Can Decentralized Markets be More Efficient?

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Decentralized markets are often characterized as opaque and prone to trade delays, leading to the perception that they are less efficient than standard centralized limit order markets. We show that in the presence of information asymmetries decentralized markets can promote higher trade efficiency than centralized limit order markets through at least two channels. First, screening behavior may be more aggressive and inefficient in centralized markets as sellers face multiple competing buyers simultaneously. Second, when these buyers compete among themselves for the asset, they have lower incentives to acquire information about common and private valuations for the asset. In asset classes where information acquisition is required to improve allocative efficiency, decentralized markets may thus dominate as predictable trading interactions and exclusive trading terms encourage information acquisition. The opposite is, however, true when private information merely induces adverse selection. (JEL D82, G23, L10)

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1 Introduction

Many real and financial assets are traded primarily in decentralized markets — real estate, consumer durable goods, foreign exchange instruments, interest-rate derivatives, and municipal and corporate bonds, to name only a few. Interestingly the prevalence of over-the-counter markets is not restricted to assets that are non-standardized or have low trading volume: according to the Securities Industry and Financial Markets Association and the Bank of International Settlements, *daily* volume reaches on average \$5.4T in the global foreign exchange market, \$2.3B in the U.S. interest-rate derivative market, and \$0.8T in the U.S. bond market.

Despite their size, these decentralized markets are commonly thought of as opaque and illiquid compared to centralized exchanges that are the primary trading venues for assets like stocks. Many commentators and policy makers have even blamed decentralized trading for exacerbating the recent financial crisis and suggested significant reforms.[1] Clearly, most assets currently traded over-the-counter *could* in principle be traded in centralized venues instead. In many cases, investors even have the option to trade in a centralized venue but decide not to. In addition, from a technological perspective, exchanges should incur low marginal cost from listing additional securities. Why would agents trade large quantities of certain assets using "inferior" decentralized technologies (e.g., phone calls) but prefer to trade other assets in centralized markets? This paper attempts to shed light on the popularity of decentralized markets by investigating the efficiency of (de)centralized trade when agents may have private information about asset values. Our model identifies specific situations for which decentralized trading socially dominates centralized trading, as well as situations for which the opposite is true. In particular, we show that moving assets currently traded in decentralized venues toward centralized venues may impede the efficiency of trade by lowering the incentives to acquire information and increasing the incentives to screen counterparties.

Our model features the owner of an asset (or good) who can sell the asset to two potential buyers (or customers) and realize exogenous, but potentially uncertain, gains to trade. When the market is decentralized, the seller first contacts one buyer and quotes him a price. If the buyer rejects the offer, the seller searches for a second buyer, and, provided he finds one, quotes him a potentially different price. This search for the second buyer may, however, delay the realization of the trade surplus. When the market is centralized instead,

[1] For specific examples, see "Implementing the Dodd-Frank Act," a speech given by U.S. CFTC's chairman Gary Gensler in January 2011, "Comparing G-20 Reform of the Over-the-Counter Derivatives Markets," a Congressional Report prepared by James K. Jackson and Rena S. Miller in February 2013, or "Canadian regulators push toward more transparency, oversight for huge fixed income market" by Barbara Shecter in the September 17, 2015 issue of the Financial Post.

search is not necessary: the seller posts a limit order and the two buyers simultaneously decide whether to pick up the order. We first compare the social efficiency of trade in these two types of market assuming that traders' information sets are independent of the market structure. Then, we perform a similar analysis but allow traders to choose how much information to acquire.

When delays in trade lead to the loss of trade surplus and the market structure does not change buyers' information acquisition nor the seller's pricing strategies, centralized trade socially dominates decentralized trade. However, decentralizing trade can incentivize traders to change their behaviors in ways that are socially beneficial. First, since centralized trade makes it more likely that a high price quote will be accepted quickly by at least one buyer, a seller may choose a more aggressive trading strategy in a centralized market than in a decentralized market — the seller then screens the privately informed buyer(s), inefficiently destroying gains to trade. Search frictions that exist in decentralized markets and lead to trade delays can thus reduce inefficient screening in the presence of information asymmetries, contrasting with the predictions of search-based models where traders are symmetrically informed like in Duffie, Gârleanu, and Pedersen (2005). Moreover, search frictions in decentralized markets in combination with sequential offers imply the exclusivity of the terms of trade. This exclusivity allows a contacted buyer to profit more from his private information, providing stronger incentives to invest in information acquisition in the first place. When information acquisition is required to ensure allocative efficiency, such behavior is efficient. We thus show that decentralized markets tend to socially dominate centralized markets if information acquisition is socially valuable. The opposite is, however, true if information only improves traders' rent-seeking ability in a zero-sum trading game, thus impeding trade due to adverse selection.

Our paper differs from the related market microstructure literature in several ways. First, our model focuses on the role of information asymmetries, rather than liquidity externalities (Admati and Pfleiderer 1988, Grossman and Miller 1988, Pagano 1989), monopoly power and order size (Viswanathan and Wang 2002), and counterparty risk (Duffie and Zhu 2011, Acharya and Bisin 2014), in determining the costs and benefits of (de)centralized trade. Second, unlike in Grossman (1992) where it is assumed that the upstairs (i.e., decentralized) market features dealers who possess information about unexpressed demand that is not available to the traders in the downstairs (i.e., centralized) market, our analysis compares the efficiency of decentralized and centralized markets both when traders' information is exogenous and stays the same across market structures and when traders' information is endogenous to the market structure. Third, our focus on the social efficiency of trade distinguishes our paper from Kirilenko (2000) who studies the choice of a trading arrangement (one-shot batch auction vs. continuous dealer market) by an authority trying to maximize price discovery in the context of emerging foreign exchange markets.

The idea that decentralized markets allow traders to reach various potential counterparties in a sequential/exclusive manner while centralized markets allow traders to reach all potential counterparties in a simultaneous/competitive manner also relates our paper to Seppi (1990), Bulow and Klemperer (2009), and Zhu (2012). Seppi (1990) studies the existence of dynamic equilibria where a trader prefers to submit a large order to a dealer than a sequence of small market orders to an exchange. Central to this result is the assumption that the dealer knows the identity of his counterparties, which allows for the implementation of dynamic commitments not possible in anonymous centralized markets. In Bulow and Klemperer (2009), potential buyers can enter the market and bid on the asset sold by an informed seller only if they pay a cost. Paying this cost is, however, also associated with receiving an informative signal about the value of the asset. Hence, unlike in our model all agents trying to buy the asset in their model are informed. The main result in Bulow and Klemperer (2009) thus differ greatly from ours: in their model, sequential entry and bidding socially dominates simultaneous bidding through an auction, regardless of whether the uncertainty is in common or private values. Like us, Zhu (2012) models decentralized trading as a sequence of ultimatum offers to multiple counterparties. However, his focus is on the impact that repeated contacts have on the dynamics of trade. In our model, each potential counterparty can only be contacted once, hence, the "ringing phone curse" that is central in Zhu (2012) plays no role in our results. Moreover, unlike in Seppi (1990) and Zhu (2012) where traders' information is exogenously given, our paper studies how traders' incentives to acquire information depend on the market structure, and how this endogeneity of information affects social efficiency.

Although our economic environment differs from theirs, the way we model both market structures in the current paper is reminiscent of Glosten and Milgrom (1985) and Glosten (1989) where an uninformed liquidity provider quotes ultimatum prices to several potentially informed traders. In Glosten and Milgrom (1985) and Glosten (1989), these traders arrive one at a time in a random order and each must choose whether to accept the terms of trade posted by the liquidity provider before a new trader arrives. In contrast, in our paper we alter traders' arrival process to differentiate the types of market in which traders operate. In our centralized market, all traders arrive at the same time and the "liquidity provider" (i.e., uninformed seller) quotes them an ultimatum price. This particular trading protocol is also how Jovanovic and Menkveld (2015) model their limit order market (except when they allow for the presence of high-frequency middlemen). The fact that multiple traders must simultaneously respond to the liquidity provider's quote affects their incentives to acquire information, relative to the decentralized market. In our decentralized market, traders instead arrive sequentially and the liquidity provider quotes terms of trade that are exclusive to the counterparty he is facing at the time. The delay in trader arrival and, possibly, in the realization of the trade surplus (due to search frictions and/or immediacy concerns) imposes a social cost, relative to the centralized market. Finally, we assume as in Glosten (1989) that the liquidity provider is a monopolist — his incentives to inefficiently screen privately informed counterparties will play a key role in determining the optimal market structure in our model.

2 Model

The owner of an asset considers selling it to one of two potential buyers. Each agent i values the asset as the sum of two components: $v_i = v + b_i$. The common value component v matters to all traders and is distributed as $v \in \{\bar{v} - \sigma_v, \bar{v} + \sigma_v\}$ with equal probabilities. The private value component b_i is independent for each trader i. It is assumed to be zero for the seller while it takes a value $b_i \in \{\Delta - \sigma_b, \Delta + \sigma_b\}$ with equal probabilities for each buyer i. In expectation, moving the asset from the seller to a buyer creates a social surplus of $E[b_i] = \Delta > 0$.

Agents are asymmetrically informed about the value of the asset. To eliminate the possibility of multiple equilibria due to potential signaling games, we assume the seller of the asset only knows the ex-ante distributions for v and b_i when he tries to sell the asset. Each buyer i is, however, assumed to have private information about his own realization of v_i with probability $\pi \in (0, 1)$ when deciding whether to buy the asset.

Throughout the paper, we will compare the social welfare and the owner's profit from selling the asset in two types of market. In a centralized market, the seller posts a price that can be accepted by any of the two potential buyers. If both buyers accept to pay the posted price, then one buyer is randomly chosen to participate in the trade. In a decentralized market, the seller quotes a price exclusively to the first buyer. If this price is accepted, trade occurs at that price, but if it is rejected, the seller moves on to the second buyer. This delay in the timing of the trade can, however, be socially costly. We model this cost by assuming that, once the first price has been rejected, contacting a second buyer who can help realize the surplus from trade is possible only with probability ρ. This reduction in surplus can capture any search friction that makes locating a second buyer costly (Ashcraft and Duffie 2007, Green, Hollifield, and Schürhoff 2007, Feldhütter 2012), but it can also be interpreted as the result of traders' immediacy or liquidity concerns (Grossman and Miller 1988, Chacko, Jurek, and Stafford 2008, Nagel 2012). If trade fails with both buyers, the seller is confined to keeping the asset and the surplus from trade is lost. Buyers' position in the seller's network (i.e., as first or second buyer) is assumed to be known to all agents, which allows our model to capture the persistence and predictability in OTC interactions documented by Li and Schürhoff (2014) and Hendershott et al. (2015).

Assuming sequential and exclusive ultimatum offers in the decentralized market simplifies the analysis of equilibrium bidding strategies and is consistent with the characterization of inter-dealer trading in financial markets by Viswanathan and Wang (2004, p.3) as "very quick interactions". Ultimatum offers are also consistent with how Duffie (2012, p.2) describes the typical negotiation process in OTC markets and the notion that each OTC dealer tries to maintain "a reputation for standing firm on its original quotes." In the centralized market, these ultimatum price quotes can be interpreted as limit orders that all buyers can choose to execute or not (Jovanovic and Menkveld 2015). The common problem plaguing both markets is that the seller may use his market power to screen his privately informed counterparties, at the cost of probabilistically destroying gains to trade.

