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Financial Expertise as an Arms Race

Abstract

We propose a model in which firms involved in trading securities overinvest in financial expertise. Intermediaries or traders in the model meet and bargain over a financial asset. Investment in financial expertise improve the ability of the intermediary to value an asset at short notice when responding to an opportunity to supply liquidity. These investments are made before the parties know about their role in the bargaining game, as proposer or responder, buyer or seller. A prisoner's dilemma arises because investments in expertise improve bargaining outcomes given the other party's expertise, even when the information acquired through expertise has no social benefit. These investments lead to breakdowns in trade, or liquidity crises, in response to random but infrequent increases in asset volatility.

1 Introduction

The financial sector attracts extremely qualified employees. Philippon and Reshef (2010) document that the phenomenal growth in financial services in recent decades has been associated with increases in employees' academic education, task complexity, and compensation, relative to other sectors of the economy. In this paper, we develop a model in which the acquisition of expertise by financial firms, such as hiring Ph.D. graduates to design and value financial instruments of ever increasing complexity, becomes an "arms race."[1] By this phrase we mean two things:

- Investment in financial expertise confers an advantage on any one player in competing for a fixed surplus that is neutralized in equilibrium by similar investment by his opponents.
- Investment in financial expertise is dangerous, in that it creates a risk of destruction of the surplus itself when there is an exogenous shock.

Our model shows that financial firms involved in trading assets with uncertain value may find it optimal to acquire socially undesirable levels of expertise and this might interfere with the efficient functioning of financial markets. In the model, traders (or financial intermediaries generally) acquire expertise in processing information about an asset. The resulting efficiency in acquiring information gives them an advantage in subsequent bargaining with competitors. Neither the information, nor the expertise in acquiring and evaluating it, has any social value in the main version of the model. Yet intermediaries build such expertise despite the knowledge that it may increase adverse selection in subsequent trading and cause breakdowns in liquidity.

In our model, financial expertise is dangerous. Firms invest in expertise to the point where any additional investment would lead to breakdowns in trade because of adverse selection. We show that they will invest to this level even when there is some probability of a jump in volatility, and that when such a jump occurs levels of expertise that are benign under normal circumstances become destructive of value due to adverse selection. Thus, our model contributes to a better

[1] Expertise can also include the infrastructure (e.g., computers, databases) that helps these qualified employees to generate more profits for their firms when responding to trade offers under time pressure. For example, in an article titled "Fast Traders Face Off with Big Investors over 'Gambling' ", the Wall Street Journal reported on June 29, 2010: "The showdown has led to an escalating arms race, with players on both sides plowing money into ever-more-powerful technology to trade effectively."

understanding of why, in recent financial crises, liquidity broke down in those parts of the financial sector where intermediaries were operating with very high levels of financial expertise.

For example, before the recent crisis financial firms had invested vast resources transforming relatively straight-forward securities, such as residential mortgages and credit-card debt, into complex instruments through securitization. They had then created trillions of dollars worth of derivative contracts based on these asset-backed securities. To facilitate this, financial firms hired legions of highly trained and highly compensated experts to design, value, and hedge the complex securities and derivatives. Unfortunately, when housing prices fell and default rates rose, the complexity of the financial instruments, and the opacity of the over-the-counter markets where they traded, made it extremely difficult to identify where in the system the riskiest or most impaired liabilities were located. Estimates for the fundamental value of these financial instruments became highly uncertain and volatile. Of course, uncertainty per se does not interfere with trade, as long as the uncertainty is symmetric. As our model illustrates, however, when firms acquire high levels of financial expertise increases in uncertainty can lead to increases in asymmetric information. The very expertise firms had developed may have worked against them in the crises. Their relative advantage in valuing securities may have increased the asymmetric information they faced in dealing with relatively uninformed parties, who were in a position to take the opposite side of their trades.

In line with these arguments, our model provides an explanation for why so many financial intermediaries were so suddenly unwilling to trade with each other, despite the apparent gains to trade. Our model suggests these outcomes may be, at least in part, the consequences of inefficient over investment in financial expertise. In our model, levels of expertise that normally do not lead to illiquidity because of adverse selection do cause breakdowns in trade when volatility unexpectedly jumps.

The model we propose also explains why firms, whose business it is to facilitate or intermediate trade, would voluntarily acquire expertise, knowing it has the potential to create adverse selection that can impede trade, and thus destroy their business. In most models with adverse selection in finance, some party is exogenously asymmetrically informed. If they could (publicly) avoid becoming informed, they would do so.

For example, in the classic setting described in Myers and Majluf (1984), an owner-manager-entrepreneur wishes to finance investment in a new project by selling securities to outsiders who know less about the intrinsic value of his existing assets than he does. The positive Net Present Value of this new investment is common knowledge. The entrepreneur is assumed to have acquired his information through his past history managing the firm. This informational advantage, however, is an impediment to the entrepreneur in his dealings with the financial markets, as it costs him gains to trade associated with the NPV of the new investment. If he could manage the firm's assets effectively without acquiring this information, he would do so in order to minimize frictions associated with financing. Similarly, used-car dealers would not choose to employ expert mechanics if they could manage the car dealership without them and thus avoid the costs of the lemons problem in dealing with customers.

Given the obvious value of precommitting *not* to acquire information, why do we see financial firms, whose major business is intermediating and facilitating trading, investing vast resources in expertise that speeds and improves their ability to acquire and process information about the assets they trade? Indeed, as these entities have hired more Ph.D. graduates in finance, economics, and mathematics, and built up the elaborate information systems required to support their activities, they have increased the complexity and opacity of the financial instruments the experts and expert-systems are used to evaluate. That this has a social cost in the form of adverse-selection problems is quite evident from the massive breakdowns in liquidity associated with the sub-prime mortgage crises.

In our model, the acquisition of expertise becomes a prisoner's dilemma. Given the expertise of others, it confers upon any one party an advantage in bargaining that protects him from opportunism by his counterparties. In the simplest version of the model, traders invest resources in expertise in anticipation of future trading encounters with other traders. In each such encounter, an uninformed trader with private value for the asset offers to buy or sell with a take-or-leave it offer. His counterparty then observes a signal of the asset's value before accepting or rejecting the offer. The precision or informativeness of this signal is greater for traders who have invested in more financial expertise. The party with the bargaining advantage of making the initial offer offers a better price to a counterparty with more expertise, in order to preserve the gains to trade that are common knowledge. At this better price, efficient trade occurs, but the responding party claims some of the gains to trade. Looking forward, firms invest in expertise in anticipation of this advantage, but offsetting investments by other firms neutralizes the advantage in equilibrium. Under normal circumstances these investments are wasteful, but they do not interfere with efficient trade. The problem occurs if uncertainty about asset values jumps, and firms cannot immediately adjust their levels of expertise. At that point the adverse selection becomes too severe for efficient trade to be sustained. The central tradeoffs from this simple model survive in the more complex signalling game that arises when both parties come to a trading encounter with private information.

In the main version of our model, financial expertise, and the information experts acquire, are assumed to have no social value. We do not mean to imply that highly trained and compensated financial professionals literally "do nothing useful" for their pay. Rather, these arguments illustrate that part of their value to their firms, and thus of their compensation, is due to their ability to deter others from opportunistic behavior. From a social perspective, financial experts might be viewed as overqualified for the routine activities associated with their work. By analogy, the most highly paid divorce lawyers might well neutralize each other's impact on the division of their clients' assets. In equilibrium, the tasks they perform might be performed as competently by lawyers with less experience, expertise, and reputation who would charge less, but those lawyers would not serve to deter the other party's more expensive and experienced counsel. We also show that adding other benefits to expertise only strengthens the extent to which trade will break down in equilibrium.

The model in our paper is naturally interpreted as trading in an over-the-counter market, since trade involves bilateral bargaining rather than intermediation through a specialist or an exchange. Most of the complex securities associated with high levels of financial expertise are traded over the counter—including mortgage- and asset-backed securities, collateralized debt obligations (CDOs), credit default swaps (CDSs), currencies, and fixed-income products such as treasury, sovereign, corporate, and municipal debt. Several models of over-the-counter trading have been proposed in the literature, such as Duffie, Garleanu and Pedersen (2005) and Duffie, Garleanu and Pedersen (2007). In these models search frictions and relative bargaining power are the sources of illiquidity.

The search frictions are taken as exogenous. Investments in "expertise" that reduced search frictions would be welfare enhancing, and would lead to greater gains to trade. In contrast, adverse selection is the central friction in our model. Investments in expertise are socially wasteful and put gains to trade at risk.

Other models such as Carlin (2009) and Carlin and Manso (2010) view financial complexity as increasing costs to counterparties. In these two papers, however, the financial intermediary directly manipulates search costs to consumers, so these costs are most naturally interpreted as hidden fees for mutual funds, bank accounts, credit cards, and other consumer financial products. Our intent is to model an arms race among equals—intermediaries trading with each other in the financial markets. We interpret financial expertise as a relative advantage in verifying the value of a common-value financial asset in an environment where the complexity of the security, or the opacity of the trading venue, makes this costly.

