Bilateral Learning Before Trading?*

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Abstract

A buyer and a seller can privately learn the quality of an asset - initially unknown to both - by incurring a fixed cost before trading. Asset quality determines their valuations and the seller makes a take-it-or-leave-it price offer. Under a weak "lemons-like" condition, asymmetric information arises endogenously when learning costs are small; as these costs vanish, the seller learns for sure but the buyer remains uninformed with probability bounded away from zero. Nevertheless, efficient limiting equilibria always exist; the buyer earns strictly positive surplus in such an equilibrium if, and only if, she can learn after knowing the price offer.

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1 Introduction

In many markets, buyers and sellers are uncertain about the quality of the goods or assets they trade. Cases where the seller does not know the value of the asset attract newspaper attention when, for example, an owner finds a painting in their family mansion, not knowing whether it was painted by an old master. The seller as well as a potential buyer may find out the true worth of the painting by consulting an expert. The acquisition of information is costly, however, and likely to be private. Similarly, the value of a piece of land depends on whether or not it is polluted or whether it is rich in minerals or precious metals and it is unclear whether the seller and/or a potential buyer have this information. The value of a house depends on whether or not the foundations are properly built, and the seller and potential buyer may well be uninformed about this. All these markets share the following features: (i) values of both parties are interdependent, (ii) both parties may acquire—but are initially uncertain about—the true quality and (iii) information acquisition is private and not publicly observable: a trader does not know whether the other side of the transaction is informed.

We study bilateral information acquisition and trade in markets that share these three common features. More specifically, we consider a framework where a buyer and a seller meet to trade an asset of unknown quality. Both buyer and seller are initially (equally) uninformed about true quality. Their valuations depend on the quality of the asset (and are therefore, correlated). Before trade takes place, both buyer and seller have the option of learning the true realization of quality by incurring a (fixed) information acquisition cost. Bargaining takes the canonical form of a take-it-or-leave-it offer. For convenience, we have the seller making the offer, but it is easy to see that qualitatively identical (symmetric) results hold if the buyer makes the offer.

In our framework, there are gains from trade for each realized quality. If quality were commonly (un)known, the outcome would be efficient as trade would occur with probability one and the seller would extract all surplus. In addition, a weak "lemons"-like condition is assumed to hold: the buyer's valuation of the lowest quality is smaller than the seller's reservation value for the highest quality. Note that this condition is considerably weaker than the classic lemon's condition where the buyer's value of average quality is smaller than the seller's reservation value for the highest quality.

Our analysis addresses three central questions. First, who chooses to learn quality? In particular, will both sides of the transaction be symmetrically informed or not? Second, if information asymmetry arises endogenously, does it lead to inefficiency? Finally, how is surplus divided in equilibrium? To answer these questions and to highlight the strategic role of potential bilateral information acquisition, we characterize properties of all perfect Bayesian equilibria when the cost of information acquisition is sufficiently small relative to the value of the asset.

When acquisition costs are exactly zero, different kinds of equilibria exist of which two stand out:[1] (i) an efficient equilibrium where both sides acquire information and the seller takes all surplus by setting a price equal to the valuation of the buyer for every quality, and (ii) an inefficient revealing equilibrium where only the seller acquires information and sets a price equal to the conditional expected valuation of the buyer for every quality. In the latter case, for almost all qualities, the buyer buys with a probability strictly smaller than one to deter lower quality sellers from imitating the prices set by higher quality sellers. We want to understand to what extent these different outcomes are robust to costly information acquisition. Thus, we focus on acquisition costs being small and the properties of equilibria where these costs vanish.

Our first result is that asymmetric information arises endogenously when information acquisition costs are small. In particular, as acquisition costs vanish, the seller acquires information almost surely but the buyer remains uninformed and therefore, we have asymmetry of information, with strictly positive probability. We outline an exogenous strictly positive lower bound for this probability. Of the equilibria when information is free, only ones that allow for such asymmetric information outcomes can be robust to costly acquisition. Interactions between the strategic information acquisition incentives of the buyer and the seller play important roles in this result. For instance, an uninformed seller creates incentives for the buyer to learn about quality to avoid buying in very low quality states and this, in turn, incentivizes the seller to get informed in order to lower prices and trade in such low quality states. Conversely, a buyer engages in costly learning only if the price is not fully revealing and by being informed, she can avoid buying from the lowest quality seller types that offer a pooling price. However, as low quality sellers can always secure a positive pay-

[1] Note that efficient equilibria where both traders are uninformed do not exist as either the buyer will have an incentive to acquire information and not buy if quality turns out to be too low or the seller has an incentive to acquire if the price is too low.

off by offering very low prices, they will deviate unless the buyer remains uninformed with sufficient probability. Hence, asymmetric information is a pervasive outcome. The weak "lemons" condition is both necessary and sufficient for its emergence: without it, a symmetric (and efficient) equilibrium exists in which neither side acquires information.

Second, despite asymmetric information emerging endogenously, an efficient robust equilibrium always exists.[2] That is, there always exists an equilibrium where trade takes place with probability one regardless of realized quality. Thus, unlike the classic "lemons" framework, our weaker condition does not threaten market efficiency.

Our third result concerns surplus division in efficient equilibria. When information can be acquired after observing the price—so learning is a short-run decision—any efficient limiting equilibrium must leave the buyer with strictly positive surplus. In other words, the efficient equilibrium for zero acquisition costs where the seller takes all surplus is *not* robust to small acquisition costs.[3] Two considerations are important in this respect. First, the seller's price strategy should give the buyer an incentive to acquire after observing any possible equilibrium price. Thus, any possible equilibrium price should be set by different seller types and the informed buyer should not buy with strictly positive probability. Second, to extract all surplus prices along the sequence of equilibria should converge to the buyer's willingness to pay. We show that these two conditions cannot hold simultaneously. This does not mean, however, that efficient limiting equilibria do not exist. On the contrary, we characterize an efficient limiting equilibrium with partial pooling and incomplete surplus extraction by the seller. In this equilibrium, for different intervals of qualities, the seller sets different prices and each price is equal to the buyer's value of the lowest quality in the interval. The incentive to imitate the higher price charged by qualities in a higher interval is deterred by the fact that the buyer becomes informed (after seeing these higher prices) and will not buy from a deviating lower quality seller.

If instead information acquisition must occur before bargaining—because learning requires time or expertise—the nature of efficient limiting equilibria changes. The partial pooling equilibrium disappears as the buyer cannot condition her acquisition

[2] Clearly robust equilibria can also be Inefficient. In particular, there is an inefficient fully revealing equilibrium where the seller acquires and sets a price equal to the valuation of the buyer and the buyer not acquiring and buying with a probability that pevents low quality sellers to imitate higher prices.