In this paper, we focus on two specific cases regarding the uncertainty in asset values: a case where σ_b is large and $\sigma_v = 0$ and another case where σ_v is large and $\sigma_b = 0$. Focusing on these two cases allows us to highlight how uncertainty in private valuations b_i and in the common value v differently affect the optimality of a market structure. An appropriate benchmark case in our model is one where $\sigma_v \to 0$ and $\sigma_b \to 0$. Both buyers are then always willing to pay at least $\bar{v} - \sigma_v + \Delta - \sigma_b$ for the asset. However, the seller can also quote prices higher than $p = \bar{v} - \sigma_v + \Delta - \sigma_b$ but the upside of collecting these prices is at most $\sigma_v + \sigma_b$, which is too small to justify the discrete drops in the probability of acceptance and in the surplus from trade. The seller thus finds it optimal to quote a price $p = \bar{v} - \sigma_v + \Delta - \sigma_b$ that is accepted with probability 1, regardless of whether he is contacting the two buyers simultaneously (i.e., in a centralized market) or sequentially (i.e., in a decentralized market). The expected surplus generated by trade is then Δ in both types of market.

3 Asymmetric Information about Private Values

In this section, we study the case where σ_v is small (i.e., $\sigma_v = 0$) and equilibrium trading outcomes are driven by the mean and the volatility of buyers' private valuations (i.e., Δ and σ_b). Moreover, we assume that the uncertainty in private valuations is large enough to have $\sigma_b \geq \Delta$, meaning that trading the asset from the seller to the buyer does not always create a social surplus. This case can thus shed light on the optimal market structure for securities like highly rated municipal and corporate bonds or foreign-exchange and interest-rate derivatives that are primarily traded for hedging purposes.

3.1 Centralized Market

We first consider a market where the seller posts a price that can be accepted by any of the two buyers. If both buyers are willing to pay the posted price, then one of them is randomly chosen to participate in the trade.

The highest price that has a positive probability of being accepted is $p = \bar{v} + \Delta + \sigma_b$. This price is accepted only if at least one of the buyers is informed and values the asset at $v_i = \bar{v} + \Delta + \sigma_b$, which occurs with probability $\frac{3}{4}\pi^2 + \pi(1-\pi)$. By quoting this price, the seller collects an expected payoff of:

$$\left[\frac{3}{4}\pi^2 + \pi(1-\pi)\right](\bar{v} + \Delta + \sigma_b) + \left[1 - \frac{3}{4}\pi^2 - \pi(1-\pi)\right]\bar{v} = \bar{v} + \pi\left(1 - \frac{\pi}{4}\right)(\Delta + \sigma_b). \tag{1}$$

The seller may also consider quoting a price $p = \bar{v} + \Delta$, which is low enough to be accepted by buyers who do not have private information about their v_i. An informed buyer accepts a price $p = \bar{v} + \Delta$ only when he knows that his own $v_i = \bar{v} + \Delta + \sigma_b$. Since $\sigma_v = 0$ and buyers only condition their trading decision on a private value component, each buyer does not have to protect himself against the private information of the other buyer. (Later, when we look at cases where $\sigma_v > 0$, adverse selection among buyers will affect trading outcomes.) By quoting a price $p = \bar{v} + \Delta$, the seller collects an expected payoff of:

$$\left[\frac{3}{4}\pi^2 + 2\pi(1-\pi) + (1-\pi)^2\right](\bar{v} + \Delta) + \left[1 - \frac{3}{4}\pi^2 - 2\pi(1-\pi) - (1-\pi)^2\right]\bar{v} = \bar{v} + \left(1 - \frac{\pi^2}{4}\right)\Delta. \tag{2}$$

Finally, the seller may consider quoting a price $p = \bar{v} + \Delta - \sigma_b$, which is accepted by all buyers, but quoting this price is dominated by keeping the asset which in expectation is worth $\bar{v}$ to him. Keeping the asset is, in turn, dominated by quoting either $p = \bar{v} + \Delta + \sigma_b$ or $p = \bar{v} + \Delta$.

The seller thus quotes the price $p = \bar{v} + \Delta$ whenever:

$$\begin{aligned} \bar{v} + \left(1 - \frac{\pi^2}{4}\right)\Delta &\geq \bar{v} + \pi\left(1 - \frac{\pi}{4}\right)(\Delta + \sigma_b) \\ \Leftrightarrow \frac{\Delta}{\sigma_b} &\geq \left(1 - \frac{\pi}{4}\right)\left(\frac{\pi}{1-\pi}\right), \end{aligned} \tag{3}$$

and in such case, the social surplus from trade is $\left(1 + \frac{\pi}{2}\right)\left[\left(1 - \frac{\pi}{2}\right)\Delta + \frac{\pi}{2}\sigma_b\right]$. Otherwise, the seller quotes the high price $p = \bar{v} + \Delta + \sigma_b$ and the social surplus from trade is $\pi\left(1 - \frac{\pi}{4}\right)(\Delta + \sigma_b)$. Since the buyers' valuations are uncertain, the seller must make a price concession to encourage less informed traders to buy the asset. This price concession also leaves rents for any informed buyer who decides to buy the asset. When the expected surplus from trade (Δ) is large, the seller is willing to make this price concession. However, when the uncertainty in the surplus from trade (σ_b) is large, the price concession needed is too high and the seller prefers to quote a higher price to screen informed buyers. This "aggressive" trading strategy eliminates the rents going to informed buyers and destroys the surplus from trade with a higher probability.

From a social standpoint, the surplus from trade is greater if the seller quotes the low price $p = \bar{v} + \Delta$ than the high price $p = \bar{v} + \Delta + \sigma_b$ whenever:

$$\begin{aligned} \left(1 + \frac{\pi}{2}\right)\left[\left(1 - \frac{\pi}{2}\right)\Delta + \frac{\pi}{2}\sigma_b\right] &> \pi\left(1 - \frac{\pi}{4}\right)(\Delta + \sigma_b) \\ \Leftrightarrow \frac{\Delta}{\sigma_b} &> \frac{1}{2}\left(\frac{\pi}{1-\pi}\right). \end{aligned} \tag{4}$$

Hence, in the region where $\frac{1}{2}\left(\frac{\pi}{1-\pi}\right) < \frac{\Delta}{\sigma_b} < \left(1 - \frac{\pi}{4}\right)\left(\frac{\pi}{1-\pi}\right)$, the seller quotes a socially inefficient, high price.

3.2 Decentralized Market

We now consider an alternative market structure where the seller quotes a price to a first buyer and if this price is rejected, he tries to contact a second buyer. If trade is delayed due to the first buyer's rejection however, the surplus from trade disappears with probability $1 - \rho$ (or equivalently, the second buyer cannot be found). Hence, only with probability ρ can the seller successfully contacts the second buyer and quote him an ultimatum price, just like he did with the first buyer. If trade fails with both buyers, the seller is confined to keeping the asset and the surplus from trade is lost. Buyers' order in the seller's trading sequence is assumed to be known to all agents.

Since $\sigma_v = 0$ in this section, a rejection by the first buyer is only informative about the private valuation of the first buyer, or about the fact that he is uninformed. With probability ρ, the seller then quotes the second buyer one of the following prices: $p = \bar{v} + \Delta + \sigma_b$, $p = \bar{v} + \Delta$, or $p = \bar{v} + \Delta - \sigma_b$. With probability $(1 - \rho)$, the surplus from trade disappears and the seller retains the asset, which is worth $\bar{v}$ to him.

By quoting the high price $p = \bar{v} + \Delta + \sigma_b$ to the second buyer, the seller collects an expected payoff of:

$$\frac{\pi}{2}(\bar{v} + \Delta + \sigma_b) + \left(1 - \frac{\pi}{2}\right)\bar{v} = \bar{v} + \frac{\pi}{2}(\Delta + \sigma_b). \tag{5}$$

The seller may instead quote a price $p = \bar{v} + \Delta$, which is low enough to be accepted by a second buyer who does not have private information about his v_i. By quoting this price, the seller collects an expected payoff of:

$$\left[\frac{\pi}{2} + (1 - \pi)\right](\bar{v} + \Delta) + \frac{\pi}{2}\bar{v} = \bar{v} + \left(1 - \frac{\pi}{2}\right)\Delta. \tag{6}$$

Finally, the seller may quote a price $p = \bar{v} + \Delta - \sigma_b$, which is always accepted by the second buyer, but quoting this price is dominated by keeping the asset which in expectation is worth $\bar{v}$ to him. Keeping the asset is, in turn, dominated by quoting the high price $p = \bar{v} + \Delta + \sigma_b$. The seller thus quotes the price $p = \bar{v} + \Delta$ to the second buyer whenever:

$$\begin{aligned} \bar{v} + \left(1 - \frac{\pi}{2}\right)\Delta &\geq \bar{v} + \frac{\pi}{2}(\Delta + \sigma_b) \\ \Leftrightarrow \frac{\Delta}{\sigma_b} &\geq \frac{1}{2}\left(\frac{\pi}{1 - \pi}\right), \end{aligned} \tag{7}$$

otherwise he quotes the high price $p = \bar{v} + \Delta + \sigma_b$.

When choosing a price to quote to the second buyer, the seller picks the price that maximizes his expected payoff. We denote the seller's maximal payoff from trade conditional on the first buyer rejecting the first price quote as $\bar{v} + \rho W^*$, where $W^* \equiv \max\{\frac{\pi}{2}(\Delta + \sigma_b), \left(1 - \frac{\pi}{2}\right)\Delta\}$. Knowing that he can still collect $\bar{v} + \rho W^*$ in expectation if his first price quote is rejected, the seller can quote a price $p = \bar{v} + \Delta + \sigma_b$ to the first buyer and collect:

$$\frac{\pi}{2}(\bar{v} + \Delta + \sigma_b) + \left(1 - \frac{\pi}{2}\right)(\bar{v} + \rho W^*) = \bar{v} + \frac{\pi}{2}(\Delta + \sigma_b) + \left(1 - \frac{\pi}{2}\right)\rho W^*. \tag{8}$$

The seller may instead quote a price $p = \bar{v} + \Delta$ to the first buyer and collect:

$$\left[\frac{\pi}{2} + (1-\pi)\right](\bar{v} + \Delta) + \frac{\pi}{2}(\bar{v} + \rho W^*) = \bar{v} + \left(1 - \frac{\pi}{2}\right)\Delta + \frac{\pi}{2}\rho W^*. \tag{9}$$

Finally, the seller may quote a price $p = \bar{v} + \Delta - \sigma_b$, which is always accepted by the first buyer, but quoting this price is dominated by keeping the asset which in expectation is worth $\bar{v}$ to him. As before, keeping the asset is, in turn, dominated by quoting either $p = \bar{v} + \Delta + \sigma_b$ or $p = \bar{v} + \Delta$.

The seller thus quotes the price $p = \bar{v} + \Delta$ to the first buyer whenever:

$$\begin{aligned} \bar{v} + \left(1 - \frac{\pi}{2}\right)\Delta + \frac{\pi}{2}\rho W^* &\geq \bar{v} + \frac{\pi}{2}(\Delta + \sigma_b) + \left(1 - \frac{\pi}{2}\right)\rho W^* \\ \Leftrightarrow \frac{\Delta}{\sigma_b} &\geq \frac{\rho W^*}{\sigma_b} + \frac{1}{2}\left(\frac{\pi}{1-\pi}\right), \end{aligned} \tag{10}$$

otherwise he quotes the high price $p = \bar{v} + \Delta + \sigma_b$. Since $W^* > 0$, we know that this inequality is strictly more restrictive than condition (7), which means that if the seller quotes $p = \bar{v} + \Delta$ to the first buyer, he will also quote $p = \bar{v} + \Delta$ if he contacts the second buyer.