Economists since Hirshleifer (1971) have recognized that in a competitive equilibrium, private incentives may lead agents to overinvest in information gathering activities that have redistributive consequences but no social value. Our model captures, in addition, the potential these investments have to create adverse selection, and thus destroy value beyond the resources invested directly in acquiring information. In addition, agents in our model behave strategically, rather than competitively, so we can capture the prisoner's dilemma they face, which drives them to invest in expertise in gathering information.

The general notion that economic actors may over-invest in professional services that help them compete in a zero-sum game goes back at least to Ashenfelter and Bloom (1993), which empirically studies labor arbitration hearings and argues that outcomes are unaffected by legal representation, as long as both parties have lawyers. A party that is not represented, when his or her opponent has a lawyer, suffers from a significant disadvantage. In this setting, however, the investment in legal services is not destructive of value beyond the fees paid to the lawyers. In our setting, expertise in finance has the potential to cause breakdowns in trade since it creates adverse selection.

Baumol (1990) and Murphy, Shleifer, and Vishny (1991) draw parallels between legal and financial services in arguing that countries with large service sectors devoted to such "rent-seeking" activities grow less quickly than economies where talented individuals are attracted to more entrepreneurial careers. They do not directly model the source of rent extraction, as we do.

Other papers such as Hauswald and Marquez (2006) and Fishman and Parker (2010) show that banks or investors can overinvest in acquiring information, as they do in our model. The banks in Hauswald and Marquez (2006) acquire information about the credit worthiness of borrowers because it softens price competition between the banks as they compete for market share. Investors in Fishman and Parker (2010) acquire information about the value of multiple projects because it helps them choose which projects to finance. Information can be socially useful in both of these settings in efficiently allocating capital. We model the interaction between financial intermediaries in their role as traders, where more expertise facilitates the (inefficient) acquisition of information about the assets to be traded and consequently improves bargaining positions. In our paper, expertise leads to periodic break downs in trade that can naturally be interpreted as periods of illiquidity.

The paper is organized as follows. In the next section we describe the model in its simplest form. An uninformed trader, who demands liquidity, makes a take-or-leave it offer to another trader, who can then observe a signal of the asset's value. That signal is more informative or precise if the trader has made investments in expertise. Section 3 studies the equilibria of the trading subgame where financial firms meet and bargain over the price of an asset. In Section 4 we evaluate the decision to invest in financial expertise, and prove our main results. Section 5 uses a parametric example to illustrate some of the features of the model. Section 6 studies how allowing for revenues from expertise that are unrelated to OTC trading affects the model's implications. In Section 7 we study the signalling game that arises when both parties to any one trading encounter come with private information from a signal. We show that the central tradeoffs from the simpler model survive in pooling equilibria in this setting, where play proceeds much as in the simpler case. Section 8 concludes.

2 Model

There is a continuum of risk-neutral and infinitely-lived financial intermediaries or traders. In each period t, $t = 1, \ldots, \infty$, trader i meets a random counterparty drawn from the set of potential traders, and they have the opportunity to exchange a financial security through bargaining in an ultimatum game. When they meet, agent i is assigned the role of "liquidity supplier" or "liquidity demander" with equal probability, and his counterparty assumes the other role. The liquidity demander can either be a buyer or seller, again with equal probability, and the liquidity supplier assumes the other role. At $t = 0$ trader i can invest resources, denoted e_i, in financial expertise. This serves to increase the precision of information about the values of the assets he will be bargaining over when he must respond to future offers to buy or sell in his role as a liquidity supplier. The asset traded in any given encounter has a common-value component, v. The party demanding liquidity also has a private value for the asset that generates gains to trade. If he is a buyer his valuation of the object is $v + 2\Delta$, and if he is a seller his valuation is $v - 2\Delta$. The gains to trade are common knowledge and constant through time. The liquidity supplier simply values the asset at its common value, v. The difference in private value can be interpreted as the result of a hedging need or from an opportunity to sell to or buy from a client at a favorable price.

The common value v is independently distributed through time. It can be high, $v = v_h$, or low, $v = v_l$, with equal probability. The distance between the two possible values is a measure of the uncertainty about that asset's value, or its volatility. We assume the common values are drawn from two possible regimes, high-volatility and low-volatility. The high-volatility regime is defined by more uncertainty concerning the common value—a larger distance between the possible outcomes, $(v_h - v_l)$. In the low-volatility regime, $v_h - v_l = \sigma > 0$, while in the high-volatility regime $v_h - v_l = \theta\sigma$, with $\theta > 1$. The high-volatility regime occurs infrequently, with probability π, compared to the low-volatility regime. Traders know, when they engage in bargaining, whether they are in the high or the low-volatility regime. They do not, however, know whether the value of the asset is high or low. Our central result is that, for any magnitude of volatility jump, if the probability of such jump is small enough, then traders will acquire the same level of expertise as if volatility is always low and liquidity will break down when volatility jumps.

We assume the party with private value for the asset (the liquidity demander) initiates trade, and acts as the first mover in an ultimatum game. He makes a take-it-or-leave-it offer to his counterparty at a price of p. The liquidity supplier responds by gathering information about the common value, and either accepting or rejecting the offer. Specifically, he observes a signal, $s = H$ or $s = L$, that the value is high or low. The probability that each signal received by trader i is correct is $\mu_i = \frac{1}{2} + e_i$, where $e_i \in [0, \frac{1}{2}]$ denotes his expertise, resulting from investments he has made at the initial date $t = 0$. The cost of resources that must be invested initially to attain expertise of e_i is $c(e_i)$. We assume this cost is positive, twice continuously differentiable, convex, and monotonically increasing ($c'(e) > 0, c''(e) > 0$). Expertise, which can be viewed as both human capital and the infrastructure to support it, allows a trader or an institution to more accurately value a security when responding to an offer under time pressure. Agents who do not acquire expertise receive uninformative signals, with $\mu_i = \frac{1}{2}$.

If the liquidity supplier accepts an offer of p and trade takes place, the proposer receives

$$v + 2\Delta - p$$

or

$$p - (v - 2\Delta)$$

depending on whether he is buying or selling, respectively. The liquidity supplier's payoff is $v - p$ or $p - v$. If no trade occurs both parties receive zero.

Some aspects of the model warrant comment at this point. First, we do not, at this point, allow the party demanding liquidity to acquire a signal about the value of the asset before making his offer. This simplifies the analysis, but allows us to describe the central intuition. It avoids the complications that arise when the first mover in the game has private information. In that case, the price he offers conveys information about his signal, resulting in a signalling game. We show in Section 7 that the central tradeoffs we describe here can be reproduced as a pooling equilibrium in the signalling game with off-equilibrium beliefs that are not unreasonable. Thus, the intuition we explore in this simpler setting carries over to the more complex environment. Traders have incentives to invest in expertise to the point that further investment would destroy gains to trade due to adverse selection under normal conditions of low volatility. In the simpler model this boundary is due to the incentives the responder has to act on his information. In the general case, it might also be associated with decision made by the proposer.

Second, the benefits of expertise are modelled here as higher precision to a signal that the liquidity provider always obtains. This avoids the complications associated with a decision to acquire information that depends on the offered price. Again, this allows us to describe in a simple setting tradeoffs that also arise in more complex ones. Other models for the benefits conferred by expertise in trading encounters will also support an arms race. For example, one could allow the responder to pay a cost to observe the common value, as in model of bargaining in Dang (2008), where this cost is decreasing in expertise.[2] This requires an analysis of the decision to pay the cost in the trading subgame, resulting in more possible outcomes and cases to consider than in the model we employ. One could also assume expertise simply increases the probability a trader knows the common value. This results in more cases to analyze, especially when the first mover can be informed, because traders then have private information both about whether they are informed and about the asset's value. In all these settings, however, the proposer will offer the responder a higher price to keep him from acquiring or responding to information and preserve gains to trade. This advantage in bargaining then leads to wasteful investment in expertise that can cause trade to break down when volatility jumps.

Finally, we give the liquidity demander all the bargaining power associated with the opportunity to make an ultimatum offer. Expertise, as we will see, protects the responding party from the opportunism of the proposer. Under alternative protocols, where the surplus is divided in some other way, the incentives we describe to acquire expertise should survive as long as the responding party is subject to some disadvantage.

More generally, this trading game is a relatively simple mechanism, in which the consequences of adverse selection are stark and straightforward to characterize. We can then highlight the trade-off between bargaining power gained with expertise and the increased risk of illiquidity, which is

[2]This is shown formally in earlier versions of this paper, available from the authors on request.

our central focus. The effects adverse selection has on trading outcomes in this setting, however, are similar to those in more complex and general mechanisms. Trade "breaks down" when parties bargaining are asymmetrically informed about valuations, even if it is common knowledge that there are gains to trade. For example, Myerson and Satterthwaite (1983) demonstrate that no bilateral trading mechanism (without external subsidies) achieves efficient ex-post outcomes. Efficient mechanisms all involve mixed strategies that with non-zero probability lead to inefficient allocations. Samuelson (1984) shows that when only the responder is informed, exchange occurs if and only if the proposer can successfully make a take-or-leave it offer, as we assume he can in our model. Admati and Perry (1987) show in pure-strategy bargaining games that asymmetric information results in costly delays in bargaining. Thus, illiquidity, or the loss of gains to trade in some circumstances, is a general feature of bilateral exchange mechanisms with asymmetric information. It is in no way unique to our setting.