[3] Note that in this equilibrium both sides of the transaction acquire information.

decision on the price observed, and the seller can extract full surplus in a fully revealing equilibrium that is robust. For any small, positive acquisition cost, the equilibrium is (slightly) inefficient with the seller setting the same price for an interval of the very lowest and highest quality goods and (interestingly) the *low* quality not being traded if the buyer is informed (which happens with strictly positive probability). For all intermediate qualities, the seller's price fully reveals quality and both the informed and uninformed buyer always buy. This form of partial pooling by the seller gives the buyer an incentive to acquire information for a positive acquisition cost. As the pooling interval vanishes when the acquisition costs for the buyer converges to zero, the inefficiency vanishes and the limiting equilibrium is efficient. Thus, it is only when the buyer can condition her acquisition decision on the price proposed by the seller that she can guarantee herself positive surplus.

Related literature. The questions we address in this paper in a bargaining context go back to the seminal paper of Grossman and Stiglitz (1980) where they argued that efficient competitive markets that aggregate information are incompatible with the costly activity of acquiring information. Our result that in any equilibrium even when their acquisition cost vanish, buyers will not acquire information for sure relates to the fact that if prices fully reveal information, buyers do not want to acquire information themselves. Nevertheless, we show that efficient equilibria do exist when acquisition costs vanish.

Most of the extensive literature on information acquisition since that seminal paper considers one-sided acquisition by either the buyer or the seller. Most of that literature deals with independent valuations, however, for instance when a monopoly firm sells to a buyer (see, e.g., Crémer and Khalil (1992), Shavell (1994), Roesler and Szentes (2017), Yang (2020), Ravid et al. (2022), Guo (2023), Chatterjee et al. (2024)).[4] These (and other) papers in this literature differ along a variety of dimensions. For example, (i) by acquiring information, the agent either obtains a partially or fully informative signal of the valuation, (ii) the decision on information acquisition by the buyer (agent) may either be before or after prices are announced, or (iii) the other

[4] Kaya (2010) studies a repeated principal–agent problem where both sides start out symmetrically uninformed, but only the principal has the option to learn their value (at no cost). Similarly, Eliaz and Frug (2018) analyze a situation where a seller can decide over time whether to acquire (some) information, whereas the buyer remains uninformed. Kim et al. (2024) consider information acquisition by firms about potential future employees and how this strengthens the "stigma" effect of long unemployment duration.

side of the transaction is either uninformed or informed. Naturally, as information acquisition is one-sided, that literature cannot address the key issue of this paper, which is to understand whether asymmetric information arises endogenously and the role played by the interaction between the strategic incentives of the buying and the selling side.[5] In addition, as is well-known from the bargaining (and auction) literature, properties of markets with independent valuations differ greatly from those under interdependent valuations.

Dilmé (2019) considers pre-trade unobserved costly investment in quality by a seller that can also be interpreted as one-sided information acquisition in a correlated value setting. Like the buyer in our setting, the seller randomizes between investing and not investing. Thereze (2023) studies one-sided information acquisition by buyers in a market with informed sellers, but has valuations of sellers and buyers being perfectly correlated. Information is acquired after prices are posted. He shows that the cost of acquiring information has two opposing effects as higher costs worsen the quality of choices consumers make, but they also alleviate adverse selection by reducing the amount of private information in the market. Pavan and Tirole (2025) study a model where an uninformed leader may decide to acquire information before taking one of two actions, where one is adverse selection sensitive and the other is not.[6] As with the literature on independent valuations reviewed above, these papers cannot address the key question of the current paper as information acquisition is only one-sided.

There is a small literature on two-sided information with independent values. Dang (2008) studies a model a la Shavell (1994) where quality is either high or low and the gains from trade are independent of quality. His results for this specific setting are very different from the results we obtain when quality is continuously distributed and the gains from trade may not be constant. In particular, where we get that asymmetric information will always arise endogenously with positive probability and efficient equilibria always exist, he claims that even though agents maintain symmetric information in equilibrium the possibility of information acquisition can cause no

[5] Even though, for example, Shavell (1994) and Guo (2023) do acknowledge that both sides of the transaction may be uninformed about the value of the product, they do not analyze the interaction between the acquisition decisions of the buyer and the seller.

[6] Levin (2001) studies how the informativeness of both sides of the market affects the lemons' problem. Kartik and Zhong (2025) analyze bilateral trade and characterize equilibrium payoffs under general information structures. They do not analyze the incentives to acquire information.

trade. Two-sided information acquisition models with specific features have also been applied to study specific issues in finance such as asset valuation and the possibility of market collapse (see, e.g., Fishman and Parker (2015)), acquiring financial expertise (see, e.g., Glode et al. (2015)) or whether combining financial assets in bundles facilitate trade (see, e.g., Farhi and Tirole (2015)). Depending on the context, information acquisition is either considered to be a short-run or a long-run decision. None of these papers addresses the issue of information asymmetry arising endogenously and no one considers a general setting with a continuum of possible types as we do. This is important as the nature of our results (especially the existence of efficient equilibria and the division os surplus in these equilibria) differs substantially from that in the literature. Also, as we do not employ any equilibrium refinement our statements pertain to properties of all equilibria or the existence of efficient equilibria and the division of surplus rather than to specific equilibria that satisfy certain refinements.

The rest of the paper proceeds as follows. Section 2 presents the model. Section 3 discusses equilibria when acquisition costs are zero. Sections 4 and 5 analyze the endogenous emergence of asymmetric information and efficiency, respectively. Section 6 studies the case of long-run information acquisition. All proofs are contained in the Appendix.

2 The Model

A buyer (she) and a seller (he) meet to trade one unit of a good (or asset). The seller's opportunity cost of selling the good is given by c. We interpret c as the quality of the good.[7] The buyer's valuation of the good depends on quality c and is given by $V(c)$, with $\underline{V} = V(\underline{c})$ and $\overline{V} = V(\overline{c})$. Initially, both the buyer and the seller are symmetrically uninformed about the true value of c. Let F denote the prior distribution function of c with $c^e = E(c)$ and let $V^e = E[V(c)]$. We assume:

A1. F is a continuous and strictly increasing distribution function on an interval $[\underline{c}, \overline{c}]$ where $0 < \underline{c} < \overline{c}$.

A2. $V(c)$ is continuous and strictly increasing in c on $[\underline{c}, \overline{c}]$ and $V(c) > c$ for all $c \in [\underline{c}, \overline{c}]$.