Overall, we have three possible trading strategies for the seller. First, the seller quotes $p = \bar{v} + \Delta$ to both buyers whenever:

$$\begin{aligned} \frac{\Delta}{\sigma_b} &\geq \frac{\rho W^*}{\sigma_b} + \frac{1}{2}\left(\frac{\pi}{1-\pi}\right) \\ &= \left(1 - \frac{\pi}{2}\right)\rho\frac{\Delta}{\sigma_b} + \frac{1}{2}\left(\frac{\pi}{1-\pi}\right), \end{aligned} \tag{11}$$

which can be rewritten as:

$$\frac{\Delta}{\sigma_b} \geq \frac{1}{2}\left(\frac{1}{1-\rho+\frac{\rho\pi}{2}}\right)\left(\frac{\pi}{1-\pi}\right). \tag{12}$$

In such case, the social surplus from trade is $\left(1 + \frac{\rho\pi}{2}\right)\left[\left(1 - \frac{\pi}{2}\right)\Delta + \frac{\pi}{2}\sigma_b\right]$.

Second, the seller quotes $p = \bar{v} + \Delta + \sigma_b$ to the first buyer and $p = \bar{v} + \Delta$ to the second buyer when needed whenever:

$$\frac{1}{2}\left(\frac{\pi}{1-\pi}\right) \leq \frac{\Delta}{\sigma_b} < \frac{1}{2}\left(\frac{1}{1-\rho+\frac{\rho\pi}{2}}\right)\left(\frac{\pi}{1-\pi}\right), \tag{13}$$

and, in such case, the social surplus from trade is $\left[\frac{\pi}{2} + \rho\left(1 - \frac{\pi}{2}\right)^2\right]\Delta + \frac{\pi}{2}\left(1 + \rho - \frac{\rho\pi}{2}\right)\sigma_b$.

Third, the seller quotes $p = \bar{v} + \Delta + \sigma_b$ to both buyers whenever:

$$\frac{\Delta}{\sigma_b} < \frac{1}{2}\left(\frac{\pi}{1-\pi}\right), \tag{14}$$

and, in such case, the social surplus from trade is $\frac{\pi}{2}\left(1+\rho-\frac{\rho\pi}{2}\right)(\Delta+\sigma_b)$.

3.3 Optimal Market Structure

Now, we compare the social efficiency of trade across the different types of market.

We begin by considering the scenario where Δ is small enough relative to σ_b to have the seller quoting the same price $p = \bar{v} + \Delta + \sigma_b$ whether he is simultaneously trading with both buyers in the centralized market or sequentially trading with them in the decentralized market. For this to be the case, we need:

$$\frac{\Delta}{\sigma_b} < \left(\frac{\pi}{1-\pi}\right)\min\{\left(1-\frac{\pi}{4}\right), \frac{1}{2}\} = \frac{1}{2}\left(\frac{\pi}{1-\pi}\right). \tag{15}$$

If this condition is satisfied, the social surplus created by trade is $\pi\left(1-\frac{\pi}{4}\right)(\Delta+\sigma_b)$ in the centralized market and $\frac{\pi}{2}\left(1+\rho-\frac{\rho\pi}{2}\right)(\Delta+\sigma_b)$ in the decentralized market. The centralized market is socially optimal whenever:

$$\begin{aligned}
\pi\left(1-\frac{\pi}{4}\right)(\Delta+\sigma_b) &\geq \frac{\pi}{2}\left(1+\rho-\frac{\rho\pi}{2}\right)(\Delta+\sigma_b) \\
\Leftrightarrow 1-\frac{\pi}{4} &\geq \frac{1}{2}\left(1+\rho-\frac{\rho\pi}{2}\right) \\
\Leftrightarrow 1-\rho &\geq \frac{\pi}{2}(1-\rho),
\end{aligned} \tag{16}$$

which always holds and becomes a strict inequality when $\rho < 1$. The centralized market allows the seller to simultaneously quote the same high price to both buyers instead of sequentially contacting them. Thus, when the uncertainty in b_i is high relative to Δ and delaying trade is costly, the centralized market socially dominates the decentralized one.

At the other extreme, we consider the scenario where Δ is large enough relative to σ_b to have the seller quoting the same price $p = \bar{v} + \Delta$ whether he is simultaneously trading with both buyers in the centralized market or sequentially trading with them in the decentralized market. For this to be the case, we need:

$$\frac{\Delta}{\sigma_b} \geq \left(\frac{\pi}{1-\pi}\right) \max\{\left(1-\frac{\pi}{4}\right), \frac{1}{2}\left(\frac{1}{1-\rho+\frac{\rho\pi}{2}}\right)\}. \tag{17}$$

If this condition is satisfied, the social surplus created by trade is $\left(1+\frac{\pi}{2}\right)\left[\left(1-\frac{\pi}{2}\right)\Delta+\frac{\pi}{2}\sigma_b\right]$ in the centralized market and $\left(1+\frac{\rho\pi}{2}\right)\left[\left(1-\frac{\pi}{2}\right)\Delta+\frac{\pi}{2}\sigma_b\right]$ in the decentralized market. The centralized market is socially optimal whenever:

$$1+\frac{\pi}{2} \quad \geq \quad 1+\frac{\rho\pi}{2} \tag{18}$$

which always holds and becomes a strict inequality when $\rho < 1$. As in the earlier case, the centralized market allows the seller to simultaneously reach both buyers and when delaying trade is costly, a centralized market socially dominates a decentralized market.

The common feature in the two scenarios above is that the market structure does not change the type of buyers the seller targets with his price quotes. In such cases, simultaneous trade is socially better than sequential trade with a positive probability of a costly delay. Comparing the two types of market, however, yields different implications when we look at intermediate values for $\frac{\Delta}{\sigma_b}$, that is, when:

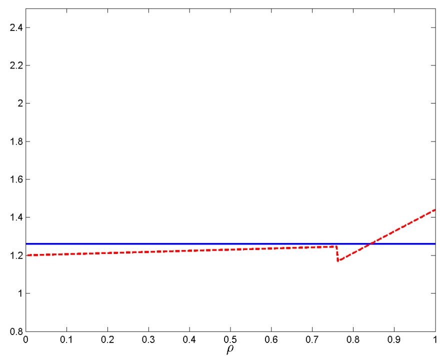
$$\frac{1}{2}\left(\frac{\pi}{1-\pi}\right) \leq \frac{\Delta}{\sigma_b} < \left(\frac{\pi}{1-\pi}\right) \max\{\left(1-\frac{\pi}{4}\right), \frac{1}{2}\left(\frac{1}{1-\rho+\frac{\rho\pi}{2}}\right)\}. \tag{19}$$

Unlike outside these bounds, we now have instances where the market structure influences the seller's pricing strategy and where decentralized trading socially dominates centralized trading. To see this, we set $\bar{v} = 100$, $\sigma_v = 0$, $\sigma_b = 10$, $\Delta = 1$, and $\pi = 0.1$. In a centralized market, the seller finds it optimal to quote a price $p = 111$ and collect a surplus of 1.0725 rather than quoting a price $p = 101$ and collecting a surplus of 0.9975. The social surplus from trade is then 1.0725 in the centralized market. The seller's optimal trading strategy in the decentralized market depends on the cost of delaying trade. In the current parameterization, the seller finds it optimal to quote the low price $p = 101$ to the second buyer rather than a high price $p = 111$. When $\rho = 1$ and the seller knows for sure that he will be able to contact the second buyer (delay is thus costless), he also prefers to quote a price $p = 111$ to the first buyer and collect a surplus of 1.4525 over quoting a price $p = 101$ and collecting a surplus of 0.9975. The social surplus is then 1.9275 in the decentralized market, which is higher than the surplus in the centralized market. Now when $\rho = 0.5$, the seller quotes a price $p = 111$ to the first buyer, but since delay is costly, the social surplus from trade drops to 1.23875. Finally, when $\rho = 0$, the seller quotes a price $p = 101$ to the first buyer and collect a surplus of 0.95 rather than quoting a price $p = 111$ and collecting a surplus of 0.55. The social surplus from trade is then 1.45 in the decentralized market, which is higher than the surplus in the centralized market.

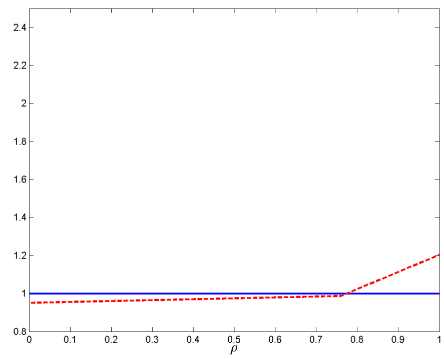
Note that this social surplus is also higher than the social surplus from the case where $\rho = 0.5$, suggesting that "opaque" decentralized markets (i.e., with lower ρ) may, under some circumstances, incentivize traders to behave in more socially efficient ways compared to more transparent decentralized markets or even centralized markets. This social benefit of opacity contrasts with the predictions from Duffie, Gârleanu, and Pedersen (2005), where search frictions unambiguously lower the efficiency of trade. In our model, the seller's trading strategy with the first buyer depends on the payoff he expects to collect if trade fails and he behaves less aggressively if the expected surplus available with the second buyer is low due to a high probability of the surplus vanishing when trade is delayed. This response by the seller is absent from Duffie, Gârleanu, and Pedersen (2005) where traders are symmetrically informed and the surplus from trade is split among them using Nash bargaining.

This relationship between ρ and the social surplus from trade is more broadly illustrated in Figure 1. Panels (c) and (d) set $\sigma_b = 10$ just as above and show that decentralized trading then socially dominates centralized trading for any value of ρ. When ρ is small, the seller quotes a low price to the first buyer to ensure that trade occurs with a higher probability. This trading strategy helps preserve a higher surplus from trade in the decentralized market than in the centralized market, where the seller quotes the socially inefficient, high price (see condition (4)). As ρ increases, however, the seller faces stronger incentives to quote the high price to the first buyer, since the surplus from trade available when trying to contact the second buyer grows with ρ. Once the seller starts quoting the high price to the first buyer, we see a drop in the social surplus from trade, but since enough surplus can be created with the second buyer, decentralized trading still socially dominates centralized trading. As far as the seller is concerned, trading in a decentralized market allows to collect a higher surplus from trade whenever delay is not too costly. Hence, for large values of ρ, the decentralized market dominates the centralized market from both the seller's and the social planner's standpoints.

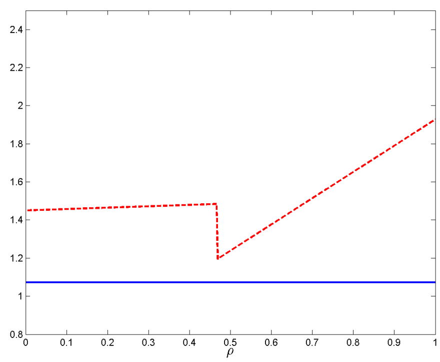
When we increase the uncertainty in private valuations to $\sigma_b = 15$ (panels (e)-(f)), the seller still finds it optimal to quote the low price to the second buyer when needed in the decentralized market. As earlier, the decentralized market generates a higher social surplus and a higher seller's surplus than a centralized



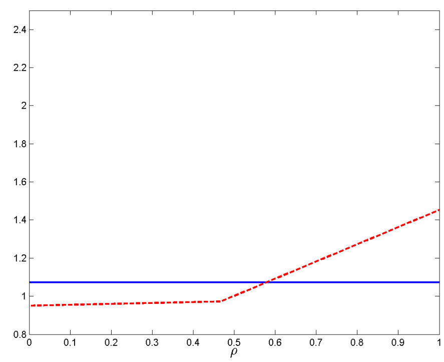
(a) Social surplus for $\sigma_b = 5$.