We assume that all random variables are drawn independently across time, and that the trading histories of firms are not observable, consistent with the opacity of OTC markets. Levels of expertise, which are the result of investments made at $t = 0$, are known to all counterparties. These assumptions ensure that agent i plays the same trading game in each period, conditional on the expertise of his counterparty.

Information about the common value has no social value in this model. It simply serves to increase one's share of a fixed pie, unless it destroys value by shutting down trade due to adverse selection. Thus, investments in expertise, since they only serve to alter the precision of information, are socially wasteful. For now, we are abstracting from any broader benefits to expertise and information acquisition, such as improved risk sharing or better coordination of real investment due to more informative prices. This highlights the incentives to engage in an arms race in expertise, despite the costs of adverse selection it engenders In Section 6, we consider how allowing for revenues from expertise that are unrelated to OTC trading affects the model's implications

3 The Trading Subgame

In this section we take the precision of traders' signals as given, and analyze the bargaining problem that results.

In each bargaining subgame, the gains to trade are 2Δ. Under symmetric information, where the signal, s, received by the liquidity supplier is public, the proposer would simply make a take-or-leave-it offer of $p = E(v \mid s)$. The liquidity supplier would accept, and earn his reservation expected payoff of zero, while the proposer would capture the full surplus. Since each party moves first half the time, the expected surplus to each is Δ.

Suppose, instead, the signal is private, and agent i is in the position of supplying liquidity. His signal is accurate with probability $\mu_i = \frac{1}{2} + e_i$. The party proposing a price now faces adverse selection. He must take into account that his counterparty may sell only if his signal is high, or buy only if it is low. We explicitly analyze the case where the demander of liquidity wishes to buy. Proposition 1 summarizes the results of these arguments, and provides formulas for all possible cases.

The first mover (buyer) will always prefer to pay a lower price, given the liquidity supplier's (seller's) response. That response depends on his signal. For sufficiently high prices, where

$$p \geq E(v \mid s_i = H), \tag{1}$$

he will sell even if his signal tells him the asset is valuable. If the price is lower than $E(v \mid s_i = H)$ he will reject the offer unless his signal is low, and so trade will only occur half the time at such a price. Let the lowest price at which agent i would accept with a low signal be denoted

$$\begin{aligned} p^* &= E(v \mid s_i = L) \\ &= (1 - \mu_i)v_h + \mu_i v_l, \end{aligned} \tag{2}$$

and the lowest price at which he will always accept be

$$\begin{aligned} p^{**} &= E(v \mid s_i = H) \\ &= \mu_i v_h + (1 - \mu_i) v_l. \end{aligned} \tag{3}$$

If the proposer offers the higher price, p^{**}, trade always occurs, but he shares some of the surplus with the seller because he is overpaying when the seller receives a low signal. The buyer's expected surplus is

$$\begin{aligned} E(v) + 2\Delta - p^{**} &= 2\Delta - (v_h - v_l)\left(\mu_i - \frac{1}{2}\right) \\ &= 2\Delta - (v_h - v_l) e_i. \end{aligned} \tag{4}$$

The seller's expected surplus at this price (unconditionally, across both possible realizations of his signal) is

$$\begin{aligned} E[p^{**} - E(v \mid s_i)] &= p^{**} - E(v) \\ &= (v_h - v_l)(\mu_i - \frac{1}{2}) \\ &= (v_h - v_l) e_i. \end{aligned} \tag{5}$$

If the buyer offers p^*, which will only be accepted when the seller has received a low signal, his expected payoff is

$$\frac{1}{2}(2\Delta + E(v \mid s_i = L) - p^*) = \Delta, \tag{6}$$

and the expected surplus for the seller is his reservation price of zero.

The buyer's offer in the trading subgame will be the price that yields the higher expected payoff to him. Comparing (6) and (4), he will offer the higher price p^{**} if

$$2\Delta - (v_h - v_l) e_i \geq \Delta \tag{7}$$

or if

$$e_i \leq \frac{\Delta}{v_h - v_l} \tag{8}$$

The tradeoffs from the proposer's perspective in this model are simple. If he pays a higher price, he preserves gains to trade but he must share some of those gains with the liquidity provider. As is evident in equations (4) and (5) the "bribe" the buyer must pay to keep the seller from responding to his information is increasing in the accuracy of that information—in his financial expertise. This drives the arms race in our model. If the liquidity provider's level of expertise is too high, however, condition (8) tells us that the buyer will switch to a lower price at which the seller earns no surplus and trade breaks down half the time due to adverse selection. This limits the arms race. Note that the bound on expertise tightens if volatility rises relative to the gains to trade. Therefore, investments in expertise that still allow for efficient trade under normal circumstances might inhibit trade and destroy value when volatility is abnormally high.

The proposition below summarizes the equilibrium for the subgame:

Proposition 1 *In the trading subgame with an uninformed proposer, if the responder's level of expertise satisfies* $e_i \leq \frac{\Delta}{v_h - v_l}$*:*

- *the proposer's expected payoff is*
$$2\Delta - (v_h - v_l)e_i$$
- *the responder's expected payoff is*
$$(v_h - v_l)e_i$$
- *the equilibrium price is* $E(v \mid s_i = H)$ *if the proposer is buying and* $E(v \mid s_i = L)$ *if the proposer is selling.*

If instead $e_i > \frac{\Delta}{v_h - v_l}$*:*

- *the proposer's expected payoff is* Δ
- *the responder's expected payoff is zero*
- *the equilibrium price is* $E(v \mid s_i = L)$ *if the proposer is buying and* $E(v \mid s_i = H)$ *if the proposer is selling.*

Proof: The arguments in the text above prove the result for the case when the proposer is the buyer. The appendix provides analogous derivations when the proposer is the seller.

4 Investing in Expertise

It is evident from the previous section that if all traders invest in expertise below the bound $\bar{e} = \frac{\Delta}{v_h - v_l}$ then trade is efficient: it takes place with probability one. In this section we consider the equilibrium choices of expertise, and show that for reasonable cost functions for investment in expertise the equilibrium involves all traders investing to this boundary for the low-volatility regime. An arms race occurs. As a result, when volatility rises unexpectedly, liquidity breaks down.

We assume the common values are drawn from two possible regimes, high-volatility and low-volatility. In the normal, or low-volatility regime, $v_h - v_l = \sigma$. This regime occurs with probability $1 - \pi$. The high-volatility regime occurs infrequently, with probability π. The two possible values are then further apart: $v_h - v_l = \theta\sigma$, where $\theta > 1$. Traders know, when they engage in bargaining, whether they are in the high or the low-volatility regime.

To understand the incentives at work, consider agent's i's best response assuming $\pi = 0$—that is, if there is just one volatility regime and $v_h - v_l = \sigma$. Suppose his counterparty is agent j, and $e_j \leq \bar{e} = \frac{\Delta}{\sigma}$. Then the analysis in the previous section tells us that agent i's expected payoff in any subgame where he is the proposer is

$$2\Delta - \sigma e_j \tag{9}$$

and his payoff when he supplies liquidity is

$$\sigma e_i. \tag{10}$$

as long as $e_i \leq \bar{e}$. Each of these outcomes occur with probability one-half, so his ex ante expected payoff in such a subgame at the time when he invests in expertise, is, for $e_i \leq \bar{e}$,

$$\Delta + \frac{1}{2}\sigma(e_i - e_j) \tag{11}$$

In a Nash equilibrium, trader i takes the investment his counterparties make in expertise as given. His payoff increases linearly in his own expertise up to the boundary $\bar{e}$, where it drops discontinuously, and so if the marginal cost of investment in expertise does not rise to quickly, he will invest to that point. But then so will agent j, so that the advantage offered by expertise is neutralized in equilibrium. Whatever bargaining advantage the trader gains as a proposer through expertise, he loses as a responder to the expertise of others. Trade is efficient, and the expected surplus earned by any trader ex-ante is Δ, half the total gains to trade. With one volatility regime, the only destruction due to expertise is the wasted resources of $c(\bar{e})$ for each trader.