Assumption A2 implies there are always gains from trade. As $V(c) - c$ is bounded

[7] The seller's opportunity cost of trading may reflect an outside option or payoff from retaining the asset for own future use.

away from zero on $[\underline{c}, \overline{c}]$ there is always a "gap" between the valuations of the buyer and the seller and the full information first-best outcome is one where the good is traded regardless of quality.

The buyer and the seller can each acquire a fully informative signal that reveals the true value c by incurring a fixed acquisition cost. Information acquisition is private, i.e., neither the buyer nor the seller can observe whether the other side has acquired information. The buyer's acquisition cost is denoted by $b \geq 0$, while the seller's acquisition cost is denoted by $s \geq 0$. We focus on the strategic effects of costly acquisition and in particular, on outcomes when these costs are small.

Trading occurs through ultimatum bargaining. In particular, the seller makes a take-it-or-leave-it price offer to the buyer. A buyer, whether or not she is informed, will buy for sure if the price is below $\underline{V}$. We assume:

A3. $\underline{V} < \overline{c}$

Assumption A3 implies that an uninformed seller that charges a low price close to $\underline{V}$ will makes losses when realizations of c are close to $\overline{c}$. It rules out an efficient equilibrium outcome where neither side acquires information and trade occurs for sure at a relatively "low" price, i.e., a price p with $\overline{c} \leq p \leq \underline{V}$. The assumption is comparable to, but significantly weaker than, the "lemons" condition used to show inefficient trading in markets with adverse selection and an exogenous asymmetric information structure. To compare, the lemons condition would have required $V^e < \overline{c}$.

In the next two sections, we will study bargaining when information can be acquired at short notice so that both players can acquire information before or after the price is set. It is obvious that if the seller wants to acquire information, he will do so before setting the price. As the buyer has to decide whether or not to accept the price offer, she has nothing to gain by acquiring information before receiving the price offer. So, without loss of generality, we analyze the following three stage game:

1. The seller decides whether or not to acquire information. If he acquires information, he learns the true value of c. Neither the seller's acquisition decision nor the realization of the signal (if acquired) is observed by the buyer.

2. The seller makes a take-it-or-leave-it price offer.

3. The buyer decides whether or not to acquire information. If she acquires information, she observes the true value of c. She then decides whether to buy the good at the price proposed by the seller.

The solution concept is perfect Bayesian equilibrium. Payoffs are standard. Both buyer and seller are risk-neutral so that if true quality is c and trade occurs at price p, the seller's pay-off is $p - c$, while the buyer's pay-off is $V(c) - p$; payoffs are 0 if no trade occurs. We will confine attention to equilibria where the seller, whether or not he is informed, does not randomize over prices.

The seller's strategy is a three-tuple $(\phi, p_{NA}, p(c))$ where $\phi \in [0,1]$ is the probability with which he acquires information, $p_{NA} \geq 0$ is the price offered when he does not acquire information and $p(c) : [\underline{c}, \overline{c}] \rightarrow \mathbb{R}_+$ is the price offered by an informed seller of type c. The buyer's strategy is a three tuple $(\psi(p), \sigma^I(p,c), \sigma^U(p))$ where $\psi(p) : \mathbb{R}_+ \rightarrow [0,1]$ indicates the probability with which the buyer acquires information after observing a price offer $p, \sigma^I(p,c) : \mathbb{R}_+ \times [\underline{c}, \overline{c}] \rightarrow [0,1]$ is the probability which the informed buyer buys when she faces price p and learns true quality is c, and $\sigma^U(p) : \mathbb{R}_+ \rightarrow [0,1]$ is the probability the uninformed buyer buys when she faces price p.

3 Zero acquisition cost

As a benchmark consider the case where information is free, i.e., $b = s = 0$. In this case, there are a variety of perfect Bayesian equilibrium outcomes and we discuss below some of the more interesting ones.

First, there are equilibria where the price fully reveals quality. At one extreme, the standard outcome of the ultimatum game where the outcome is efficient and the seller acquires all surplus can be supported as an equilibrium. The equilibrium strategies are such that the seller acquires information for sure and reveals true value of c by setting $p(c) = V(c)$. The buyer also acquires information with probability one (after observing any price) and buys (at all prices) if she makes non-negative surplus. Note that information acquisition by the buyer prevents a lower quality seller from imitating the price set by a higher quality seller. As acquisition cost is zero, the buyer is indifferent between acquiring and not acquiring information. At the other extreme, we also have an equilibrium where the seller acquires information for sure and once again, reveals true value of c by setting $p(c) = V(c)$; but now the buyer does *not* acquire information at all. Such an equilibrium is necessarily inefficient as the only way to prevent a lower quality seller imitating the price set by a higher quality seller is for the buyer to buy with lower probability at higher prices. There are other equilibria with fully revealing prices that are a combination of these two extremes.

Second, there are equilibria where the seller acquires information for sure but prices do not fully reveal quality; in these equilibria, out-of-equilibrium beliefs prevent the seller from deviating. One extreme example is a partial pooling equilibrium where the seller acquires for sure and sets a price $p(c) = \underline{V}$ if $c \in [\underline{c}, \underline{V}]$ and $p(c) = \overline{V}$ if $c > \underline{V}$; the buyer does not acquire information and buys for sure if $p \leq \underline{V}$ but does not buy if $p > \underline{V}$. The buyer's strategy is optimal as she may rationally reject all prices $p \in (\underline{V}, \overline{V})$ believing these prices are set by a seller with quality $\underline{c}$. In this equilibrium, the seller makes a strictly positive expected profit $\int_{\underline{c}}^{\underline{V}}(\underline{V} - c)dF(c)$, which is the smallest pay-off an informed seller can realize in any equilibrium (as the buyer buys for sure at any price below $\underline{V}$, whether or not she is informed). Clearly, given the buyer's strategy the seller cannot benefit from pricing differently and if he deviates to not acquiring information, then he either earns zero profit (if he sets a price larger than $\underline{V}$) or he makes a smaller profit (or even a loss) if he sets a price $p < \underline{V}$.

In the rest of the paper, we will focus on acquisition costs that are strictly positive but small or vanishing.

4 Asymmetric information Emerges Endogenously

As a first step towards understanding the nature of equilibrium outcomes with (mildly) costly acquisition, we ask what information structure will emerge endogenously if both buyer and seller have strictly positive, but arbitrarily small acquisition cost? Will the buyer and the seller end up with symmetric information? If information asymmetries arise, which side is likely to be more informed?