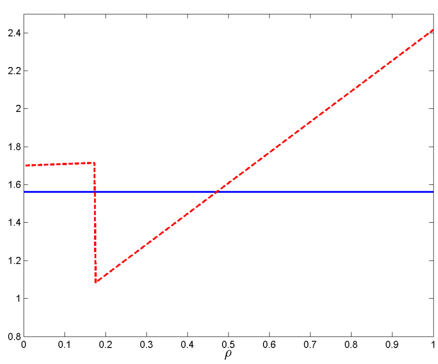
(b) Seller's surplus for $\sigma_b = 5$.



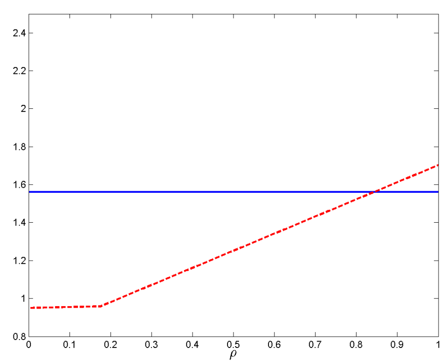
(c) Social surplus for $\sigma_b = 10$.



(d) Seller's surplus for $\sigma_b = 10$.



(e) Social surplus for $\sigma_b = 15$.



(f) Seller's surplus for $\sigma_b = 15$.

Figure 1: **Surplus from trade with uncertain private values.** In these figures, we set $\Delta = 1$, $\sigma_v = 0$, and $\pi = 0.1$ and plot the social surplus from trade and the seller's expected surplus as functions of the delay parameter ρ. The dash line represents the surplus in a decentralized market while the solid line represents the surplus in a centralized market.

market as long as delay is not too costly, that is, ρ is high enough. Decentralized trading is, however, socially dominated by centralized trading when ρ is moderate. That is due to the fact that the expected surplus from trade when trying to contact the second buyer (i.e., ρb_i) is small compared to the benefit of quoting a price to both buyers simultaneously. When ρ is small, the seller switches to quoting a low price to the first buyer, which ensures that trade occurs with a high enough probability to socially dominate centralized trade.

Finally, when we decrease the uncertainty in private valuations to $\sigma_b = 5$ (panels (a)-(b)), the seller quotes the low price in the centralized market. Since this price is socially optimal in the centralized market (see condition (4)), it becomes harder for decentralized trade to socially dominate centralized trade. Yet, a decentralized market can socially dominate a centralized market when ρ is high enough and delay is not too costly.

Note that we could also go beyond the Glosten and Milgrom-type framework and allow for dynamic, strategic behavior by traders. We could model two periods of centralized trading between the seller and the two buyers and assume that there is also a delay parameter ρ_c associated with trading in the second period. (Dynamic, strategic behavior does not occur across periods of decentralized trading because the buyer being contacted is different in each period.) This second period of centralized trade would then strengthen the seller's incentives to quote an aggressive price in the first period of centralized trade, just as was the case in the decentralized market. Thus, on the one hand, the second period of trade provides an additional opportunity to implement efficient trade, but on the other hand, it incentivizes inefficient screening by the seller in the first period. We know from setting $\rho = 0$ in our baseline model (where effectively we have $\rho_c = 0$) that if both ρ and ρ_c were set to be small enough (e.g., immediacy needs are high in both markets) in this alternative setting, the more severe screening in the centralized market would lead to the decentralized market being socially optimal (see Figure 1, panels (c) and (e)).

4 Information Acquisition with Uncertain Private Values

We now endogenize the probabilities at which buyers obtain private information about their valuation of the asset, that is, buyer i can incur a cost $\frac{c}{2}\pi_i^2$ before he is contacted by the seller and learn his own v_i with probability π_i. We analyze how the market structure affects traders' incentives to acquire information.

4.1 Centralized Market

In order to analyze the information acquisition choice of buyers, we first need to generalize to asymmetric levels of π_i our earlier derivations of the seller's trading behavior and of the resulting allocation of surplus.

As earlier, in a centralized market the seller considers quoting either a high price $p = \bar{v} + \Delta + \sigma_b$ or a lower price $p = \bar{v} + \Delta$. The high price is accepted with probability:

$$\frac{3}{4}\pi_1\pi_2 + \frac{1}{2}\pi_1(1-\pi_2) + \frac{1}{2}\pi_2(1-\pi_1) = \frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right). \tag{20}$$

Thus, by quoting the high price $p = \bar{v} + \Delta + \sigma_b$, the seller collects an expected payoff of:

$$\begin{aligned} & \frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right)(\bar{v} + \Delta + \sigma_b) + \left[1 - \frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right)\right]\bar{v} \\ = \; & \bar{v} + \frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right)(\Delta + \sigma_b). \end{aligned} \tag{21}$$

If the seller quotes the lower price $p = \bar{v} + \Delta$ instead, this price is only rejected when both buyers are informed and value the asset at $v_i = \bar{v} + \Delta - \sigma_b$, which occurs with probability $\frac{1}{4}\pi_1\pi_2$. The seller then collects an expected payoff of:

$$\left(1 - \frac{1}{4}\pi_1\pi_2\right)(\bar{v} + \Delta) + \frac{1}{4}\pi_1\pi_2\bar{v} = \bar{v} + \left(1 - \frac{1}{4}\pi_1\pi_2\right)\Delta. \tag{22}$$

The seller thus quotes the high price $p = \bar{v} + \Delta + \sigma_b$ whenever:

$$\begin{aligned} \bar{v} + \frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right)(\Delta + \sigma_b) \quad &> \quad \bar{v} + \left(1 - \frac{1}{4}\pi_1\pi_2\right)\Delta \\ \Leftrightarrow \frac{\Delta}{\sigma_b} \quad &< \quad \frac{\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2}{2 - \pi_1 - \pi_2}. \end{aligned} \tag{23}$$

If that is the case, the social surplus from trade is $\frac{1}{2}\left(\pi_1 + \pi_2 - \frac{1}{2}\pi_1\pi_2\right)(\Delta + \sigma_b)$ as both buyers collect zero surplus. Otherwise, the seller quotes the lower price $p = \bar{v} + \Delta$ and the social surplus from trade is $\left(1 - \frac{1}{4}\pi_1\pi_2\right)\Delta + \frac{1}{4}(\pi_1 + \pi_2 + \pi_1\pi_2)\sigma_b$. Buyer i's surplus is then:

$$\frac{\pi_i}{2}\left((1-\pi_j)\frac{1}{2} + \pi_j\left(\frac{1}{2}\frac{1}{2} + \frac{1}{2}\right)\right)\sigma_b = \frac{\pi_i}{4}\left(1 + \frac{\pi_j}{2}\right)\sigma_b. \tag{24}$$

We restrict our attention to equilibria where the seller picks a pure-strategy price quote. Right away, we can rule out equilibria where π_i and π_j are high enough for the seller to always quote the high price. In such case, buyers would be better off not acquiring information and the high price would always be rejected. We can also rule out equilibria where buyers never acquire information since the marginal cost of acquiring information is $c\pi_i$ and increasing π_i is strictly profitable when the seller quotes the low price. Hence, in equilibrium, the seller must quote the low price $p = \bar{v} + \Delta$ and both buyers must choose $\pi_i \in (0, 1)$.

Conditional on the seller choosing the low price $p = \bar{v} + \Delta$, buyer i chooses π_i to maximize:

$$\frac{\pi_i}{4}\left(1 + \frac{\pi_j}{2}\right)\sigma_b - \frac{c}{2}\pi_i^2. \tag{25}$$

Given an interior optimum $\pi_i \in (0, 1)$, we obtain:

$$\pi_i^*(\pi_j) = \left(1 + \frac{\pi_j}{2}\right)\frac{\sigma_b}{4c}, \tag{26}$$

which by symmetry implies that in the unique pure-strategy equilibrium, both buyers acquire:

$$\pi^* = \frac{\sigma_b}{\left(4c - \frac{\sigma_b}{2}\right)}. \tag{27}$$

For this π^* to be sustained in equilibrium, it must be that the seller optimally quotes the low price, which we know from condition (3) only occurs when:

$$\frac{\Delta}{\sigma_b} \geq \left(1 - \frac{\pi^*}{4}\right)\left(\frac{\pi^*}{1 - \pi^*}\right). \tag{28}$$

4.2 Decentralized Market

As was the case with exogenous information, a rejection by the first buyer contacted in the decentralized market is uninformative about the seller's and the second buyer's valuations of the asset. Hence, the seller quotes the second buyer ($i = 2$) either $p = \bar{v} + \Delta + \sigma_b$ or $p = \bar{v} + \Delta$. We can use the reasoning from the case with exogenous information and replace π by π_2 in condition (7) in order to conclude that the seller quotes the low price $p = \bar{v} + \Delta$ to the second buyer whenever:

$$\frac{\Delta}{\sigma_b} \geq \frac{1}{2}\left(\frac{\pi_2}{1 - \pi_2}\right), \tag{29}$$

otherwise he quotes the high price $p = \bar{v} + \Delta + \sigma_b$.

We now denote the seller's maximal expected payoff from trade once the first buyer rejects as $\bar{v} + \rho W^*(\pi_2)$, where $W^*(\pi_2) \equiv \max\{\frac{\pi_2}{2}(\Delta + \sigma_b), \left(1 - \frac{\pi_2}{2}\right)\Delta\}$. The seller must choose whether to quote $p = \bar{v} + \Delta + \sigma_b$ or $p = \bar{v} + \Delta$ to the first buyer ($i = 1$), knowing that the asset will be worth $\bar{v} + \rho W^*(\pi_2)$ in expectation if this first price is rejected. The seller thus quotes the low price $p = \bar{v} + \Delta$ to the first buyer whenever:

$$
\begin{aligned}
\bar{v} + \left(1 - \frac{\pi_1}{2}\right)\Delta + \frac{\pi_1}{2}\rho W^*(\pi_2) \quad &\geq \quad \bar{v} + \frac{\pi_1}{2}(\Delta + \sigma_b) + \left(1 - \frac{\pi_1}{2}\right)\rho W^*(\pi_2) \\
\Leftrightarrow \frac{\Delta}{\sigma_b} \quad &\geq \quad \frac{\rho W^*(\pi_2)}{\sigma_b} + \frac{1}{2}\left(\frac{\pi_1}{1 - \pi_1}\right), \qquad (30)
\end{aligned}
$$

otherwise he quotes the high price $p = \bar{v} + \Delta + \sigma_b$. Since $W^*(\pi_2) > 0$, we know that this inequality is at least as restrictive as condition (29) whenever $\pi_1 \geq \pi_2$, implying that if the seller quotes $p = \bar{v} + \Delta$ to the first buyer, he will quote $p = \bar{v} + \Delta$ to the second buyer when he contacts him.

As in a centralized market, we can rule out equilibria where the seller always quotes the high price to a buyer. Otherwise, the buyer would not acquire information and the seller would find it optimal to quote the low price instead. As a result, we can also rule out any equilibrium where the buyer chooses $\pi_i = 1$, since it implies that the seller would find it optimal to quote the high price to that buyer and the same contradiction would arise.