The conditions on the cost function that ensure a symmetric equilibrium at the upper boundary with $\pi = 0$ are straightforward. The expected payoff for agent i in any given trading encounter, assuming his counterparty is agent j, is:

$$\frac{1}{2}e_i\sigma\chi\left(e_i \leq \frac{\Delta}{\sigma}\right) + \frac{1}{2}\left[\Delta + (\Delta - e_j\sigma)\chi\left(e_j \leq \frac{\Delta}{\sigma}\right)\right]. \tag{12}$$

The first term represents the expected payoff for agent i when he is a responder, which occurs with probability $\frac{1}{2}$, and the second term represents his expected payoff when he is a proposer. As is obvious from the equation, his choice of e_i will be independent of his counterparties' choices of expertise, $e_j, j \neq i$. Hence, agent i's optimal investment in expertise will maximize:

$$\frac{1}{2(1-\delta)}e_i\sigma\chi\left(e_i \leq \frac{\Delta}{\sigma}\right) - c(e_i). \tag{13}$$

This expression is the discounted sum of the portion of his periodic payoffs that depends on his own expertise less the initial cost of building expertise.

Assuming, as we do, that all agents face the same cost function $c(\cdot)$, all agents acquire will $\bar{e}$ of expertise if $c'(\bar{e}) \leq \frac{1}{2(1-\delta)}\sigma$. Otherwise all agents acquire $\hat{e}$, the level of expertise that satisfies

$$c'(\hat{e}) = \frac{1}{2(1-\delta)}\sigma, \tag{14}$$

which is the first-order condition of equation (13). Furthermore, the strict convexity of the cost function ensures that no other expertise level can provide agent i with the same payoff as $\bar{e}$ or $\hat{e}$, hence no mixed strategy equilibria will exist either. Therefore, the equilibrium above is unique.

Now, consider the same steps when volatility is stochastic. The expected periodic payoff for agent i is then given by:

$$\frac{1}{2}\left[(1-\pi)e_i\sigma\chi\left(e_i \leq \frac{\Delta}{\sigma}\right) + \pi e_i\theta\sigma\chi\left(e_i \leq \frac{\Delta}{\theta\sigma}\right)\right] \tag{15}$$
$$+ \quad \frac{1}{2}\left[\Delta + (1-\pi)(\Delta - e_j\sigma)\chi\left(e_j \leq \frac{\Delta}{\sigma)}\right) + \pi(\Delta - e_j\theta\sigma)\chi\left(e_j \leq \frac{\Delta}{\theta\sigma}\right)\right].$$

As before, the first term represents the expected payoff for agent i when he is a responder and the second term in brackets represents his expected payoff when he is a proposer. The independence of optimal strategies is again obvious from this expression. The effects of changes in e_i do not depend on e_j. Trader i's choice of e_i will be independent from his opponent's expertise level e_j. Hence, agent i's optimal investment in expertise will maximize

$$\frac{1}{2(1-\delta)}\left[(1-\pi)e_i\sigma\chi\left(e_i \leq \frac{\Delta}{\sigma}\right) + \pi e_i\theta\sigma\chi\left(e_i \leq \frac{\Delta}{\theta\sigma}\right)\right] - c(e_i). \tag{16}$$

When volatility is stochastic, there are four candidates for the equilibrium level of expertise:

1. the highest level of expertise that allows efficient trade in the low-volatility regime: $\bar{e} \equiv \frac{\Delta}{\sigma}$,
2. the highest level of expertise that allows efficient trade in the high-volatility regime: $\bar{\bar{e}} \equiv \frac{\Delta}{\theta\sigma}$,
3. the level of expertise that satisfies the first-order condition in the low-volatility regime: $\hat{e}_h$ such that,
$$\frac{1}{2(1-\delta)}(1-\pi)\sigma = c'(\hat{e}_h), \tag{17}$$
4. the level of expertise level that satisfies the first-order condition in the high-volatility regime: $\hat{e}_l$ such that,
$$\frac{1}{2(1-\delta)}\left[(1-\pi)\sigma + \pi\theta\sigma\right] = c'(\hat{e}_l). \tag{18}$$

The next proposition shows that if the marginal cost of expertise does not increase too quickly, so that expertise is relatively inexpensive in comparison to its discounted expected benefits in the low-volatility regime and $\bar{e}$ is the equilibrium with $\pi = 0$, then the continuity of an agent's payoff function in π ensures that all agents acquiring $\bar{e}$ remains the unique equilibrium as long as the high-volatility regime is sufficiently unlikely.

Proposition 2 *Suppose that*

$$\frac{\sigma}{2(1-\delta)} > c'\left(\frac{\Delta}{\sigma}\right), \tag{19}$$

so that $\bar{e} = \frac{\Delta}{\sigma}$ is the unique equilibrium with a single, low-volatility regime (with $\pi = 0$). Then, for any $\theta > 1$, there exists a $\pi^{\theta} > 0$ such that, for any $\pi < \pi^{\theta}$, $\bar{e}$ remains the unique equilibrium in the choice of expertise.

The upper bound on π is given by:

$$\pi^{\theta} = \min\left\{1 - \frac{2(1-\delta)}{\sigma}c'\left(\frac{\Delta}{\sigma}\right), \frac{\left(1-\frac{1}{\theta}\right)\Delta - 2(1-\delta)\left[c\left(\frac{\Delta}{\sigma}\right) - c\left(\frac{\Delta}{\theta\sigma}\right)\right]}{\left(2-\frac{1}{\theta}\right)\Delta}\right\}. \tag{20}$$

Proof: Provided in the appendix.

The intuition behind the proof is that if π is less than the first term under the $\min\{\cdot,\cdot\}$ operator in (20), then the inequality (19) in the proposition ensures that the marginal gains from expertise in the the low-volatility regime exceed the marginal cost of expertise, even though the low-volatility regime is less probable. The convexity of the cost function then allows us to rule out the two candidate equilibrium levels of expertise associated with the first-order conditions holding with equality, and limit the comparison to $\bar{e}$ and $\bar{\bar{e}}$. The second term under the $\min\{\cdot,\cdot\}$ operator ensures that the probability of the high-volatility regime is sufficiently low to ensure that the extra cost of investing the higher level of expertise, $c(\bar{e}) - c(\bar{\bar{e}})$, combined with the expected loss of gains to trade when volatility is high, do not offset the extra benefits associated with gaining a better price when responding to offers when volatility is low.

Hence, our model predicts that, in some circumstances, financial intermediaries might find optimal to acquire expertise even though it makes trade fragile when the volatility in fundamental value is high. Acquiring expertise makes an intermediary better able to assess an asset's value, which amplifies the possibility of an adverse selection problem. The threat of facing a better informed counterparty might force an intermediary to make him a better offer to ensure that trade takes place. But as volatility goes up, the value of information also goes up and the proposer is unable to make an offer that is simultaneously viable for him and always accepted by the responder. Trade will break down half of the time in the high-volatility regime. However, if the probability of the high-volatility regime is small enough, the gains to trade lost in the high-volatility regime will not be as important as the increase in profits that added expertise, and the ensuing improved bargaining position, bring in the low-volatility regime. The intermediary will find optimal to acquire the level of expertise that maximizes expected profits in the more probable low-volatility regime, even though it leads to a loss of profits due to trade breakdowns in the less probable high-volatility regime. As a result, trade will break down with an unconditional probability of $\frac{\pi}{2}$ in equilibrium.

5 Parameterization

In this section we parameterize our model, in order to better illustrate the model's implications. We assume the cost $c(e)$ of acquiring a level of expertise e is given by $c(e) = \frac{\kappa}{2}e^2$. In this case, the threshold π^θ becomes:

$$\pi^\theta = \min\left\{1 - 2(1-\delta)\frac{\kappa\Delta}{\sigma^2}, \frac{\left(1-\frac{1}{\theta}\right) - (1-\delta)\left(1-\frac{1}{\theta^2}\right)\kappa\frac{\Delta}{\sigma^2}}{\left(2-\frac{1}{\theta}\right)}\right\}. \tag{21}$$

Note that both arguments in the $\min\{\cdot,\cdot\}$ operator are decreasing in $\frac{\kappa\Delta}{\sigma^2}$. If, instead, we take π as given, we can rewrite the two conditions ensuring that $\bar{e}$ is the unique equilibrium in expertise as:

$$\frac{\kappa\Delta}{\sigma^2} < \min\left\{\frac{1-\pi}{2(1-\delta)}, \frac{1-2\pi-\frac{(1-\pi)}{\theta}}{(1-\delta)\left(1-\frac{1}{\theta^2}\right)}\right\}. \tag{22}$$

Thus, the arms race equilibrium, which of course puts gains to trade at risk, is more likely to hold when these gains to trade, Δ, are low relative to the routine volatility, σ. Increasing the cost of acquiring expertise, κ, also works against the arms race equilibrium for obvious reasons.

Figure 1 plots the maximum probability for the high-volatility regime, π^θ, that supports the arms-race equilibrium with trade breakdowns as a function of the magnitude of the jump, θ. The parameter values used in this figure are $\sigma = 1$ (base volatility is a free normalization), $\Delta = 0.2$ (gains to trade), $\delta = 0.9$ (discount factor), and $\kappa = 10$ (marginal cost of acquiring expertise). The lesson to be drawn from this figure is that the probability of a jump to the high volatility regime, with a loss of half the gains to trade, can be quite substantial. It ranges from around 5% when the jump in volatility is 10%, to around 15% when that jump is 50%. The relationship between π^{θ} and θ is increasing in this figure because, in this parameterization, a higher θ increases the differential in payoffs between $\bar{e}$ and $\bar{\bar{e}}$, in the low volatility regime, at a higher rate than the differential in costs of expertise. Essentially, when the two regimes are close together (θ close to one) then the cost, under normal circumstances, of lowering expertise so that efficient trade is preserved when volatility jumps is reduced.