That an equilibrium exists for small acquisition costs is not difficult to see given the equilibria outlined for the case of zero acquisition cost in the previous section. In particular, the partial pooling equilibrium where the buyer never acquires, the seller acquires for sure and sells at price $\underline{V}$ if $c \leq \underline{V}$ (but does not sell if $c > \underline{V}$) continues to be an equilibrium for any $b > 0$ if $s < \int_{\underline{c}}^{\underline{V}}(\underline{V} - c)dF(c)$; if the seller deviates to not acquiring information in order to save on the acquisition cost, then (given the buyer's strategy) he can sell with positive probability only if he charges a price $p \leq \underline{V}$ and in that case, will make losses if the realized quality $c \in (\underline{V}, \overline{c}]$ so that the expected deviation profit is strictly smaller than $\int_{\underline{c}}^{\underline{V}}(\underline{V} - c)dF(c)$. In addition, the equilibrium (at zero acquisition costs) where the buyer never acquires while the seller acquires information for sure, reveals c by setting $p(c) = V(c)$ and sells with a probability less than one, can also be shown to be an equilibrium for any $b > 0$ if $s > 0$ is small enough. In both these equilibria, asymmetric information arises endogenously. It turns out that this is a general property of equilibrium outcomes with vanishing acquisition costs as the next proposition states.

If information acquisition costs are strictly positive and sufficiently small, ; in particular, as acquisition costs vanish, the probability that the seller acquires converges to one but the probability that the buyer acquires information on the equilibrium path is bounded above by

Proposition 1 *If $b > 0, s > 0$ are sufficiently small, information asymmetry (with the seller being informed and the buyer uninformed) emerges with strictly positive probability, bounded away from zero as acquisition costs vanish. In particular, for any sequence of strictly positive acquisition costs $\{(b_n, s_n)\}_{n=1}^{\infty} \to (0, 0)$ and any sequence of equilibria $\{E_n\}_{n=1}^{\infty}$ where E_n is an equilibrium for $b = b_n, s = s_n$,*

(i) the probability that the seller acquires information in E_n converges to 1,

(ii) the ex ante probability that the buyer acquires information in E_n is (eventually) at most

$$\overline{\psi} = 1 - \max_{z \in [\underline{c}, \underline{V}]} F(z) \left[\frac{\underline{V} - z}{\overline{V} - z} \right] < 1.$$

A large class of economic models of market trading with correlated valuations *assume* asymmetric information structures where the seller is more informed than the buyer. Proposition 1 indicates that it is natural for such an asymmetric information structure to emerge when buyers and sellers choose whether to acquire information at a small cost and the seller has bargaining power. In fact, such asymmetry may emerge even if neither side has any prior informational advantage and even if there is no asymmetry in the cost of information acquisition.

The proof of the proposition is based on the strategic interplay between acquisition by the buyer and the seller. This is most transparent in the key argument behind why the seller must acquire information as acquisition costs vanish. Suppose the seller does not acquire information with strictly positive probability and in that case sets a somewhat high price. The buyer facing such a price must then be acquiring information with probability one (when b is small enough) to avoid buying in the state of the world where the realized c is small and, in particular, her valuation is less than this price. The uninformed seller is therefore faced with the prospect of not selling for low realizations of c in this equilibrium. But then the seller can (for small enough s) gainfully deviate to acquiring information and for low realizations of c, charge a low enough price (such as $\underline{V}$) at which he can sell for sure whether or not the buyer is informed. Assumption A2 guarantees that $\underline{c} < \underline{V}$ so that low qualities can always make a profit. On the other hand, if the uninformed seller sets a low price (below $\underline{V}$), he makes a loss if the realized quality c is larger than the price (between $\underline{V}$ and $\bar{c}$) and this creates a strict incentive to deviate and acquire information when s is sufficiently small. Assumption A3 guarantees that there are such qualities.

Perhaps more surprising is our result that in all equilibria, the buyer remains uninformed with a probability uniformly bounded away from zero as acquisition costs vanish. So, why can the buyer's probability of information acquisition not go to 1 as acquisition costs vanish? Here too, the strategic interplay between acquisition by the buyer and the seller is important. The key fact here is that as (under assumption A2) $\underline{c} < \underline{V}$, an informed seller of type c in a neighborhood of $\underline{c}$ can guarantee himself a minimum strictly positive profit by charging $\underline{V}$ as it is optimal for the buyer to buy at that price, regardless of whether she is informed or uninformed. We show that after observing any price p set by an informed seller in such a neighborhood of $\underline{c}$, the buyer cannot be acquiring information with very high probability. For the buyer to get informed after observing p while incurring a strictly positive acquisition cost, p must be a pooling price and there must be very low qualities in the pool of types that charge p which the buyer avoids buying when she is informed. For such quality types at the lower end of the pool, the informed seller would only sell to the uninformed buyer. If the buyer would acquire information with probability close to 1, the seller's profit would fall below the guaranteed minimum profit.

The inequalities $\underline{c} < \underline{V} < \bar{c}$ (ensured by assumptions A2 and A3) are not only used in the proof of Proposition 1 (as outlined above) but are actually necessary for the asymmetric information outcome in Proposition 1. If there are no gains from trade at the lowest quality, so that $\underline{c} \geq \underline{V}$ (the so called "no-gap" configuration), the lowest quality types cannot guarantee themselves a minimum positive profit that is bounded away from zero. In this case, there is an equilibrium with symmetric information (for all positive acquisition costs) where both the buyer and the seller remain uninformed and the seller sets a price equal to $\overline{V}$ at which the buyer does not buy and no trade occurs. On the other hand, if $\underline{V} \geq \bar{c}$, there is an efficient equilibrium with symmetric information (for all positive acquisition costs) where once again the buyer and seller remain uninformed, the seller sets price $\underline{V}$ and the buyer buys for sure. In both cases deviations from the pooling equilibrium price are "punished" by the buyer believing quality is $\underline{c}$ so that the buyer does not buy if $p(c) > \underline{V}$.

The role played by assumption A3 namely, $\underline{V} < \bar{c}$, in *generating* asymmetric information structure in Proposition 1 is interesting as a stronger version of this assumption (the so called "lemons" condition which requires $E(V(c)) < \bar{c}$) has been used to study the *implications* of asymmetric information among market participants and, in particular, to establish inefficiency. We will see later that even though we make a much weaker assumption than (and therefore allow for) the "lemons" condition, there is always a limiting equilibrium that is efficient even though the generated information structure is asymmetric with positive probability.

Proposition 1 also indicates that of the various equilibria when information acquisition is free, only the ones with asymmetric information outcomes are "robust" to costly acquisition. To make this more precise, we define the notion of a limiting equilibrium with vanishing acquisition costs.