In a conjectured equilibrium where the seller quotes the low price $p = \bar{v} + \Delta$ to both buyers, the first buyer picks π_1 to maximize:

$$
\frac{\pi_1}{2}\sigma_b - \frac{c}{2}\pi_1^2, \qquad (31)
$$

meaning that in an interior optimum where $\pi_1^* \in (0, 1)$ we obtain:

$$
\pi_1^* = \frac{\sigma_b}{2c}. \qquad (32)
$$

Further, the second buyer picks π_2 to maximize:

$$
\frac{\pi_1^*}{2}\frac{\pi_2}{2}\rho\sigma_b - \frac{c}{2}\pi_2^2, \qquad (33)
$$

meaning that in an interior optimum where $\pi_2^* \in (0,1)$ we obtain:

$$\begin{aligned}\pi_2^* &= \frac{\pi_1^* \rho \sigma_b}{4c} \\ &= \frac{\rho}{2}\pi_1^{*2}.\end{aligned} \tag{34}$$

Note that, for any interior optimum $\pi_1^* \in (0,1)$, it follows that $0 \leq \pi_2^* < \pi_1^*$. Finally, for the seller to indeed prefer to quote the low price to both buyers sequentially, we need:

$$\begin{aligned}\frac{\Delta}{\sigma_b} &\geq \frac{\rho W^*(\pi_2^*)}{\sigma_b} + \frac{1}{2}\left(\frac{\pi_1^*}{1-\pi_1^*}\right) \\ &= \left(1 - \frac{\pi_2^*}{2}\right)\rho\frac{\Delta}{\sigma_b} + \frac{1}{2}\left(\frac{\pi_1^*}{1-\pi_1^*}\right),\end{aligned} \tag{35}$$

which can be rewritten as:

$$\frac{\Delta}{\sigma_b} \geq \frac{1}{2}\left(\frac{1}{1-\rho+\frac{\rho\pi_2^*}{2}}\right)\left(\frac{\pi_1^*}{1-\pi_1^*}\right). \tag{36}$$

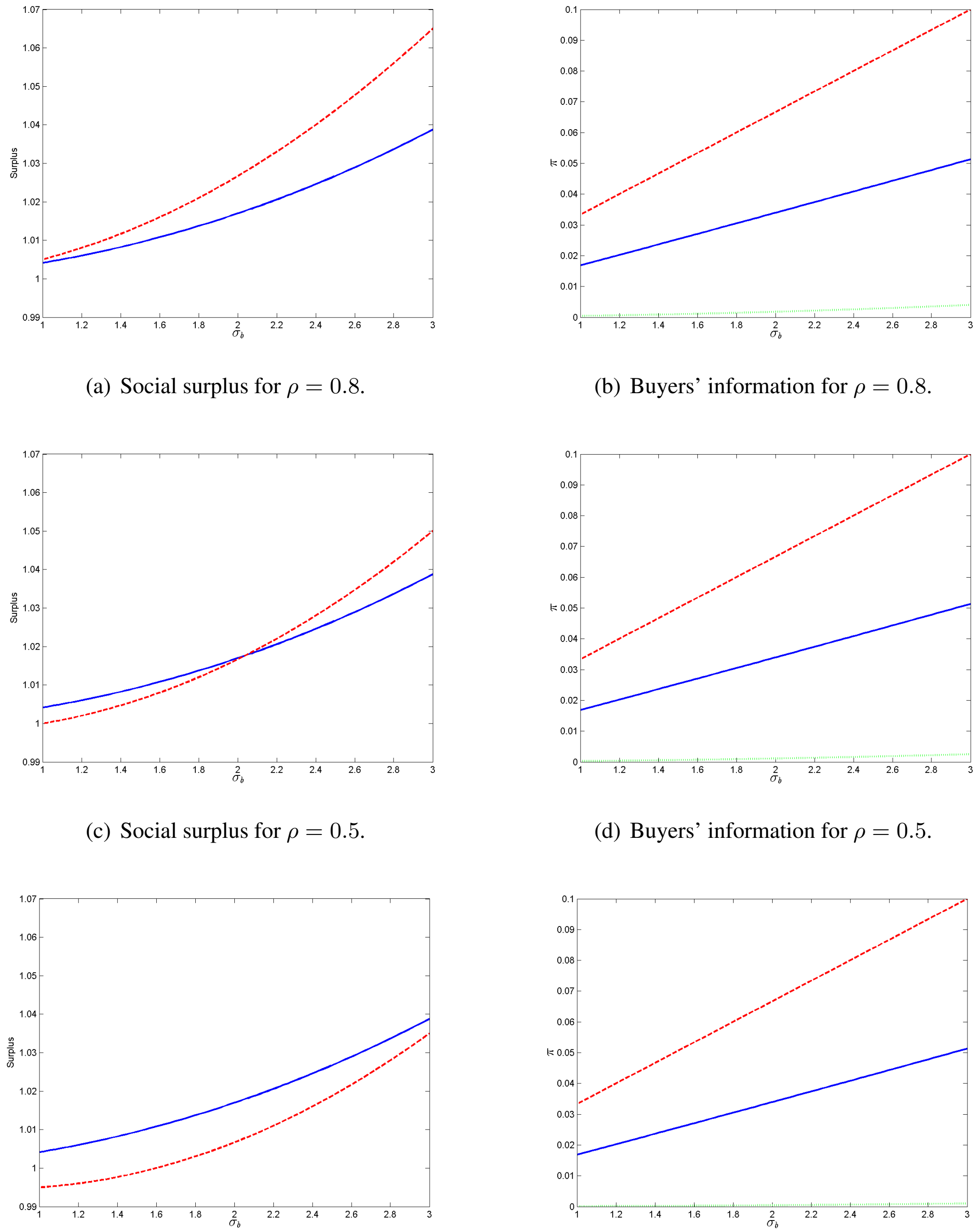
If that condition is satisfied, the social surplus from trade in equilibrium is:

$$\begin{aligned}& \pi_1^*\left(\frac{1}{2}(\Delta+\sigma_b) + \frac{1}{2}\left(\frac{\pi_2^*}{2}\rho(\Delta+\sigma_b) + (1-\pi_2^*)\rho\Delta\right)\right) + (1-\pi_1^*)\Delta \\ = & \left[1 - \frac{\pi_1^*}{2} + \frac{\rho\pi_1^*}{2}\left(1-\frac{\pi_2^*}{2}\right)\right]\Delta + \frac{\pi_1^*}{2}\left(1+\frac{\rho\pi_2^*}{2}\right)\sigma_b.\end{aligned} \tag{37}$$

4.3 Optimal Market Structure

As earlier, we parameterize the model and compare the social efficiency of trade across the two market structures. In contrast to the previous section however, buyers' information sets are now endogenous. We normalize $\Delta = 1$ and set $c = 15$. In Figures 2-3 we plot the social surplus from trade, net of information acquisition costs, and the privately optimal information acquisition as a function of the uncertainty in private valuations (σ_b), for various parameterizations of ρ.

The plots highlight that the trading venue that maximizes the social surplus from trade, net of information acquisition costs, varies with asset characteristics and with the social cost of trade delays in decentralized markets. Panel (a) in Figure 2 shows that, when trade delays are not too costly (e.g., $\rho = 0.8$), a decentralized market socially dominates a centralized market. The exclusivity associated with decentralized trade gives the first buyer greater assurance that information acquisition will be worthwhile — the first buyer obtains the



(a) Social surplus for $\rho = 0.8$.

(b) Buyers' information for $\rho = 0.8$.

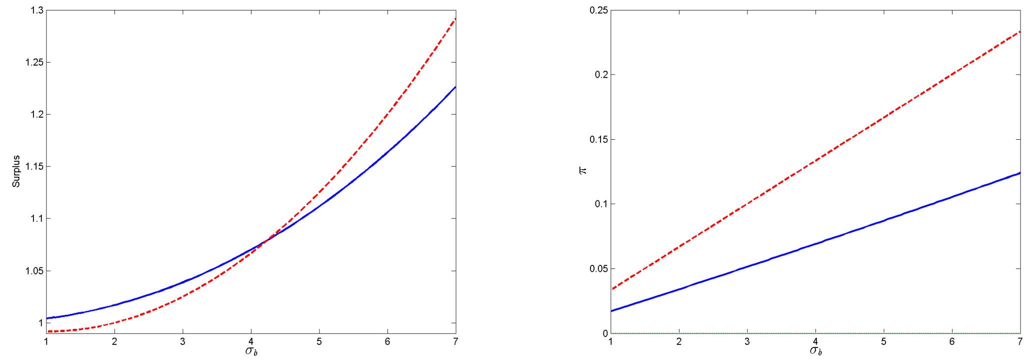
(c) Social surplus for $\rho = 0.5$.

(d) Buyers' information for $\rho = 0.5$.

(e) Social surplus for $\rho = 0.2$.

(f) Buyers' information for $\rho = 0.2$.

Figure 2: **Surplus from trade and information acquisition with uncertain private values.** In these figures, we set $\Delta = 1$, $\sigma_v = 0$, and $c = 15$ and plot the social surplus from trade, net of the information costs, and the buyers' information as functions of the uncertainty in private valuations. In panels (a), (c), and (e), the dash line represents the surplus in the decentralized market while the solid line represents the surplus in the centralized market. In panels (b), (d), and (f), the dash line represents the first buyer's information π_1 and the dotted line represents the second buyer's information π_2 in the decentralized market, while the solid line represents the buyers' symmetric information in the centralized market.



(a) Social surplus for $\rho = 0$. (b) Buyers' information for $\rho = 0$.

Figure 3: **Surplus from trade and information acquisition with uncertain private values and $\rho = 0$.** In these figures, we set $\Delta = 1$, $\sigma_v = 0$, and $c = 15$ and plot the social surplus from trade, net of the information costs, and the buyers' information as functions of the uncertainty in private valuations. In panel (a), the dash line represents the surplus in the decentralized market while the solid line represents the surplus in the centralized market. In panel (b), the dash line represents the first buyer's information π_1 and the dotted line represents the second buyer's information π_2 in the decentralized market, while the solid line represents the buyers' symmetric information in the centralized market.

asset with probability 1 when accepting the offered price and can thus realize the gains to trade whenever he knows that he values the asset at $v_i = \bar{v} + \Delta + \sigma_b$. In contrast, in the centralized market buyers are competing for the asset and may not obtain the asset every time they accept the seller's price quote. Even if a buyer knows that he values the asset at $v_i = \bar{v} + \Delta + \sigma_b$, he might still lose the asset to the other buyer. In the centralized venue, the threat of competition thus reduces each buyer's private incentives for information production, potentially leading to lower allocational efficiency and welfare.

From a welfare perspective, decentralized trading can, however, also be inferior to centralized trading when the cost of trade delay is large. This result is evidenced by Panels (c) and (e) that compare the social surplus when $\rho = 0.5$ and $\rho = 0.2$. Yet, as shown in Figure 3, even when $\rho = 0$, that is, all surplus is destroyed once the first buyer rejects a price quote, it is still possible for the decentralized market to be more efficient than a centralized market, provided that the uncertainty in private valuations σ_b is sufficiently large. When σ_b is large, the provision of sufficient incentives for information acquisition is essential and it is better achieved in a decentralized market.

5 Asymmetric Information about Common Value

In this section, we focus our analysis on a case where equilibrium trading outcomes are driven by the surplus from trade (Δ) and the volatility of the asset's common value (σ_v). We set $\sigma_b = 0$ and assume that the uncertainty in common value is large enough to have $\sigma_v \geq \Delta$, meaning that the seller is better off keeping the asset than quoting a low price $p = \bar{v} + \Delta - \sigma_v$. This case can thus shed light on the optimal market structure for securities like stocks or derivatives that are primarily traded for speculation purposes.