Figure 2 shows the relationship between the equilibrium level of expertise and the gains to trade when we set $\theta = 1.2$, and $\pi = 0.05$ and Δ is allowed to vary. When Δ is small enough for the inequality in (22) to hold ($\Delta < 3.55$), the equilibrium level of expertise is equal to $\bar{e}$, which is increasing in Δ. Once Δ becomes large enough, however, and (22) is violated ($\Delta \geq 3.55$), expertise drops discretely from $\bar{e} = \frac{\Delta}{\sigma}$ to $\bar{\bar{e}} = \frac{\Delta}{\theta\sigma}$, which is also increasing in Δ but at a lower rate.

Intuitively, when gains to trade are small enough relative to the volatility in asset value, intermediaries are willing to acquire high levels of expertise even though this expertise leads to some trade breakdowns when volatility is high. On the other hand, when gains to trade get larger, the potential losses due to trade breakdowns become too important and intermediaries prefer to dial down on expertise to ensure that trade takes place even when volatility is high.

6 Other Benefits from Financial Expertise

The simple model we analyzed so far focuses on the role of expertise in valuing and trading securities in an over-the-counter setting. Abstracting away all other benefits from financial expertise yields stark results about the incentives of financial firms to acquire expertise before trading with competing firms. Of course, in reality financial expertise can have other benefits, and produce revenues, that are unrelated to trading and that affect firms' decisions to acquire expertise.

So let's assume that, in addition to earning revenues from the trading game in our model, a firm with expertise e earns in each period a revenue $r(e)$ that is unrelated to trading. This revenue is increasing and weakly concave in the level of expertise and can come, for example, from investment banking activities or revenues and fees from improving their clients' risk-management processes. The expected periodic payoff for firm i is the payoff we had in equation (15) for the simple model plus $r(e_i)$.

The consequence of adding revenue $r(e)$ to the benefits of expertise in our model is that the acquisition of expertise more attractive for all firms. Since it is unrelated to trading payoffs, adding $r(e)$ where $r'(e) > 0$ is equivalent to reducing the cost $c(e)$ of expertise by $\frac{1}{1-\delta}r(e)$. Therefore, the earlier conditions required for expertise $\bar{e}$ to be optimal are easier to satisfy when $r(e)$ enters the payoff function.

The novelty from adding $r(e)$ is that, in some circumstances, firms will not stop at $\bar{e}$ when acquiring expertise. If $r(e)$ increases sufficiently quickly in the region where $e > \bar{e}$, the unique equilibrium will now be an arms race in expertise where all firms acquire a level of expertise $\widetilde{e}$ ($> \bar{e}$) that satisfies:

$$\frac{1}{1-\delta}r'(\widetilde{e}) = c'(\widetilde{e}). \tag{23}$$

In such equilibrium, the marginal benefits of expertise are so high that firms continue to acquire expertise well past the previous equilibrium level $\bar{e}$ even though it implies that trade will break down half of the time in the low-volatility regime as well as in the high-volatility regime. The extra revenues $\frac{1}{1-\delta}[r(\widetilde{e}) - r(\bar{e})]$ from the higher expertise are larger than the expected loss in gains to trade in the low-volatility regime $\frac{1}{1-\delta}\pi\Delta$ and the cost savings $[c(\bar{e}) - c(\widetilde{e})$. Hence, firms maximize their total payoff, net of the cost of expertise, by picking the same level of expertise they would pick if expertise did not affect what happens in the trading game.

To summarize, accounting for other revenues generated by financial expertise strengthens the incentives of financial firms to acquire expertise and breakdowns in trade are then as frequent, if not more, than in our earlier model without such revenues.

7 The Signalling Game with Two-Sided Asymmetric Information

In the previous sections we treated financial expertise as a capacity to accurately assess the value of an asset under time pressure in response to an offer to trade. We assumed that the intermediaries or traders use this expertise in their role as liquidity suppliers. The party making the offer to trade was the source of private benefits, but did not receive an informative signal. This simplified the analysis, since the first mover's offer did not convey private information, while still allowing us to illustrate the incentives that create an arms race. Intermediaries have private incentives to invest in expertise as a deterrent in bargaining, even though it risks the social surplus generated by trade.

Our goal in this section is to show that these tradeoffs survive in the signalling game that arises when expertise informs the actions of both the proposer and responder in any given trading encounter. When the proposing party is informed, his offer influences the beliefs of the responder, and thus his willingness to accept. As is typically the case in such settings, there are many equilibria. Our approach is to show, first, that only pooling equilibria, where proposers with high signals offer the same price as proposers with with low signals, support efficient trade. Second, we show that a pooling equilibrium exists in which the first mover offers the same price as he would if he were uninformed, and play proceeds as in the previous sections. This equilibrium is supported by off-equilibrium beliefs that appear quite reasonable. Third, we show that the conditions under which this pooling equilibrium exists restrict the level of expertise of the players in terms of the volatility. Finally, the ex-ante expected payoffs in the pooling equilibrium to the players are the same as in the subgame with an uninformed first mover. They are linear and increasing in their own expertise. Thus, if play in the trading subgames proceeds in a manner that preserves gains to trade under normal, low-volatility conditions, and traders increase their expertise in anticipation of this, a jump in volatility will lead to a breakdown in trade.

Again, we develop in details the case where the first mover wishes to buy, and the responding, liquidity supplier takes the role of a potential seller. We provide solutions for both cases, and proofs of them, in the proposition at the end of the section.

Let $s_b \in \{H, L\}$ denote the buyer's signal and $s_s \in \{H, L\}$ that of the seller. We similarly denote as $\mu_s = \frac{1}{2} + e_s$ and $\mu_b = \frac{1}{2} + e_s$ the probabilities, which depend on expertise, that the signals are correct. We must now also consider the following quantities for the low-signal buyer,

$$\begin{aligned}\psi_L^L &\equiv \Pr\{s_s = L \mid s_b = L\} \\ &= \mu_b\mu_s + (1-\mu_b)(1-\mu_s) \end{aligned} \tag{24}$$

$$\begin{aligned}\phi_{LL}^l &\equiv \Pr\{v = v_l \mid s_b = L, s_s = L\} \\ &= \frac{\mu_b\mu_s}{\mu_b\mu_s + (1-\mu_b)(1-\mu_s)}, \end{aligned} \tag{25}$$

and for the high-signal buyer,

$$\begin{aligned}\psi_L^H &= \Pr\{s_s = L \mid s_b = H\} \\ &= \mu_b(1-\mu_s) + \mu_s(1-\mu_b) \end{aligned} \tag{26}$$

$$\begin{aligned}\phi_{HL}^l &= \Pr\{v = v_l \mid s_b = H, s_s = L\} \\ &= \frac{\mu_s(1-\mu_b)}{\mu_b(1-\mu_s) + \mu_s(1-\mu_b)}, \end{aligned} \tag{27}$$

It is straightforward to demonstrate the following result.

Proposition 3 *The only equilibria in which efficient trade always occurs are pooling equilibria in which the high-signal and low-signal proposers offer the same price.*

Proof: Suppose there is an equilibrium in which different types of proposers offer different prices. In such an equilibrium, if trade is to be efficient, the responder always accepts the proposer's offer. If the proposer anticipates such a response, then he should offer the price that is favorable to himself (lower if he buys, higher if he sells), regardless of his signal, a contradiction.∎

The next question, then, is whether pooling equilibria that support efficient trade exist. We conjecture an equilibrium of the following sort.

- Buyers of both types offer the lowest price at which the seller, knowing nothing about the buyer's signal, would accept regardless of the seller's signal. This is, of course, the same price buyers offer when they are uninformed, as in Section 3:

$$p^{**} = \mu_s v_h + (1 - \mu_s) v_l \tag{28}$$

- Sellers believe any offer of a lower price is uninformative, equally likely to come from either type.

We argue that the seller's off equilibrium beliefs are reasonable, since all buyers prefer a lower price. The marginal impact of a lower price on their payoffs is the same, irrespective of their type. In contrast, the beliefs that typically make it "easy" to sustain pooling are that any defector from the pool is a "bad" type. In this context, that would correspond to beliefs that any lower offer comes from a buyer with a high signal.

Given that both buyer types offer p^{**}, when the seller accepts he receives the same unconditional expected payoff as he obtains with an uninformed buyer, which from equation (5) is $(v_h - v_l)\left(\mu_s - \frac{1}{2}\right)$. Since the seller accepts this price regardless of his signal, the buyer learns nothing about the seller's signal.