Definition. An equilibrium E_0 at $b = s = 0$ is said to be a *limiting equilibrium as acquisition costs vanish* if there exist: (i) a sequence of acquisition costs $\{(b_n, s_n)\}_{n=1}^{\infty}$ converging to $(0, 0)$ where $b_n > 0, s_n > 0$ for all n,

and (ii) a sequence of equilibria $\{E_n\}_{n=1}^{\infty}$ where for each n, E_n is an equilibrium when $b = b_n, s = s_n$, such that as $n \to \infty$, the equilibrium strategies of the buyer and the seller in E_n converge to their respective equilibrium strategies in E_0 (where for elements of the strategy profile that are functions, the convergence is point-wise).

It follows immediately:

Corollary 1 *A limiting equilibrium (as acquisition costs vanish) must be one where the seller acquires information for sure but the buyer remains uninformed with probability at least as large as* $1 - \overline{\psi} > 0$.

In particular, the fully revealing equilibrium at zero acquisition cost where both traders are fully informed (and the seller acquires all surplus) is *not* a limiting equilibrium.

5 Efficiency

Proposition 1 indicates that when acquisition costs are strictly positive and small, an asymmetric information structure with an informed seller and an uninformed buyer must emerge with strictly positive probability and this probability remains bounded away from zero as acquisition costs vanish. In settings with *exogenous* information structure, such asymmetry generates inefficiency. For instance, under the lemons' condition that the ex ante expected valuation of the buyer is smaller than the cost of the highest quality seller (allowed for under our assumptions), higher quality goods are not traded with strictly positive probability. One may therefore expect the market outcome to be inefficient (at least for some distributions of c) as acquisition costs vanish. Surprisingly, we find this is not true.

To start the discussion, it is useful to first consider an obvious candidate of an equilibrium for $b = s = 0$ that is both efficient and a limiting equilibrium as information acquisition costs vanish, namely one where both buyer and seller acquire for sure, the seller extracts full surplus by charging price equal to buyer's valuation (for each realized quality) and the buyer buys for sure. Our first result of this section is that this equilibrium is not robust to costly acquisition, or more generally, that full extraction of surplus by the seller is inconsistent with efficiency of any limiting equilibrium.

Proposition 2 *The seller does not extract full surplus (buyer earns strictly positive expected surplus) in any efficient limiting equilibrium as information acquisition costs vanish.*

The proof of this proposition first argues any efficient limiting equilibrium with full extraction of surplus by the seller must be a fully revealing equilibrium where the seller acquires information for sure, sets $p(c) = V(c)$ and sells with probability one. The only way a lower quality seller would not imitate a higher price charged by a higher quality seller is if at the higher price the buyer acquires information with sufficiently high probability. But this means the buyer must acquire information with positive probability in an equilibrium that is "close" to this limiting outcome when $b > 0$. This is worthwhile for the buyer only if there is pooling by seller types so that by acquiring information, the buyer avoids buying qualities at the lower end of the pool (that yield negative surplus). This, however, creates an incentive for a seller type at the lower end of a pooling interval to deviate and imitate a slightly lower price (chosen by a neighboring pool of lower qualities) at which he can sell to both the informed and the uninformed buyer.

Our second result of the section shows that even though the seller does not attract all surplus, this does not mean that efficient equilibria do not exist. On the contrary, there exist efficient equilibria where the seller and buyer trade with probability one.

Proposition 3 *As information acquisition costs vanish, there is an efficient limiting equilibrium.*

In the proof of Proposition 3, we construct an equilibrium with the indicated efficiency properties when b and s are lower than a strictly positive upper bound. We then show as $b, s \to 0$, this equilibrium converges to an equilibrium for $b = s = 0$ that is fully efficient i.e., where all qualities trade with probability one. From the discussion regarding Proposition 2 it is clear that such an equilibrium must involve pooling.

Consider the following candidate efficient equilibrium E_0^* at $b = 0, s = 0$. The seller acquires information for sure. Define $c_0 = \underline{c}$ and for $i \geq 1$ define

$$c_i = \min\{V(c_{i-1}), \bar{c}\}$$

and let $T = \min\{i : V(c_{i-1}) \geq \bar{c}\}$.For $i = 1, ...T$ define prices $p_i = V(c_{i-1})$. In this equilibrium where the seller's types in $[c_{i-1}, c_i)$ pool to offer price p_i; note that $p_i = c_i$ for $i = 1, ...T - 1$ and $p_T \geq c_T = \bar{c}$. Further, $p_i \leq V(c)$ for all $c \in [c_{i-1}, c_i)$.The buyer acquires information with probability zero when he observes price p_1 and with probability one when he observes prices $p_2, ...p_T$. The buyer buys with probability one at all prices. If the buyer observes any out-of-equilibrium price he believes $c = \underline{c}$ for sure. If he observes such a price he buys only if the price is strictly below $\underline{V}$ (which is smaller than or equal to p_i for all i.) The construction of the limiting equilibrium is illustrated in Figure 1a.

There is no incentive for any seller of type $c \in [c_{i-1}, c_i)$ to deviate to a higher equilibrium price p_k for $k > i$ as the buyer will be informed and will not buy (as $p_k = V(c_{k-1}) \geq V(c_i) > V(c)$).Given the out-of-equilibrium belief the seller has no incentive to deviate to any other price as, given the buyer's strategy, he would have to charge a price strictly below p_1 to sell. Finally, the seller has no incentive to deviate to not acquiring information for in that case, he either sells at price below $\underline{c}$ (in which case he can not earn strictly positive profit) or can charge one of the prices $p_i, i = 2, ...T$ in which case he is worse off (compared to being informed) if his true cost is strictly higher than p_i (the buyer is informed for sure after prices $p_i, i = 2, ...T$). Observe that this equilibrium is efficient as all qualities are traded for sure.