5.1 Centralized Market

The highest price that has a positive probability of being accepted is $p = \bar{v} + \Delta + \sigma_v$. In the centralized market, this price is accepted only if at least one of the two buyers is informed and the asset is worth $v_i = \bar{v} + \Delta + \sigma_v$. This occurs with probability $\frac{1}{2}[\pi^2 + 2\pi(1-\pi)] = \pi\left(1 - \frac{\pi}{2}\right)$. By quoting this price, the seller collects an expected payoff of:

$$\pi\left(1 - \frac{\pi}{2}\right)(\bar{v} + \Delta + \sigma_v) + \pi\left(1 - \frac{\pi}{2}\right)(\bar{v} - \sigma_v) + \left[1 - 2\pi\left(1 - \frac{\pi}{2}\right)\right]\bar{v} = \bar{v} + \pi\left(1 - \frac{\pi}{2}\right)\Delta. \tag{38}$$

The seller may also consider quoting a price that is low enough to be accepted by buyers who do not have private information, but that is higher than the value of keeping the asset. An informed buyer accepts a price $p > \bar{v}$ only when $v = \bar{v} + \sigma_v$. Since informed buyers now condition their trading decision on a common value component, an uninformed buyer needs to protect himself against the private information of competing buyers. There is thus adverse selection among buyers as any uninformed buyer recognizes that he is sure to get the asset if the other buyer is informed and $v = \bar{v} - \sigma_v$, but he only gets the asset with probability $1/2$ if the other buyer is informed and $v = \bar{v} + \sigma_v$. The highest price an uninformed buyer is willing to pay for the asset is then:

$$\frac{\frac{\pi}{2}(\bar{v} - \sigma_v) + \frac{\pi}{2}(\bar{v} + \sigma_v)\frac{1}{2} + (1-\pi)\bar{v}\frac{1}{2}}{\frac{\pi}{2} + \frac{\pi}{2}\frac{1}{2} + (1-\pi)\frac{1}{2}} + \Delta = \bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta. \tag{39}$$

This price is rejected only if both buyers are informed and $v = \bar{v} - \sigma_v$. By quoting a price $p = \bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta$, the seller collects an expected payoff of:

$$\left(1 - \frac{\pi^2}{2}\right)\left[\bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta\right] + \frac{\pi^2}{2}(\bar{v} - \sigma_v) = \bar{v} + \left(1 - \frac{\pi^2}{2}\right)\Delta - \pi\left(\frac{1+\pi}{2+\pi}\right)\sigma_v. \tag{40}$$

Finally, the seller may consider quoting a price $p = \bar{v} + \Delta - \sigma_v$, which is accepted by all buyers, but quoting this price is dominated by keeping the asset which in expectation is worth $\bar{v}$ to him. Keeping the asset is, in turn, dominated by quoting the high price $p = \bar{v} + \Delta + \sigma_v$.

The seller thus quotes the price $p = \bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta$ whenever:

$$\begin{aligned} \bar{v} + \left(1 - \frac{\pi^2}{2}\right)\Delta - \pi\left(\frac{1+\pi}{2+\pi}\right)\sigma_v &\geq \bar{v} + \pi\left(1 - \frac{\pi}{2}\right)\Delta \\ \Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \left(\frac{1+\pi}{2+\pi}\right)\left(\frac{\pi}{1-\pi}\right), \end{aligned} \tag{41}$$

and in such case, the social surplus from trade is $\left(1 - \frac{\pi^2}{2}\right)\Delta$. Otherwise, the seller quotes the high price $p = \bar{v} + \Delta + \sigma_v$ and the social surplus from trade is $\pi\left(1 - \frac{\pi}{2}\right)\Delta$. From a social standpoint, the surplus from trade is greater if the seller quotes the low price $p = \bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta$ than the high price $p = \bar{v} + \Delta + \sigma_v$ whenever:

$$\begin{aligned} \left(1 - \frac{\pi^2}{2}\right)\Delta &\geq \pi\left(1 - \frac{\pi}{2}\right)\Delta \\ \Leftrightarrow \pi &\leq 1 \end{aligned} \tag{42}$$

Hence, in the region where $\frac{\Delta}{\sigma_v} < \left(\frac{1+\pi}{2+\pi}\right)\left(\frac{\pi}{1-\pi}\right)$, the seller quotes a socially inefficient, high price.

5.2 Decentralized Market

We now analyze how trade occurs in the decentralized market. Since $\sigma_v > 0$, a rejection by the first buyer can be informative about the common value of the asset and will affect behaviors by the seller and any uninformed buyer. To keep the analysis simple and shut down the signalling game between the seller and an uninformed second buyer, we solve for equilibria where the second buyer's beliefs about how trade occurred with the first buyer is unaffected by the price the seller quotes to the second buyer. In other words, the second buyer's off-equilibrium beliefs about the value of the asset are the same as his equilibrium beliefs.

First, we conjecture an equilibrium in which the seller quotes a low price $p = \bar{v} + \Delta$ to the first buyer. This price is only rejected by an informed buyer who knows that $v = \bar{v} - \sigma_v$. Hence, both the seller and the second buyer know that the asset is then worth $v_i = \bar{v} + \Delta - \sigma_v$ to the second buyer while it is only worth $v = \bar{v} - \sigma_v$ to the seller. The seller quotes a price $p = \bar{v} + \Delta - \sigma_v$ to the second buyer, which is accepted with probability 1. For this outcome to be an equilibrium, we need to verify that the seller finds it optimal to quote a price $p = \bar{v} + \Delta$ rather than $p = \bar{v} + \Delta + \sigma_v$ to the first buyer. Note that if he were to deviate to quoting the high price to the first buyer, the seller could be tempted to retain the asset instead of trading with the second buyer. The seller, however, still finds it optimal to quote the second buyer a low price $p = \bar{v} + \Delta - \sigma_v$ after deviating with the first buyer whenever:

$$\begin{aligned} \bar{v} + \Delta - \sigma_v &\geq \frac{\frac{\pi}{2}(\bar{v} - \sigma_v) + (1-\pi)\bar{v}}{\frac{\pi}{2} + (1-\pi)} = \bar{v} - \frac{\pi}{2-\pi}\sigma_v \\ \Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{2-2\pi}{2-\pi}. \end{aligned} \tag{43}$$

If this condition is satisfied, then the seller finds it optimal to quote a price $p = \bar{v} + \Delta$ to the first buyer whenever:

$$\begin{aligned} \left(1 - \frac{\pi}{2}\right)(\bar{v} + \Delta) + \frac{\pi}{2}(\bar{v} + \rho\Delta - \sigma_v) &\geq \frac{\pi}{2}(\bar{v} + \Delta + \sigma_v) + \left(1 - \frac{\pi}{2}\right)(\bar{v} + \rho\Delta - \sigma_v) \\ \Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{3\pi - 2}{2(1-\pi)(1-\rho)}. \end{aligned} \tag{44}$$

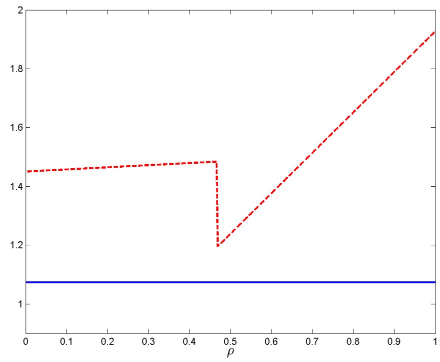
If condition (43) is violated however, condition (44) which guarantees that the seller quotes a price $p = \bar{v}+\Delta$ to the first buyer is replaced by:

$$\begin{aligned} \left(1 - \frac{\pi}{2}\right)(\bar{v} + \Delta) + \frac{\pi}{2}(\bar{v} + \rho\Delta - \sigma_v) &\geq \frac{\pi}{2}(\bar{v} + \Delta + \sigma_v) + \left(1 - \frac{\pi}{2}\right)\left(\bar{v} - \frac{\pi}{2-\pi}\sigma_v\right) \\ \Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{\pi}{2\left(1 - \pi + \frac{\rho\pi}{2}\right)}. \end{aligned} \tag{45}$$

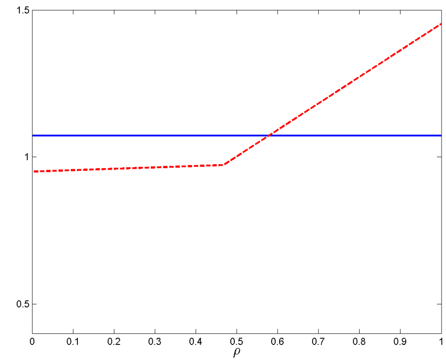
In such equilibrium, the social surplus from trade is $\left(1 - \frac{\pi}{2} + \frac{\rho\pi}{2}\right)\Delta$. When it exists, this equilibrium socially dominates any equilibrium where the seller quotes the first buyer a high price $p = \bar{v} + \Delta + \sigma_v$, since such an equilibrium can at most create a surplus of $\left[\frac{\pi}{2} + \left(1 - \frac{\pi}{2}\right)\rho\right]\Delta$. When the seller quotes the high price to the first buyer, trade occurs only with probability $\frac{\pi}{2}$ with the first buyer and, even if the second buyer accepts with probability 1 the price quoted by the seller when he contacts him, the surplus is strictly lower than the surplus in the equilibrium above due to the social cost of delay when $\rho < 1$.

5.3 Optimal Market Structure

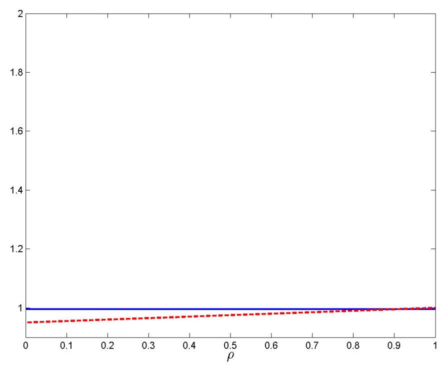
Now, we compare the social efficiency of trade across the different types of market. By inspecting condition (44), we see that it is satisfied for any values of ρ and σ_v as long as $\pi \leq \frac{2}{3}$. By inspecting condition (45), we



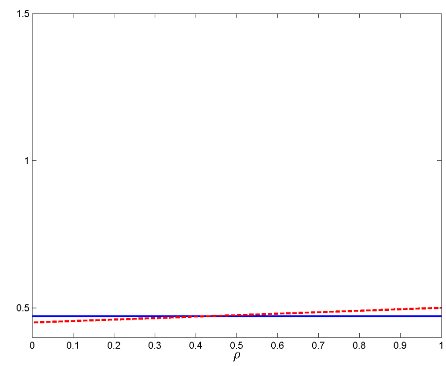
(a) Social surplus for $\sigma_b = 10$ and $\sigma_v = 0$.



(b) Seller's surplus for $\sigma_b = 10$ and $\sigma_v = 0$.



(c) Social surplus for $\sigma_b = 0$ and $\sigma_v = 10$.



(d) Seller's surplus for $\sigma_b = 0$ and $\sigma_v = 10$.

Figure 4: **Surplus from trade with low uncertainty in private vs. common values.** In these figures, we set $\Delta = 1$ and $\pi = 0.1$ and plot the social surplus from trade and the seller's expected surplus as functions of the delay parameter ρ. The dash line represents the surplus in a decentralized market while the solid line represents the surplus in a centralized market.