To verify that pooling at p^{**} is an equilibrium, we must check that it is incentive compatible for both the high- and low-signal buyers. First, note that there is no incentive for either type of buyer to defect from the proposed equilibrium by offering a price higher than p^{**}, regardless of the seller's beliefs. At best, the seller would always accept, which he will do at p^{**} in any case, and the buyer will pay more. It remains, therefore, to verify that neither buyer will defect to a lower price.

The payoff to a low-signal buyer from offering p^{**} is:

$$\begin{aligned} E(v \mid s_b = L) + 2\Delta - p^{**} &= 2\Delta + (v_h - v_l)(1 - \mu_b - \mu_s) \\ &= 2\Delta - (v_h - v_l)(e_b + e_s) \end{aligned} \tag{29}$$

As long as the signals are informative (positive expertise), the buyer must surrender some of his surplus to the seller to induce him to accept the offer. With $\mu_b = \frac{1}{2}$ and $e_b = 0$, this is the same expression as we obtained with an uninformed buyer, equation (4). The buyer's expected payoff in this case is lower because his signal is low, and he knows he is overpaying by more relative to the common value.

If the buyer offers a price $p < p^{**}$, the seller views this as uninformative about the buyer's signal. The seller will therefore only accept the offer if his own signal is low, and will earn zero surplus. Given this response, the buyer should offer the lowest price possible, which is $p^* = E(v \mid s_s = L)$. Now, however, the probability that the seller accepts, ψ_L^L, depends on the buyer's signal and its precision, and the information conveyed by this acceptance confirms the buyer's signal. The buyer's expected payoff is therefore

$$\begin{aligned}
&\psi_L^L[E(v \mid s_b = L, s_s = L) + 2\Delta - p^*] \\
&= \psi_L^L[(1 - \phi_{LL}^l)v_h + \phi_{LL}^l v_l + 2\Delta - (1 - \mu_s)v_h - \mu_s v_l] \\
&= \psi_L^L[2\Delta - (v_h - v_l)(\phi_{LL}^l - \mu_s)] \qquad (30)
\end{aligned}$$

In this expression, the buyer loses surplus, conditional on a trade occurring, as long as both signals are more informative than that of the seller alone. The buyer is overpaying ex-post, because the seller's acceptance confirms his signal. As the signals become less informative, the buyer's payoff at this price approaches Δ, as in the case of an uninformed buyer, equation (6).

Comparing these payoffs, the low-signal buyer will not deviate to a lower price as long as

$$2\Delta + (v_h - v_l)(1 - \mu_b - \mu_s) \geq \psi_L^L[2\Delta - (v_h - v_l)(\phi_{LL}^l - \mu_s)] \qquad (31)$$

Substituting for the conditional probabilities from (24) and 25), and for the signal precisions, $\mu_i = \frac{1}{2} + e_i$, we find after some simplification that the condition above is equivalent to:

$$\frac{2\Delta}{v_h - v_l} \geq \frac{\frac{e_b}{2} + e_s + 2e_b e_s^2}{\frac{1}{2} - 2e_b e_s} \qquad (32)$$

Note that as expertise rises, from zero to its maximum value of $\frac{1}{2}$, the numerator on the right-hand side of (32) approaches unity, while the denominator approaches zero. Thus, for fixed gains to trade relative to volatility, the incentive compatibility condition bounds the level of expertise, as in equation (8) when the buyer is uninformed.

For a buyer with a high signal, the expected payoff from offering p^{**}, given that it is always accepted by the responding seller, is

$$\begin{aligned} E(v \mid s_b = H) + 2\Delta - p^{**} &= 2\Delta + (v_h - v_l)(\mu_b - \mu_s) \\ &= 2\Delta - (v_h - v_l)(e_s - e_b) \end{aligned} \tag{33}$$

In this case, the buyer may be overpaying or underpaying at p^{**}, depending on whose signal is more accurate.

The same buyer's expected payoff if he offers p^* reflects the conditional probability that the seller has a low signal, which is required for him to accept a low offer, and the value of the asset conditional on the seller revealing a low signal through his decision:

$$\begin{aligned} &\psi_L^H[E(v \mid s_b = H, s_s = L) + 2\Delta - p^*] \\ &= \psi_L^H[(1 - \phi_{HL}^l)v_h + \phi_{HL}^l v_l + 2\Delta - (1 - \mu_s)v_h - \mu_s v_l] \\ &= \psi_L^H[2\Delta - (v_h - v_l)(\phi_{HL}^l - \mu_s)] \end{aligned} \tag{34}$$

As before, this expression goes to Δ as expertise goes to zero, and the signals become uninformative. Even at this lower price, the buyer may overpay conditional on trade occurring, depending on the accuracy of his signal relative to that of the seller. This determines whether ϕ_{HL}^l is less than or greater than μ_s.

Pooling will be incentive compatible for the high-signal buyer if

$$2\Delta + (v_h - v_l)(\mu_b - \mu_s) \geq \psi_L^H[2\Delta - (v_h - v_l)(\phi_{HL}^l - \mu_s)] \tag{35}$$

Substituting from (26) and (27) for the conditional probabilities, rewriting the precisions in terms of expertise and simplifying then yields:

$$\begin{aligned}\frac{2\Delta}{v_h - v_l} &\geq \frac{(1-\mu_s)\mu_b\mu_s + \mu_s^2(1-\mu_b) - \mu_s(1-\mu_b) - \mu_b + \mu_s}{1-\mu_b(1-\mu_s)+\mu_s(1-\mu_b)} \\ &= \frac{e_s - 2e_s^2 e_b - \frac{e_b}{2}}{\frac{1}{2} + 2e_b e_s} \qquad (36)\end{aligned}$$

This constraint will never bind if pooling is incentive compatible for the low-signal buyer. Comparison of (36) with the incentive compatibility constraint for the low-signal type, (32), reveals that for $0 < e_s, e_b < \frac{1}{2}$, the denominator of (32) is always lower, and the numerator is always higher, than for (36).

We see, then, that the critical condition on the parameters that support a pooling equilibrium with efficient trade is (32), the incentive compatibility condition for a buyer who has information that the value of the asset is low. This constraint will be violated when volatility is too high, relative to the gains to trade, or when the expertise of the traders is too high.

Now consider the ex-ante expected payoffs to the buyer and seller from the trading subgame, in the pooling equilibrium, before knowing their signals. The buyer receives (29) or (33), with equal probability, or

$$2\Delta + (v_h - v_l)\left(\frac{1-\mu_s-\mu_b}{2} + \frac{\mu_b - \mu_s}{2}\right) = 2\Delta - (v_h - v_l)e_s \qquad (37)$$

Since trade always takes place, the seller receives the remaining surplus of

$$(v_h - v_l)e_s. \qquad (38)$$

Not surprisingly, since trade always occurs, and at the same prices as when the buyer is uninformed, the ex-ante payoffs are the same. Agent i, then, before knowing whether he or his opponent, agent j, is buyer or seller, earns an expected payoff of

$$\Delta + \frac{1}{2}(v_h - v_l)(e_i - e_j) \qquad (39)$$

Taking as given his opponents' levels of expertise, trader i will increase his expected payoff in any given trading encounter by increasing his expertise. There is an arms race in expertise. He will do this to the point where the marginal cost of additional expertise exceeds the discounted gains, or to the point where additional expertise violates the incentive compatibility constraints for the pooling equilibrium, thus destroying surplus.

The next proposition summarizes these arguments, and covers the case where the first mover is a seller.

Proposition 4 *In the trading subgame where trader j is the proposer and trader i the responder, if the their levels of expertise satisfy*

$$\frac{2\Delta}{v_h - v_l} \geq \frac{\frac{e_j}{2} + e_i + 2e_j e_i^2}{\frac{1}{2} - 2e_j e_i} \tag{40}$$

there exists a pooling equilibrium with the following properties

- *The proposer's expected payoff is*
$$2\Delta - e_i(v_h - v_l).$$
- *The responder's expected payoff is*
$$e_i(v_h - v_l).$$
- *The equilibrium price is $E(v \mid s_i = H)$ if the proposer is buying and $E(v \mid s_i = L)$ if the proposer is selling.*
- *The responder, if selling, believes any lower proposed price is equally likely to come from either type of buyer, and if the responder is buying he believes any higher price is equally likely to come from either type.*
- *Trade always takes place.*

Proof: The arguments in the text above prove the result for the case when the proposer is the buyer. The appendix provides analogous derivations when the proposer is the seller.

In summary, the proposition shows that in any equilibrium preserving efficient trade in the trading subgame where both parties have private information expertise plays the same role it does for the simpler cases analyzed earlier. It deters opportunistic offers by the party initiating the trade. The private incentives agents have to invest in expertise are limited by the incentive compatibility conditions, and this bound decreases when volatility rises. Thus, investments in expertise made in anticipation of efficient trade in the subgame could put gains to trade at risk if volatility jumps.