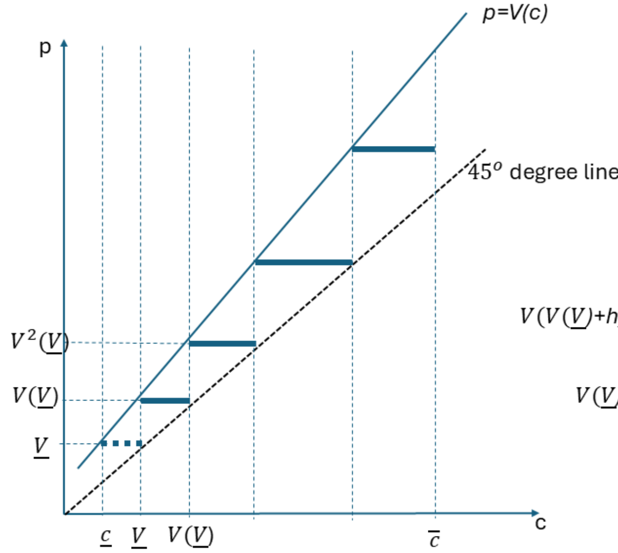

Figure 1a: Structure of the limiting equilibrium: seller partially pools; buyer does not acquire at dotted line

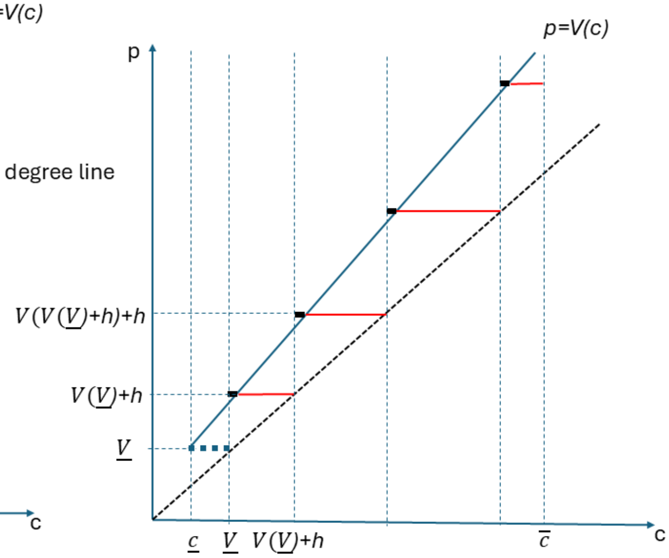

Figure 1b: Equilibrium for small b. Buyer acquires info at higher prices, but does not buy lowest c in these intervals

The proof of Proposition 3 in the Appendix shows that E_0^* can be sustained as a limiting equilibrium as information acquisition costs vanish. In particular, a similar kind of equilibrium can be constructed if $b > 0, s > 0$ are small enough where there is a small range of quality at the lower end of each pooling interval (other than the first interval) whose valuation by the buyer is below the pooling price.The buyer is thereby incentivized to acquire costly information to avoid buying for such realizations of quality. Figure 1b illustrates the construction of the equilibrium for small acquisition costs. The prices the seller sets in all but the lowest interval are slightly elevated (indicated by $h > 0$ in the figure) so that there are types $c > \underline{V}$ that set a price $p(c) > V(c)$. These types (indicated in the figure by a thick, black part above the line $p(c) = V(c)$) do not sell at all, but -by setting appropriate out-of-equilibrium beliefs- they cannot make positive surplus by choosing another price. As the costs of acquisition decline, the range of these quality types that do not sell can be made smaller and in the limit $h \to 0$ when $b \to 0$ and they disappear.

It is worth noting that if assumption A3 does not hold i.e., $\underline{V} \geq \bar{c}$, an efficient equilibrium exists for any pair of positive acquisition costs (and not just as these costs vanish). As mentioned in the previous section, in that case we always have an equilibrium where neither the seller nor the buyer acquires any information, the seller charges $\underline{V}$ and sells with probability one while out of equilibrium beliefs rule out any gainful deviation.

Finally, it is worth noting that *inefficient* limiting equilibria also exist. For instance, as discussed at the beginning of Section 4, the inefficient partial pooling equilibrium for zero acquisition cost where the buyer never acquires, the seller acquires for sure, sells at price $\underline{V}$ if $c \leq \underline{V}$ but does not sell if $c > \underline{V}$, continues to be an equilibrium for any $b > 0$ and $0 < s < \int_{\underline{c}}^{\underline{V}} (\underline{V} - c) dF(c)$,and is therefore, a limiting equilibrium.

6 When acquisition takes time

In this section, we consider a modified setting where information acquisition requires time or long-term investment. For instance, traders may need to acquire expertise in order to discern quality. To capture this, we modify the game outlined in Section 2, by requiring that *both the buyer and the seller must make decisions on information acquisition prior to the price offer* and the bargaining that takes place. Thus, in the first stage, the buyer and the seller simultaneously decide whether or not to acquire information; neither agent observes whether the other agent has acquired information and the ones that acquire information privately observe the true value of c. Next, the seller makes a take-it-or-leave-it price offer. Finally, the buyer decides whether to accept the price offer. We denote by $\psi \in [0, 1]$ the probability with which the buyer acquires information. Other notations are as outlined in Section 2.

Despite the fact both the buyer and the seller must now make their information acquisition decisions in advance, information asymmetry arises endogenously as in Proposition 1 in Section 4 for the setting where the buyer can wait to get informed till she receives the price offer.

Define $\psi^0 \in (0,1)$ and $\psi^1 \in (0,1)$ by

$$\psi^0 = \frac{\frac{\underline{V}+V^e}{2} - c^e}{V^e - c^e},$$

$$\psi^1 = \max_{c' \in [\underline{c},\overline{c}]} \frac{\overline{V} - c'}{V(c') - c' + \overline{V} - c'}$$ [8]

and take $\widetilde{\psi} \in (0,1)$ to be defined by

$$\widetilde{\psi} = \max\{\psi^0, \psi^1\}$$

Proposition 4 *When information acquisition requires time and the acquisition costs are sufficiently small, asymmetry of information emerges with strictly positive probability. As acquisition costs vanish, the probability that the seller acquires information must converge to one, but the probability that the buyer acquires information is bounded above by* $\widetilde{\psi} < 1$.

Even though Proposition 4 is similar to Proposition 1, the underlying logic and the upper bound itself are different now the buyer cannot condition the acquisition decision on price. That the probability the seller acquires information should converge to one when acquisition costs vanish can be understood as follows. If the seller would not acquire with positive probability it should set a price independent of quality. This price cannot be too low as in that case, the seller would make a loss in case quality is high and this loss can be avoided by acquiring information if the cost of doing so is low enough. If, on the other hand, the price is relatively high, then the buyer certainly wants to acquire information if the acquisition cost is low enough to avoid paying too much in case quality is low. But, if the buyer acquires, the seller certainly wants to acquire himself to be able to extract surplus by setting price equal to the buyer's willingness to pay.

To understand why, if the seller acquires information almost surely, the buyer will acquire information with a probability bounded away from one, it is important to stress that for any $b > 0$, for the buyer to acquire she should have an incentive to do so. That is, there should be situations where the informed buyer would take a different action from an uninformed buyer. It cannot be that an uninformed buyer does not

[8]Note that if $V(c) - c$ is non-decreasing in c, then $\psi^1 = \frac{\overline{V}-\underline{c}}{V(\underline{c})-\underline{c}+\overline{V}-\underline{c}}$.

buy at a certain price as this would imply that the expected quality conditional on price is smaller than the price and this in turn would imply that certain seller types do not sell at all, whereas they could always make positive profits by selling at $V(c)$ to an informed buyer. But if the uninformed buyer does not buy from some type c' then to have an equilibrium we must have that $(1-\psi)(p^*(c')-c') \geq \psi(V(c')-c')$. As the LHS is smaller than $(1-\psi)(\overline{V}-c')$ we get the inequality in the proposition.

