \frac{1-\lambda}{\lambda}(v_h - v_l) & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ \mu & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ v_h - b & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l), \end{cases} \tag{B5}$$

Moreover, the equilibrium price-quoting strategy satisfies the following properties:

$$\frac{\partial P^*}{\partial \lambda} = \begin{cases} 0 & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ -\frac{1}{\lambda^2}(v_h - v_l) & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ 0 & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ 0 & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l), \end{cases} \tag{B6}$$

and:

$$\frac{\partial P^*}{\partial b} = \begin{cases} 0 & \text{if } b \geq \frac{1}{\lambda}(v_h - v_l), \\ -1 & \text{if } \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l), \\ 0 & \text{if } \frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l), \\ -1 & \text{if } b < \frac{1}{2}\beta(\lambda)(v_h - v_l). \end{cases} \tag{B7}$$

□

The solution for P^* allows for four cases, which are the analogues of the four cases in the baseline analysis.

The next corollary establishes that in the most interesting parameter region where the seller targets the uninformed buyer as well as a subset of the informed buyer types, the seller is made better off by being paired with a buyer who is less likely to be informed about the asset being traded.

Corollary 3. *If $\frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l)$, the seller's expected surplus Π is decreasing in the probability λ that the seller is informed about the asset. If $b \geq \frac{1}{\lambda}(v_h - v_l)$, the seller's expected surplus Π is unaffected by λ. If $b < \frac{1}{2}\beta(\lambda)(v_h - v_l)$, the seller's expected surplus Π is increasing in λ.*

Proof. We first write:

$$\frac{\partial \Pi(\lambda, b, P^*(\lambda))}{\partial \lambda} = \frac{\partial \Pi(\lambda, b, P)}{\partial \lambda}|_{P=P^*} + \frac{\partial \Pi(\lambda, b, P)}{\partial P}|_{P=P^*} \cdot \frac{\partial P^*(\lambda)}{\partial \lambda}. \tag{B8}$$

From the proof of Proposition 6, we know that $\frac{\partial P^*(\lambda)}{\partial \lambda} = 0$ unless $\left(\frac{2-\lambda}{2\lambda}\right)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l)$. Moreover, in that particular region, the price P^* is chosen to satisfy the seller's first-order condition: $\frac{\partial \Pi(\lambda,b,P)}{\partial P}|_{P=P^*} = 0$. Thus:

$$\frac{\partial \Pi(\lambda, b, P^*(\lambda))}{\partial \lambda} = \frac{\partial \Pi(\lambda, b, P)}{\partial \lambda}|_{P=P^*}. \tag{B9}$$

As a result, Equation (B1) can be used to derive that:

$$\frac{\partial \Pi(\lambda, b, P^*(\lambda))}{\partial \lambda} = \begin{cases} -\frac{1}{2(v_h - v_l)}(P^* - v_l)[P^* - (v_l - 2b)] & \text{if } P^* \leq \mu, \\ \left(\frac{v_h - P^*}{v_h - v_l}\right)\left(b - \frac{v_h - P^*}{2}\right) & \text{if } P^* > \mu. \end{cases} \tag{B10}$$

From Proposition 6, $P^* \geq v_l$ for any value of b and as a result, $\frac{\partial \Pi(\lambda,b,P^*(\lambda))}{\partial \lambda} = 0$ if $b \geq \frac{1}{\lambda}(v_h - v_l)$, $\frac{\partial \Pi(\lambda,b,P^*(\lambda))}{\partial \lambda} < 0$ if $\frac{1}{2}\beta(\lambda)(v_h - v_l) \leq b < \frac{1}{\lambda}(v_h - v_l)$ and $\frac{\partial \Pi(\lambda,b,P^*(\lambda))}{\partial \lambda} > 0$ if $b < \frac{1}{2}\beta(\lambda)(v_h - v_l)$. $\square$

Corollary 3 shows that, in cases analogous to those in the baseline analysis, an investor weakly prefers being matched to a counterparty that is less likely to be informed about the asset being traded. Imposing Assumption 1 is once again sufficient to allow our analysis to zoom in on this more natural case.

B.1 Derivation of $\beta(\lambda)$ in Proposition 6

In order to establish Proposition 6, we must account for how the seller's surplus is affected by the discontinuity at $P = \mu$. In particular, we need to derive conditions under which the optimal price-quoting strategy is $P^* = v_h - b$ rather than $P = \mu$, and vice-versa.

The seller's optimal price-quoting strategy is $P^* = v_h - b$ whenever $\Pi(\lambda, b, v_h - b) > \Pi(\lambda, b, \mu)$ and $v_h - b > \mu$. Define:

$$\begin{aligned} J(\lambda, b) \equiv \Pi(\lambda, b, v_h - b) - \Pi(\lambda, b, \mu) &= \frac{\lambda}{2} \frac{b^2}{v_h - v_l} - (1-\lambda)b - \frac{\lambda}{2}\left(b - \frac{1}{4}(v_h - v_l)\right) \\ &= \frac{\lambda}{2(v_h - v_l)} \left[b^2 - \left(\frac{2}{\lambda} - 1\right)(v_h - v_l)b + \frac{1}{4}(v_h - v_l)^2\right]. \end{aligned} \tag{B11}$$

$J(\lambda, b)$ measures the difference in the seller's surplus between quoting a price above the unconditional expected value of the asset and quoting a price equal to the unconditional expected value. While quoting a higher price for the asset is best conditional on trading occurring at that price, the advantage of quoting μ is that it convinces uninformed buyer to buy the asset. When the buyer is never uninformed, however, quoting $P = v_h - b$ weakly dominates quoting $P = \mu$, that is, $J(1, b) = \frac{1}{2} \frac{1}{v_h - v_l} \left(b - \frac{v_h - v_l}{2}\right)^2 \geq 0$. Moreover:

$$\frac{\partial J(\lambda, b)}{\partial \lambda} = \frac{b^2}{2(v_h - v_l)} + \frac{b}{2} + \frac{1}{8}(v_h - v_l) > 0. \tag{B12}$$

Therefore, we know that for $0 < \lambda < 1$ the equation $J(\lambda, b) = 0$ has two roots in b, which we denote by b_1 and b_2, such that $b_1 < b_2$. The fact that $\frac{\partial^2 J(\lambda, b)}{\partial b^2} = \frac{\lambda}{v_h - v_l} > 0$ implies that the function J is convex in b for any $\lambda \in (0, 1)$. Hence, $J(\lambda, b) > 0$ for $b < b_1$ and for $b > b_2$. We can now use the standard formula for the roots of a quadratic equation and identify:

$$b_1 = \frac{1}{2}\left(\frac{2}{\lambda} - 1 - \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}\right)(v_h - v_l) \equiv \frac{1}{2}\beta(\lambda)(v_h - v_l), \tag{B13}$$

$$b_2 = \frac{1}{2}\left(\frac{2}{\lambda} - 1 + \sqrt{\left(\frac{2}{\lambda} - 1\right)^2 - 1}\right)(v_h - v_l). \tag{B14}$$

Hence, $J(\lambda, b) > 0$ for $b < b_1$ and for $b > b_2$. Yet, $b_2 > \frac{1}{2}(v_h - v_l)$, which means that the b values in the interval $b > b_2$ are inconsistent with quoting $P = v_h - b$ being optimal since the latter is only valid for $v_h - b > \mu$, i.e., for $b < \frac{1}{2}(v_h - v_l)$. Hence, only $b < b_1$ is a relevant set of b values for which $J(\lambda, b) > 0$ and, therefore, $P^* = v_h - b$ is the optimal strategy.

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