8 Conclusion

The model in this paper illustrates the incentives for financial market participants to overinvest in financial expertise. Expertise in finance increases the speed and efficiency with which traders and intermediaries can determine the value of assets when they are negotiating with potential counterparties. The lower costs give them advantages in negotiation, even when the information acquisition has no value to society, and even when it can create adverse selection that disrupts trade if uncertainty about the volatility of fundamental values increases too quickly or unexpectedly to allow intermediaries to adjust or scale back their investment in expertise. If jumps in volatility are sufficiently infrequent, the gains to trade lost in the high-volatility regime will not be as important as the increase in profits that added expertise, and the ensuing improved bargaining position, bring in the low-volatility regime. The intermediary will find optimal to acquire expertise that increases expected profits in the more probable low-volatility regime, even though the advantage gained is neutralized by similar investments by counterparties in equilibrium, and even though expertise decreases profits because of trade breakdowns when volatility jumps.

Some extensions to the model may warrant additional research. Financial expertise might also allow intermediaries to decrease the precision of information acquired by their counterparties, as well as increasing the precision of their own information. Investment in expertise permits firms to create, and make markets in, more complex financial instruments. In our notation, we can view the precision of information about intrinsic value for agent i as $\mu(e_i, e_j)$, which decreases in i's own expertise and increases in that of his counterparty. The logic of our analysis suggests firms benefit from increasing the relative costs of their counterparties. The tension between the incentives to decrease others' signal precision, which would reduce adverse selection, and increase one's own signal precision, which increases it, may help us better understand innovation and evolution in financial markets.

In our model, intermediaries invest in expertise only once, and the volatility states are drawn independently through time. This illustrates the consequences shocks to volatility have for liquidity. If volatility is persistent through time, and intermediaries can adjust, with some adjustment costs, their level of expertise in response to changing volatility, then shocks to volatility will still lead to breakdowns in liquidity, but they will also trigger contractions in “expertise” which can be interpreted as employment of financial professionals. Such a model might be informative about the nature of employment cycles in financial services.

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Appendix

Proof of Proposition 1: The arguments in the text prove the proposition for the case where the proposer buys. If the proposer sells, the highest price at which he can ensure acceptance of his offer for any signal is

$$p^{**} = E(v \mid s_i = L) \tag{A-1}$$

and his payoff is

$$\begin{aligned} p^{**} - [E(v) - 2\Delta] &= 2\Delta - (v_h - v_l)\left(\mu_i - \frac{1}{2}\right) \\ &= 2\Delta - (v_h - v_l)e_i. \end{aligned} \tag{A-2}$$

The highest price at which trade will occur at least half the time is

$$p^{*} = E(v \mid s_i = H) \tag{A-3}$$

and the seller's payoff is

$$\frac{1}{2}(p^{*} - [E(v \mid s_i = H) - 2\Delta]) = \Delta \tag{A-4}$$

Comparing these expressions for the seller's payoff to those for the buyer's payoffs in the text reveals they are identical. A comparison of the payoffs at price p^{**} and p^{*} then yields the same inequality for the level of expertise.∎

Proof of Proposition 2:

If

$$\frac{1}{2(1-\delta)}(1-\pi)\sigma \geq c'(\bar{e}). \tag{A-5}$$

then

$$\pi \leq 1 - \frac{2(1-\delta)}{\sigma}c'(\bar{e}). \tag{A-6}$$

Noting that $\bar{e} = \frac{\Delta}{\sigma}$, this inequality follows from the first terms under the $\min\{\cdot,\cdot\}$ operator in the expression for π^{θ} in the proposition.

This also implies, by the convexity of the cost function, and $\bar{e} > \bar{\bar{e}}$ the three following conditions:

$$\frac{1}{2(1-\delta)}\left[(1-\pi)\sigma + \pi\theta\sigma\right] > c'(\bar{e}), \tag{A-7}$$

$$\frac{1}{2(1-\delta)}(1-\pi)\sigma > c'(\bar{\bar{e}}), \tag{A-8}$$

and

$$\frac{1}{2(1-\delta)}\left[(1-\pi)\sigma + \pi\theta\sigma\right] > c'(\bar{\bar{e}}). \tag{A-9}$$

Thus, we can rule out as candidate equilibria levels of expertise where the first-order conditions hold with equality, $\hat{e}_h$ and $\hat{e}_l$, and focus only on whether agents will prefer $\bar{e}$ which maximizes the payoff in the low-volatility regime, but leads to breakdowns in trade with probability 0.5 in the high-volatility regime or they will prefer the expertise level $\bar{\bar{e}}$ which maximizes the payoff without triggering breakdowns in trade in the high-volatility regime.

Comparing the expected payoffs associated with the two levels of expertise, $\bar{e}$ will be preferred whenever:

$$\frac{1}{2(1-\delta)}(1-\pi)\bar{e}\sigma - c(\bar{e}) \geq \frac{1}{2(1-\delta)}\left[(1-\pi)\bar{\bar{e}}\sigma + \pi\bar{\bar{e}}\theta\sigma\right] - c(\bar{\bar{e}}). \tag{A-10}$$

Notice that due to the convexity of $c(\cdot)$, when we set $\pi = 0$ this inequality is satisfied and non-binding whenever the inequality required for $\bar{e}$ to be the equilibrium expertise level when $\pi = 0$ is satisfied, i.e., condition (19) in the Proposition. Thus, even if we allow for a small but positive probability π of high volatility, the second term on the left-hand side of (A-12) above will be small and will not violate the inequality.

Multiplying both sides of the inequality by $2(1-\delta)$ yields:

$$(1-\pi)\bar{e}\sigma - 2(1-\delta)c(\bar{e}) \geq (1-\pi)\bar{\bar{e}}\sigma + \pi\bar{\bar{e}}\theta\sigma - 2(1-\delta)c(\bar{\bar{e}}), \tag{A-11}$$

which can be written as:

$$\frac{\left[\bar{e} - \bar{\bar{e}}\right]\sigma - 2(1-\delta)\left[c(\bar{e}) - c(\bar{\bar{e}})\right]}{\left[\bar{e} + (\theta-1)\bar{\bar{e}}\right]\sigma} \geq \pi. \tag{A-12}$$

In summary, the following two conditions ensure that $\bar{e}$ remains the unique equilibrium in expertise:

$$\frac{1}{2(1-\delta)}(1-\pi)\sigma \geq c'(\bar{e}), \tag{A-13}$$

and

$$\frac{1}{2(1-\delta)}(1-\pi)\bar{e}\sigma - c(\bar{e}) \geq \frac{1}{2(1-\delta)}\left[(1-\pi)\bar{\bar{e}}\sigma + \pi\bar{\bar{e}}\theta\sigma\right] - c(\bar{\bar{e}}). \tag{A-14}$$

And since both conditions are continuous in π, then we know that if these conditions are not binding when $\pi = 0$, they will not bind for small enough positive π.

Combining these requires $\pi < \pi^{\theta}$, where:

$$\pi^{\theta} = \min\left\{1 - \frac{2(1-\delta)}{\sigma}c'(\bar{e}), \frac{\left[\bar{e} - \bar{\bar{e}}\right]\sigma - 2(1-\delta)\left[c(\bar{e}) - c(\bar{\bar{e}})\right]}{\left[\bar{e} + (\theta-1)\bar{\bar{e}}\right]\sigma}\right\}, \tag{A-15}$$

which, when substituting for the values of $\bar{e}$ and $\bar{\bar{e}}$, is equal to expression (20) in the Proposition. ∎

Proof of Proposition 4: The arguments in the text prove the proposition for the case where the proposer buys. If the proposer (agent j) sells, the highest price at which he can ensure acceptance of his offer for any signal is

$$p^{**} = E(v \mid s_i = L) \tag{A-16}$$

We must now also consider the following quantities for the high-signal proposing seller,

$$\begin{aligned}\psi_H^H &\equiv \Pr\{s_i = H \mid s_j = H\} \\ &= \mu_j\mu_i + (1-\mu_j)(1-\mu_i) \end{aligned} \tag{A-17}$$

$$\begin{aligned}\phi_{HH}^h &\equiv \Pr\{v = v_h \mid s_j = H, s_i = H\} \\ &= \frac{\mu_j\mu_i}{\mu_j\mu_i + (1-\mu_j)(1-\mu_i)}, \end{aligned} \tag{A-18}$$

and for the low-signal seller,

$$\begin{aligned}\psi_H^L &= \Pr\{s_i = H \mid s_j = L\} \\ &= \mu_j(1-\mu_i) + \mu_i(1-\mu_j) \end{aligned} \tag{A-19}$$

$$\begin{aligned}\phi_{LH}^h &= \Pr\{v = v_h \mid s_j = L, s_i = H\} \\ &= \frac{\mu_i(1-\mu_j)}{\mu_j(1-\mu_i) + \mu_i(1-\mu_j)}, \end{aligned} \tag{A-20}$$