We can define the notion of limiting equilibrium as acquisition costs vanish exactly as outlined in Section 4. As in the previous section, we find that there is an efficient limiting equilibrium, however, when the buyer has to make her information acquisition decision prior to learning the price, there is an efficient limiting equilibrium where she earns zero surplus, i.e., the seller can use his bargaining power to extract full surplus. When the buyer acquires information after seeing the price, she has to be given an incentive to acquire information at every possible price offer along the equilibrium path; when she acquires information in advance of the price offer, she only needs an incentive to acquire "in the aggregate" which reduces her bargaining power and in particular, when acquisition cost is small, she can only guarantee herself a small surplus that vanishes with acquisition cost.

We establish this result under a mild condition that requires gains from trade to be non-decreasing in quality.

Proposition 5 *Assume $V(c)-c$ is weakly increasing in c. As information acquisition costs vanish, there exists an (efficient) limiting equilibrium where the seller extracts full surplus.*

To understand the result, suppose that information acquisition is free i.e., $b = s = 0$. It is easy to check there is an equilibrium E_0 where (i) the seller acquires information for sure, (ii) the buyer acquires information with probability $\psi_0 = \frac{\overline{V}-\underline{V}}{\overline{V}-\underline{c}}$ and (iii) the seller with quality c charges price equal to $V(c)$ and sells with probability one (the outcome is efficient). Here, the seller's price fully reveals his type; the buyer is indifferent between acquiring and not acquiring as $b = 0$ and in equilibrium, she acquires information with sufficient probability so as to deter a lower quality seller type from imitating a higher quality type. In this equilibrium the seller extracts full surplus.

When the buyer acquires information after observing the price offer, E_0 is not a limiting equilibrium as acquisition costs vanish i.e., it is not robust to strictly positive acquisition cost; in fact, as shown in Proposition 2 no equilibrium with full surplus extraction by the seller can be sustained as a limiting equilibrium. However, when the buyer must commit to information acquisition in advance, E_0 can be sustained as a limiting equilibrium.

To show this, we construct a sequence of strictly positive acquisition costs and a sequence of equilibria for these costs that converge to E_0 when acquisition costs vanish. The construction balances the need for efficiency of the limiting equilibrium with providing incentives for the buyer to acquire at strictly positive acquisition cost. In the construction, a small set of lowest and highest quality types pool to set a high price, whereas all other intermediate types c reveal their quality by setting price equal to $V(c)$. The buyer buys for sure at the revealing prices while at the pooling price, the uninformed buyer buys for sure while the informed buyer only buys when the quality is at the upper end. As the buyer has to decide before observing price whether to acquire or not, the buyer may actually be indifferent for small, but positive acquisition cost and may acquire with positive probability as this gives her the option to not buy qualities at the lower end of the pool (when the pooling price is offered). The set of pooling types shrinks and disappears as the buyer's acquisition cost goes to zero but the buyer is kept indifferent (between acquiring and not acquiring information) along the way. In the limit, all seller types c set a revealing price $V(c)$ and the equilibrium E_0 obtains.

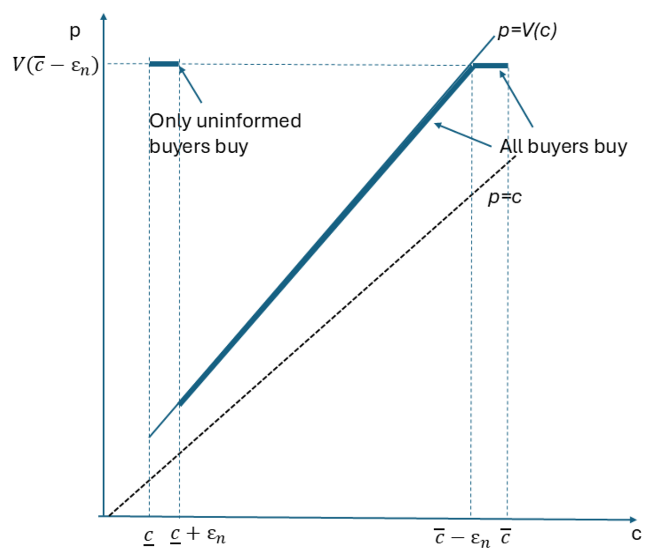

Figure 2: Long-term equilibrium prices and purchase behavior

The construction is illustrated in Figure 2. All, but the very lowest and highest quality sellers set $p(c) = V(c)$. For any positive acquisition cost b, the lowest qualities $c < \underline{c} + \varepsilon_n$ and the highest qualities $c > \overline{c} - \varepsilon_n$ pool on the buyer's value for quality $\overline{c} - \varepsilon_n$. For any $b > 0$,the ε_n are chosen such that the buyer is indifferent between acquiring and not acquiring information and $\varepsilon_n \to 0$ when $b \to 0$. The acquisition probability of the buyer is such that seller types $\underline{c}+\varepsilon_n$ is indifferent between revealing quality by setting a price equal to $V(\underline{c} + \varepsilon_n)$ and setting $V(\overline{c} - \varepsilon_n)$. Higher quality sellers do not want to set the high price as informed buyers will not buy from them if they do so.

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Appendix

Denote by E_n an equilibrium when acquisition costs are (b_n, s_n) and by ϕ_n the probability with which the seller acquires information in equilibrium E_n. We begin by showing that as information acquisition costs converge to zero, the seller's acquisition probability must converge to 1. Suppose to the contrary there exists a sequence of strictly positive acquisition costs $\{(b_n, s_n)\}$ converging to $(0,0)$ such that for each n ϕ_n is bounded above by $\overline{\phi} < 1$. We will show that the seller has an incentive to deviate if n is large enough so that the acquisition costs are smaller than certain bounds. We begin by outlining these bounds.