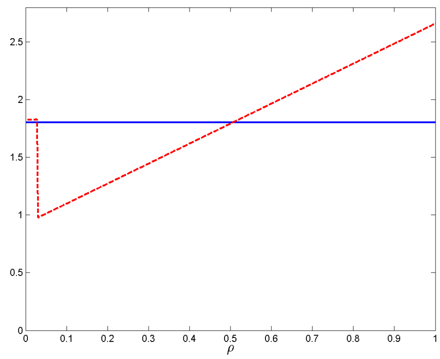
see that it is satisfied for any values of ρ as long as $\frac{\Delta}{\sigma_v} \geq \frac{1}{2}\left(\frac{\pi}{1-\pi}\right)$. Since all our parameterizations in Figure 1 of Subsection 3.3 satisfy these conditions when we replace σ_v by σ_b, in Figure 4 we produce similar plots for the case where the uncertainty is about the common value ($\sigma_v = 10$ and $\sigma_b = 0$) and compare them with those for the case where the uncertainty is about private values ($\sigma_b = 10$ and $\sigma_v = 0$).

First note that in this specific parameterization, the seller quotes the high, less efficient price $p = \bar{v} + \Delta + \sigma_b$ in a centralized market with uncertainty in private valuations but he does not quote the high, less efficient price $p = \bar{v} + \Delta + \sigma_v$ in a centralized market with uncertainty in common value. This difference is due to the fact that when $\pi \in (0, 1)$ the cutoff on $\frac{\Delta}{\sigma_v}$ in condition (41) is always lower than the cutoff on $\frac{\Delta}{\sigma_b}$ in condition (3). Thus, for a given level of uncertainty the seller's incentives to quote a high price are stronger when this uncertainty is in private values rather than in the common value. Hence, as we can observe from the parameterization of Figure 4, the difference in the social efficiency of trade between the two types of market is much larger quantitatively when the uncertainty is in private rather than in common values. In the former (see panel (a)), decentralizing trade is socially optimal for any value of ρ, whereas in the latter (see panel (c)), it is optimal only for ρ close to 1. The reason why decentralizing trade is socially optimal for $\rho \to 1$ when $\sigma_v = 10$ and $\sigma_b = 0$ is that in equilibrium trade occurs whenever the second buyer can be contacted since both traders involved have learned from the refusal of the first buyer to pay $p = \bar{v} + \Delta$ that $v = \bar{v} - \sigma_v$ and therefore, these traders are symmetrically informed. The seller thus never ends up with the asset in a decentralized market, which is not the case under centralized trade, where the seller must retain the asset whenever both buyers are informed and $v = \bar{v} - \sigma_v$. When ρ is close to 1, this higher probability of trade swamps the small cost of delay incurred by the sequential nature of trade and makes decentralized trade socially optimal.

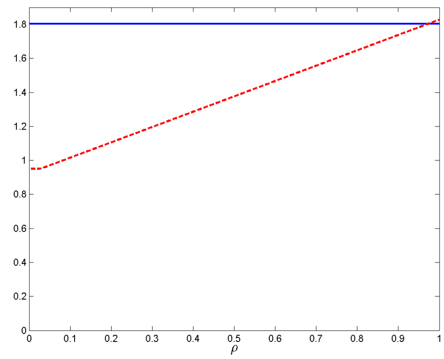
In Figure 5, we increase the level of uncertainty until the seller finds it optimal to quote the high, less efficient price in a centralized market, regardless of whether this uncertainty is in private values or in the common value. In such case, decentralizing trade becomes socially optimal for any value of ρ when the uncertainty is in the common value, but this is not the case when the uncertainty is in private values. In panel (c), we can see that the surplus from trade in a decentralized market when the seller quotes $p = \bar{v} + \Delta$ to the first buyer and $p = \bar{v} + \Delta - \sigma_v$ to the second buyer is very close to the full surplus $\Delta = 1$, whereas it is much lower in a centralized market where the seller quotes the high, less efficient price $p = \bar{v} + \Delta + \sigma_v$. Overall, these findings illustrate that regardless of whether asymmetric information is over the private or the common values, decentralizing trade may incentivize asymmetrically informed agents to change their trading behaviors in ways that are socially beneficial.

6 Information Acquisition with Uncertain Common Value

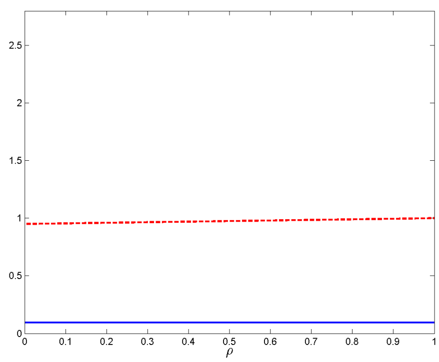
In this section we extend our analysis to allow for information acquisition about the common value component. As earlier, buyer i can incur a cost $\frac{c}{2}\pi_i^2$ before being contracted by the seller and learn v_i with probability π_i. In this context, acquiring information is socially harmful, in line with Hirshleifer (1971), Glode, Green, and Lowery (2012), Dang, Gorton, and Holmström (2015), and Yang (2015). The choice of a market structure can then be used to minimize this inefficient behavior.



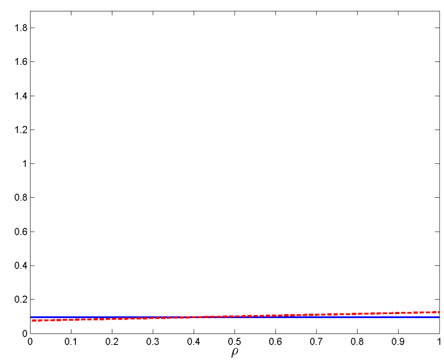
(a) Social surplus for $\sigma_b = 17.5$ and $\sigma_v = 0$.



(b) Seller's surplus for $\sigma_b = 17.5$ and $\sigma_v = 0$.



(c) Social surplus for $\sigma_b = 0$ and $\sigma_v = 17.5$.



(d) Seller's surplus for $\sigma_b = 0$ and $\sigma_v = 17.5$.

Figure 5: **Surplus from trade with high uncertainty in private vs. common values.** In these figures, we set $\Delta = 1$ and $\pi = 0.1$ and plot the social surplus from trade and the seller's expected surplus as functions of the delay parameter ρ. The dash line represents the surplus in a decentralized market while the solid line represents the surplus in a centralized market.

6.1 Centralized Market

In a first step, we repeat our analysis from the previous section, but allow for the probabilities π_i and π_j to be different from each other. The highest price that has a positive probability of being accepted is $p = \bar{v} + \Delta + \sigma_v$. In the centralized market, this price is accepted only if at least one of the two buyers is informed and knows that $v = \bar{v} + \sigma_v$, which occurs with probability:

$$\frac{1}{2}\left[\pi_i + (1-\pi_i)\pi_j\right] = \frac{1}{2}\left(\pi_i + \pi_j - \pi_j\pi_i\right). \tag{46}$$

By quoting this price, the seller collects an expected payoff of:

$$(\pi_i + \pi_j - \pi_j\pi_i)\left[\frac{1}{2}(\bar{v} + \Delta + \sigma_v) + \frac{1}{2}(\bar{v} - \sigma_v)\right] + \left[1 - (\pi_i + \pi_j - \pi_j\pi_i)\right]\bar{v} = \bar{v} + \frac{1}{2}\left(\pi_i + \pi_j - \pi_j\pi_i\right)\Delta. \tag{47}$$

The seller may also consider quoting a price that is low enough to be accepted by buyers who do not have private information, but that is higher than the value of keeping the asset. The highest price an uninformed buyer i is willing to pay for the asset, given his adverse selection concerns regarding buyer j's private information, is:

$$\frac{\frac{\pi_j}{2}(\bar{v} - \sigma_v) + \frac{\pi_j}{2}(\bar{v} + \sigma_v)\frac{1}{2} + (1-\pi_j)\bar{v}\frac{1}{2}}{\frac{\pi_j}{2} + \frac{\pi_j}{2}\frac{1}{2} + (1-\pi_j)\frac{1}{2}} + \Delta = \bar{v} - \left(\frac{\pi_j}{2+\pi_j}\right)\sigma_v + \Delta. \tag{48}$$

If $\pi_i \geq \pi_j$, a price $p = \bar{v} - \left(\frac{\pi_i}{2+\pi_i}\right)\sigma_v + \Delta$ is rejected only if both buyers are informed and $v = \bar{v} - \sigma_v$. For the centralized market we focus on symmetric equilibria where $\pi_i = \pi_j = \pi$. By quoting $p = \bar{v} - \left(\frac{\pi}{2+\pi}\right)\sigma_v + \Delta$ the seller collects an expected payoff of $\bar{v} + \left(1 - \frac{\pi^2}{2}\right)\Delta - \pi\left(\frac{1+\pi}{2+\pi}\right)\sigma_v$, as derived in equation (40).

As shown in the previous section, the seller quotes the low price $p = \bar{v} - \left(\frac{\pi_1}{2+\pi_1}\right)\sigma_v + \Delta$ whenever:

$$\frac{\Delta}{\sigma_v} \geq \left(\frac{1+\pi}{2+\pi}\right)\left(\frac{\pi}{1-\pi}\right), \tag{49}$$

and in this case, the social surplus from trade is $\left(1 - \frac{\pi^2}{2}\right)\Delta$.

As with uncertain private valuations, we can rule out equilibria where π_i and π_j are high enough for the seller to always quote the high price. In such case, buyers would be better off not acquiring information and the high price would be rejected. Thus, in the following, we conjecture an equilibrium where, with probability 1, the seller quotes a price that is accepted by uninformed buyers.

If buyer j acquires information with probability π and believes that buyer i will do the same, buyer i optimally responds to these beliefs and actions by picking π_i that maximizes:

$$\begin{aligned} & \frac{\pi_i}{2}\frac{1}{2}\left(\bar{v}+\sigma_v+\Delta-\left(\bar{v}-\left(\frac{\pi}{2+\pi}\right)\sigma_v+\Delta\right)\right)-\frac{c}{2}\pi_i^2 \\ = \quad & \frac{\pi_i}{2}\sigma_v\left(\frac{1+\pi}{2+\pi}\right)-\frac{c}{2}\pi_i^2. \end{aligned} \tag{50}$$

Given an interior solution $\pi_i \in (0,1)$ we obtain:

$$\pi_i = \frac{\sigma_v}{2c}\left(\frac{1+\pi}{2+\pi}\right). \tag{51}$$

Further, in a symmetric equilibrium we have $\pi_i = \pi_j = \pi$, which yields:

$$\pi = \frac{\sigma_v}{2c}\left(\frac{1+\pi}{2+\pi}\right). \tag{52}$$

This equation has the following two roots:

$$-1+\frac{\sigma_v \pm \sqrt{16c^2+\sigma_v^2}}{4c}, \tag{53}$$

but since $\pi \in [0,1]$, only the positive root can be a solution, that is,

$$\pi^* = -1+\frac{\sigma_v + \sqrt{16c^2+\sigma_v^2}}{4c}. \tag{54}$$

This is an equilibrium as long as $\pi^* \in (0,1)$ and the seller finds it optimal to quote the low price, that is:

$$\frac{\Delta}{\sigma_v} \geq \left(\frac{1+\pi^*}{2+\pi^*}\right)\left(\frac{\pi^*}{1-\pi^*}\right). \tag{55}$$

6.2 Decentralized Market

Again, we can rule out equilibria where the seller quotes the high price $p = \bar{v}+\Delta+\sigma_v$ to at least one of the two buyers with probability 1. Hence, we conjecture an equilibrium in which the seller always quotes a low price $p = \bar{v} + \Delta$ to the first buyer ($i = 1$). This price is only rejected by an informed buyer who knows that $v = \bar{v} - \sigma_v$. In such case, both the seller and the second buyer ($i = 2$) conclude from the first buyer's rejection that the asset is worth $v_i = \bar{v} + \Delta - \sigma_v$ to the second buyer and $v = \bar{v} - \sigma_v$ to the seller. The seller thus quotes a price $p = \bar{v} + \Delta - \sigma_v$ if he is able to contact the second buyer, which is then accepted with probability 1.