The payoff for a high-signal seller proposing p^{**}, given that acceptance is uninformative about the buyer's signal

$$\begin{aligned} p^{**} - [E(v \mid s_j = H) - 2\Delta] &= 2\Delta + (v_h - v_l)(1 - \mu_i - \mu_j) \\ &= 2\Delta - (v_h - v_l)(e_j + e_i). \end{aligned} \tag{A-21}$$

This is identical to the proposer's payoff when he is a buyer, equation (29). Since the responding buyer, agent i, interprets any higher offer as equally likely to come from either type, he rejects unless he has a high signal. The seller should choose the highest price that evokes this response, $p^* = E(v \mid s_i = H)$, and at this price his payoff is

$$\begin{aligned} &\psi_H^H[p^* - (E(v \mid s_j = H, s_i = H) - 2\Delta)] \\ &= \psi_H^H[\mu_i v_h + (1-\mu_i)v_l - \phi_{HH}^h)v_h - (1-\phi_{HH}^h)v_l + 2\Delta] \\ &= \psi_H^H[2\Delta - (v_h - v_l)(\phi_{HH}^h - \mu_i)] \end{aligned} \tag{A-22}$$

This expression is identical to (30) in the text, except for the conditional probabilities involved. Inspection of the expressions for ψ_H^H, (A-17), and ϕ_{HH}^h ((A-18) reveals that they have the same form as ψ_L^L and ϕ_{HH}^h, which are defined in (A-17) and (A-18). Since the payoffs are the same at p^{**} and p^*, the incentive compatibility condition will be the same, namely (32).

It remains to show that incentive compatibility yields the same condition for a proposing seller with $s_j = L$ as for a proposing buyer with $s_j = H$. First note that the conditional probabilities associated with this case, (A-19) and (A-20) have the same form as the probabilities associated with a high-signal proposing buyer, (26) and (27).

A seller with a low signal who proposes p^{**} receives

$$\begin{aligned} p^{**} - (E(v \mid s_j = L) - 2\Delta) &= 2\Delta + (v_h - v_l)(\mu_j - \mu_i) \\ &= 2\Delta - (v_h - v_l)(e_i - e_j) \end{aligned} \tag{A-23}$$

which is identical to the payoff for a high-signal, proposing buyer, (33).

If he instead proposes p^*, he receives:

$$\begin{aligned} &\psi_H^L[p^* - (E(v \mid s_j = L, s_i = H) - 2\Delta)] \\ &= \psi_H^L[\mu_i v_h + (1-\mu_i)v_l - \phi_{LH}^h)v_h - (1-\phi_{LH}^h)v_l + 2\Delta] \\ &= \psi_H^L[2\Delta - (v_h - v_l)(\phi_{LH}^h - \mu_i)] \end{aligned} \tag{A-24}$$

Evidently, (A-24) has the same form as the payoff for a proposing buyer with a high signal, equation (34) in the text, except for the conditional probabilities. As noted above, however, these conditional probabilities are identical in form to those associated with the case of a proposing buyer with a high signal. Since the payoffs are the same, the incentive compatibility conditions are also the same, and the same set of parameter values will support a pooling equilibrium when the proposer sells as when he buys.∎

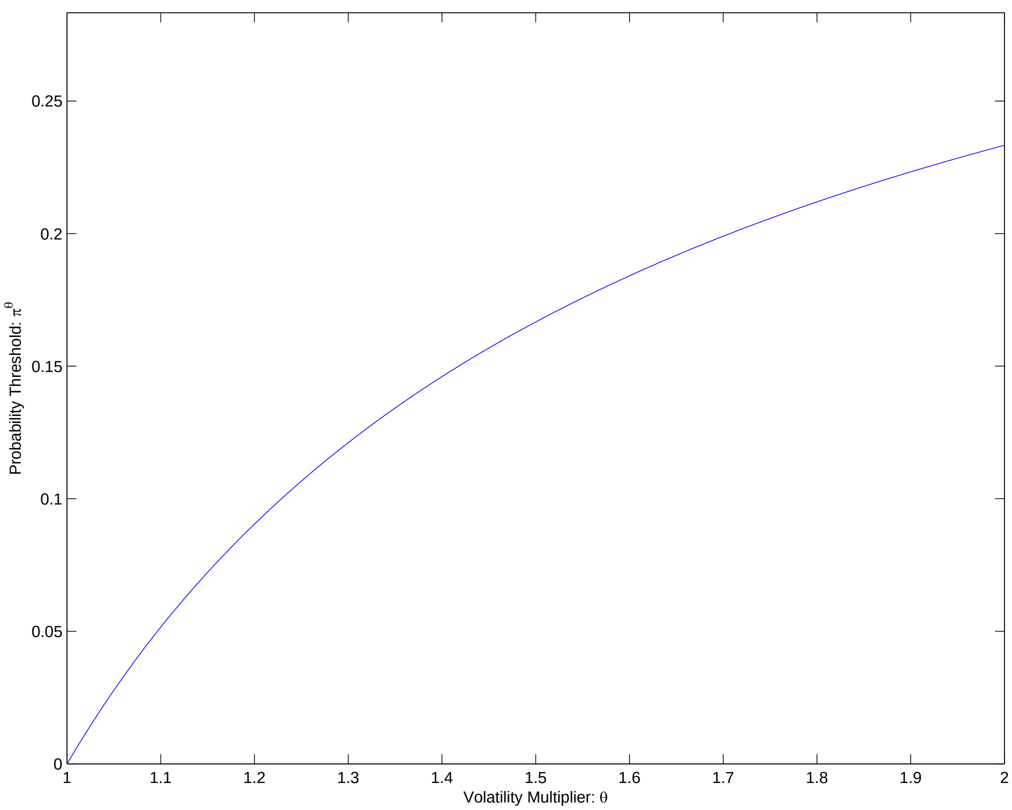

Figure 1: Bounds on π. The plot shows the maximum value of the probability of the high-volatility regime, against the increase in the volatility. For values of π below this bound, agents in the model invest in expertise to the maximum level, $\bar{e}$, even though this leads to breakdowns in trade when the high-volatility regime occurs. Figure is generated by setting: $\delta = 0.9$, $\Delta = 1$, $\kappa = 10$, and $\sigma = 0.2$.

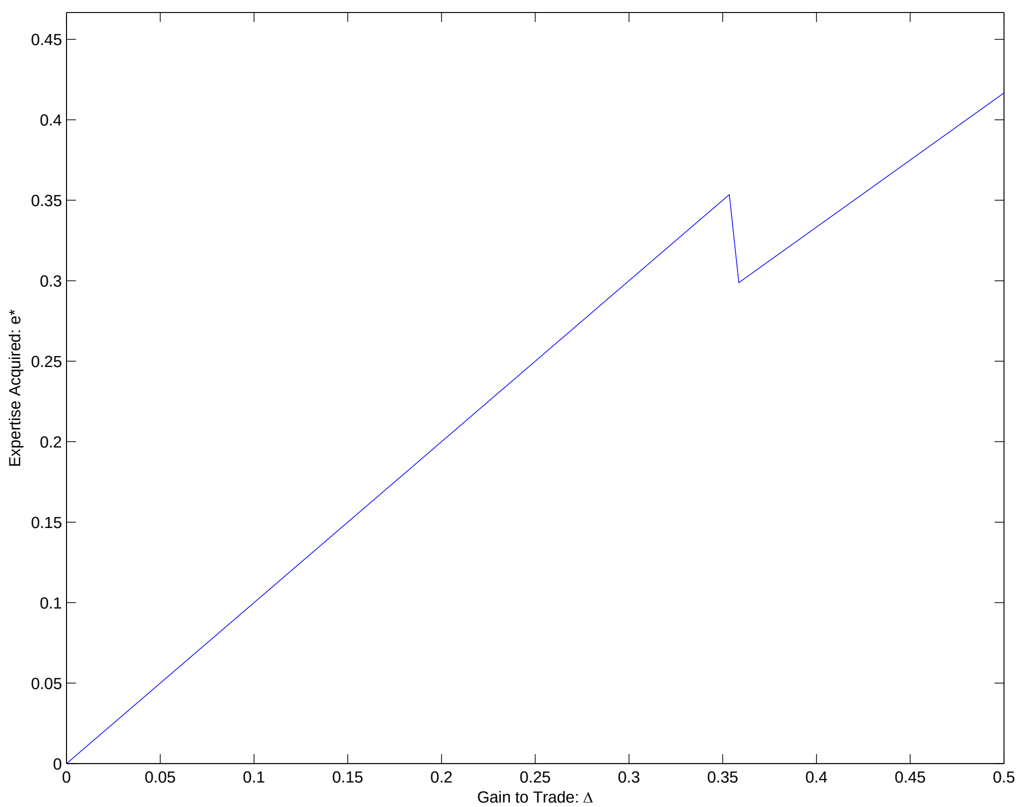

Figure 2: Expertise as a function of gains to trade Δ. The plot shows the relationship between the equilibrium level of expertise and the gains to trade. Figure is generated by setting: $\delta = 0.9$, $\kappa = 10$, $\sigma = 0.2$, $\theta = 1.2$, and $\pi = 0.05$.

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