For this outcome to be an equilibrium, we need to verify that the seller finds it optimal to quote a price $p = \bar{v} + \Delta$ rather than $p = \bar{v} + \Delta + \sigma_v$ to the first buyer. Note that if he were to deviate to quoting the high price to the first buyer, the seller could be tempted to retain the asset instead of selling it to the second buyer. The seller, however, still finds it optimal to quote the second buyer a low price $p = \bar{v} + \Delta - \sigma_v$ even after deviating with the first buyer whenever:

$$\begin{aligned}
\bar{v} + \Delta - \sigma_v &\geq \frac{\frac{\pi_1}{2}(\bar{v} - \sigma_v) + (1 - \pi_1)\bar{v}}{\frac{\pi_1}{2} + (1 - \pi_1)} = \bar{v} - \frac{\pi_1}{2 - \pi_1}\sigma_v \\
\Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{2 - 2\pi_1}{2 - \pi_1}.
\end{aligned} \tag{56}$$

If this condition is satisfied, then the seller finds it optimal to quote a price $p = \bar{v} + \Delta$ to the first buyer whenever:

$$\begin{aligned}
\left(1 - \frac{\pi_1}{2}\right)(\bar{v} + \Delta) + \frac{\pi_1}{2}(\bar{v} + \rho\Delta - \sigma_v) &\geq \frac{\pi_1}{2}(\bar{v} + \Delta + \sigma_v) \\
&+ \left(1 - \frac{\pi_1}{2}\right)\left[\rho(\bar{v} + \Delta - \sigma_v) + (1 - \rho)\left(\bar{v} - \frac{\pi_1}{2 - \pi_1}\sigma_v\right)\right] \\
\Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{\pi_1 + 2\pi_1\rho - 2\rho}{2(1 - \pi_1)(1 - \rho)}.
\end{aligned} \tag{57}$$

If condition (56) is violated however, condition (57) that ensures that the seller finds it optimal to quote a price $p = \bar{v} + \Delta$ to the first buyer is replaced by:

$$\begin{aligned}
\left(1 - \frac{\pi_1}{2}\right)(\bar{v} + \Delta) + \frac{\pi_1}{2}(\bar{v} + \rho\Delta - \sigma_v) &\geq \frac{\pi_1}{2}(\bar{v} + \Delta + \sigma_v) + \left(1 - \frac{\pi_1}{2}\right)\left(\bar{v} - \frac{\pi_1}{2 - \pi_1}\sigma_v\right) \\
\Leftrightarrow \frac{\Delta}{\sigma_v} &\geq \frac{\pi_1}{2\left(1 - \pi_1 + \frac{\rho\pi_1}{2}\right)}.
\end{aligned} \tag{58}$$

In this equilibrium, the social surplus from trade is $\left(1 - \frac{\pi_1}{2} + \frac{\rho\pi_1}{2}\right)\Delta$. In the conjectured equilibrium, the second buyer is reached only after the first buyer has private information stating that $v = \bar{v} - \sigma_v$. Since being contacted by the seller reveals this information to the second buyer, acquiring information is useless and $\pi_2^* = 0$.

When quoted a price $p = \bar{v} + \Delta$ by the seller, the first buyer picks π_1 to maximize his expected profit of:

$$\frac{\pi_1}{2}\left[\bar{v} + \sigma_v + \Delta - (\bar{v} + \Delta)\right] - \frac{c}{2}\pi_1^2 = \frac{\pi_1}{2}\sigma_v - \frac{c}{2}\pi_1^2. \tag{59}$$

In an interior solution $\pi_1 \in (0, 1)$ we have:

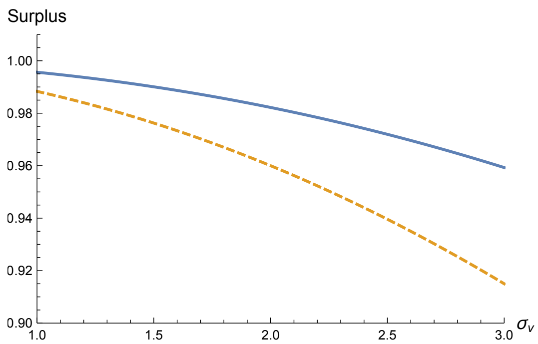
$$\pi_1^* = \frac{\sigma_v}{2c}. \tag{60}$$

The two buyers' information strategies $\pi_1^* = \frac{\sigma_v}{2c}$ and $\pi_2^* = 0$ sustain an equilibrium whenever $\pi_1^* \in (0, 1)$ and the conditions for the equilibrium, as characterized by the inequalities (56)-(58), are satisfied. Note that all the conditions for the conjectured equilibrium are satisfied for high enough values of the cost parameter c.

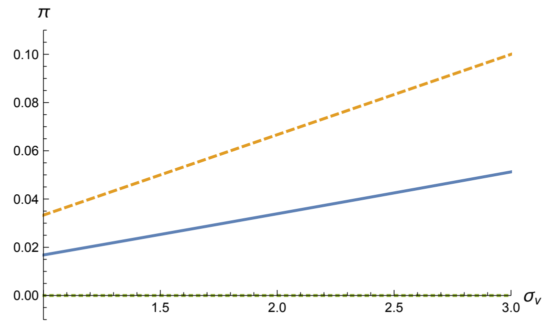
6.3 Optimal Market Structure

Figure 6 compares the social surplus and the buyers' information acquisition in the two types of market as a function of σ_v. In all our parameterizations, centralizing trade is socially optimal. A key reason for this result is the fact that, in the presence of common value uncertainty, information generates an adverse selection problem that reduces the efficiency of trade, but unlike with private value uncertainty, this information is not required to better allocate the asset to its efficient holder. Thus, the trading venue that provides lower incentives for information acquisition becomes the socially optimal one. Since competition between buyers in the centralized market lowers their ex ante incentives for information acquisition in comparison to the decentralized market, a centralized market sustains a larger surplus from trade. Moreover, as we increase σ_v buyers face higher private incentives to acquire (socially costly) information and the gap between the social efficiency of centralized and decentralized markets widens.

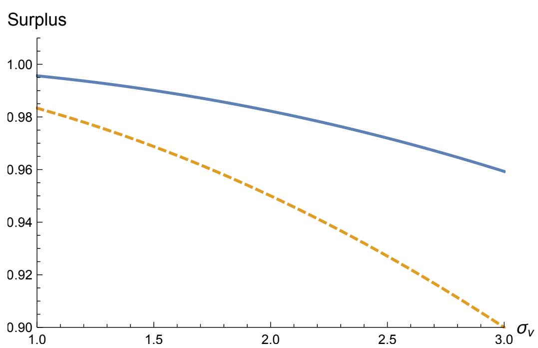
When compared to Figure 2, these plots clearly highlight that asymmetric information about the common value has very different implications than asymmetric information about private values. Since centralized trade typically weakens traders' incentives to acquire information, decentralized markets tend to socially dominate centralized markets when information is socially valuable (see Figure 2). Figure 6, however,



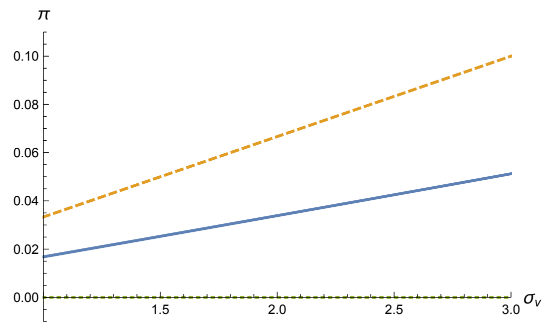
(a) Social surplus for $\rho = 0.8$.



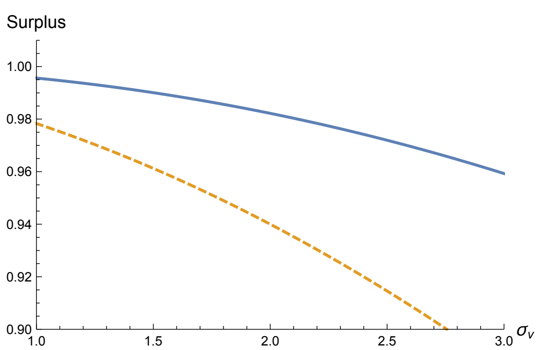
(b) Buyers' information for $\rho = 0.8$.



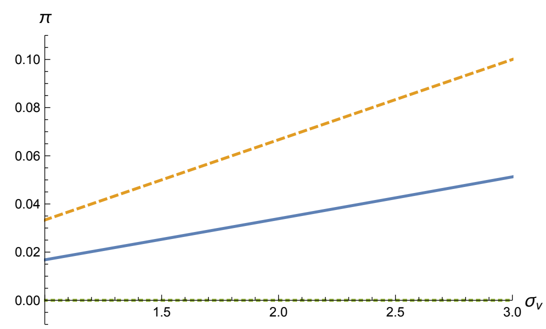
(c) Social surplus for $\rho = 0.5$.



(d) Buyers' information for $\rho = 0.5$.



(e) Social surplus for $\rho = 0.2$.



(f) Buyers' information for $\rho = 0.2$.

Figure 6: **Surplus from trade and information acquisition with uncertain common value.** In these figures, we set $\Delta = 1$, $\sigma_b = 0$, and $c = 15$ and plot the social surplus from trade, net of the information costs, and the buyers' information as functions of the uncertainty in private valuations. In panels (a), (c), and (e), the dash line represents the surplus in the decentralized market while the solid line represents the surplus in the centralized market. In panels (b), (d), and (f), the dash line represents the first buyer's information π_1 and the dotted line represents the second buyer's information π_2 in the decentralized market, while the solid line represents the buyers' symmetric information in the centralized market.

shows that when information has no social value, despite the fact it provides an advantage to its acquirer in a rent-seeking game, centralizing trade can be used to lower the socially wasteful acquisition of information and improve the social efficiency of trade.

7 Conclusion

We study a model with asymmetrically informed traders and compare the social efficiency of trade between centralized and decentralized markets. Since decentralized trade often involves costly delays (due to search frictions and/or immediacy concerns), centralizing trade is socially optimal in parameter regions where buyers' decision to acquire information and the seller's decision of which price to quote are not affected by the market structure. We show, however, that decentralizing trade may incentivize traders to change their behaviors in ways that are socially beneficial.

First, since centralized trade makes it more likely that a high price quote will be accepted quickly by at least one buyer, a seller may choose an aggressive, socially inefficient trading strategy in a centralized market, but would opt for a more conservative, socially efficient trading strategy in a decentralized market. Second, since centralized trade typically weakens traders' incentives to acquire information, decentralized markets tend to socially dominate centralized markets when private information is socially valuable and relates to traders' private valuations of the asset. The opposite is, however, true when private information relates to the common value of the asset being traded, hence only benefits a trader's rent-seeking ability in a zero-sum trading game.

Clearly, the choice of the market structure we observe for each type of assets at a point in time can also be rooted to historical circumstances. Our paper does not claim to supply the only reason for the coexistence of these types of markets, but it shows that informational problems among traders can be shaped by the choice of a market structure, and vice-versa. Overall, our analysis suggests that, contrary to the common perception, the current level of decentralization might not be socially suboptimal — the optimal market structure is likely to depend on the characteristics of the assets being traded, namely whether traders' private information relates to common or private valuations. These conclusions strike us as important for understanding why bonds, exotic derivatives, currencies and their derivatives are mostly traded in decentralized markets whereas stocks and standardized derivatives such as corporate call options are mostly traded in centralized markets.

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