Fix ϵ, $0 < \epsilon < \underline{V} - \underline{c}$. Then, $\underline{c} < \underline{V} - \epsilon$ and $\int_{\underline{c}}^{\underline{V}-\epsilon}(\underline{V} - \epsilon - c)dF(c) > 0$. Define $\underline{\pi}_A > 0$ by

$$\underline{\pi}_A = \frac{1}{2}\int_{\underline{c}}^{\underline{V}-\epsilon}(\underline{V} - \epsilon - c)dF(c). \tag{1}$$

Next, define, $\sigma_0 > 0, s' > 0$ by

$$\sigma_0 = \frac{\underline{\pi}_A}{\overline{V} - \overline{c}}, \quad s' = \sigma_0 \int_{\frac{\underline{V}+\overline{c}}{2}}^{\overline{c}} (c - \underline{V})dF(c). \tag{2}$$

Let $\delta > 0$ be defined by

$$\delta = \min\left\{\underline{\pi}_A, s', \int_{\underline{c}}^{\min\{V^{-1}(\frac{\underline{V}+\overline{c}}{2}), \underline{V}\}} (\underline{V} - c)dF(c)\right\}. \tag{3}$$

Define $b' > 0$ by

$$b' = (1 - \overline{\phi})\sigma_0 \int_{\underline{c}}^{V^{-1}(\frac{\underline{V}+\overline{c}}{2})} \left(\frac{\underline{V} + \overline{c}}{2} - V(c)\right) dF(c). \tag{4}$$

Fix n large enough such that

$$s_n \in (0, \delta), b_n \in (0, b').$$

In what follows, we consider the equilibrium E_n. Let $(\phi_n, p_{NA}, p(c), \psi(p), \sigma^I(p,c), \sigma^U(p))$ be the equilibrium strategy profile of the seller and the buyer. The uninformed seller chooses price p_{NA} and sells with probability $\sigma(p_{NA}) = \psi(p_{NA})F(V^{-1}(p_{NA})) + (1 - \psi(p_{NA}))\sigma^U(p_{NA})$. The ex ante expected profit the seller makes by not acquiring information equals $\sigma(p_{NA})(p_{NA} - c^e)$. As the seller does not acquire information with probability bounded below by $1-\overline{\phi} > 0$, the ex ante expected profit of the uninformed seller should be at least as large as what the seller can obtain by being informed (net of acquisition cost).

Observe that (regardless of belief about quality) the buyer necessarily buys for sure at any price $p < \underline{V}$. Thus, by acquiring information the seller can always make a positive profit by following a specific pricing strategy where $p(c) = \underline{V} - \epsilon$ for $c \leq \underline{V} - \epsilon$ and $p(c) = c$ for $c > \underline{V} - \epsilon$ as (using (1)) he then earns a net expected profit

$$\int_{\underline{c}}^{\underline{V}-\epsilon} (\underline{V} - \epsilon - c)dF(c) - s_n = 2\underline{\pi}_A - s_n > \underline{\pi}_A$$

as $s_n < \delta \leq \underline{\pi}_A$ (using (3)).Therefore, as $\sigma(p_{NA})(p_{NA} - c^e) \geq \underline{\pi}_A > 0$, which requires $p_{NA} \in (c^e, \overline{V}]$, we should have

$$\sigma(p_{NA}) > \frac{\underline{\pi}_A}{p_{NA} - c^e} \geq \frac{\underline{\pi}_A}{\overline{V} - c^e} = \sigma_0,$$

as defined in (2).

If $p_{NA} \leq \frac{\underline{V}+\overline{c}}{2}$, then the non-acquiring seller has an incentive to avoid the loss he makes if his true type turns out to be larger than p_{NA}. This expected loss is equal to

$$\sigma(p_{NA}) \int_{p_{NA}}^{\overline{c}} (c - p_{NA})dF(c) > \sigma_0 \int_{\frac{\underline{V}+\overline{c}}{2}}^{\overline{c}} (c - \underline{V})dF(c) = s'$$

as defined in (2) and since $s' \geq \delta > s_n$ (using (3)), the uninformed seller is strictly better off if he deviates to acquiring information for sure, a contradiction.

Next, consider $p_{NA} > \frac{\underline{V}+\overline{c}}{2}$. After observing such a price p_{NA}, by switching from not acquiring to acquiring information, the *buyer* can avoid the loss in the state where $V(c) < p_{NA}$ and this yields a gain to the buyer given by

$$\frac{(1-\phi)\sigma(p_{NA})}{\phi x + (1-\phi)} \int_{\underline{c}}^{V^{-1}(p_{NA})} (p_{NA} - V(c))dF(c)$$

where x is the probability the informed seller chooses p_{NA}. Note that $p_{NA} < \overline{V}$ for otherwise the seller earns zero profit. Further, as $p_{NA} > \frac{\underline{V}+\overline{c}}{2}$, $\phi x + (1-\phi) \leq 1, 1-\phi \geq$

$1-\overline{\phi}, \sigma(p_{NA}) > \sigma_0$ we have

$$\begin{aligned}
& \frac{(1-\phi)\sigma(p_{NA})}{\phi x+(1-\phi)} \int_{\underline{c}}^{V^{-1}(p_{NA})} (p_{NA}-V(c))dF(c) \\
> & \ (1-\overline{\phi})\sigma_0 \int_{\underline{c}}^{V^{-1}(\frac{\underline{V}+\overline{c}}{2})} \left(\frac{\underline{V}+\overline{c}}{2}-V(c)\right) dF(c) \\
= & \ b', \text{ as defined in (4)}
\end{aligned}$$

and as $b_n < b'$ the buyer must acquire information with probability one after observing price p_{NA},i.e., $\psi(p_{NA}) = 1$. The buyer will then not buy if $c \in [\underline{c}, V^{-1}(p_{NA}))$. Now, if the non-acquiring seller switches to acquiring information, charges $\underline{V}$ (and sells for sure) if $c \in [\underline{c}, \min\{V^{-1}(p_{NA}), \underline{V}\})$, charges price p_{NA} (as before the deviation) if $c \geq \min\{V^{-1}(p_{NA}), \underline{V}\}$, his net gain is

$$\begin{aligned}
G &= \int_{\underline{c}}^{\min\{V^{-1}(p_{NA}),\underline{V}\}} (\underline{V}-c)dF(c) \\
&\geq \int_{\underline{c}}^{\min\{V^{-1}(\frac{\underline{V}+\overline{c}}{2}),\underline{V}\}} (\underline{V}-c)dF(c) \ (\text{as } p_{NA} > \frac{\underline{V}+\overline{c}}{2}) \\
&\geq \delta, \text{ using (3)}
\end{aligned}$$

and as $s_n < \delta$, the seller is strictly better off deviating and acquiring information for sure, a contradiction. We have now established that when acquisition costs converge to zero, the equilibrium probability of acquisition by the seller must converge to 1.

To establish the second part of the proposition choose $z^* \in \arg\max_{z\in[\underline{c},\underline{V}]} F(z)\left[\frac{\underline{V}-z}{\overline{\overline{V}}-z}\right]$. It is easy to check that $\underline{c} < z^* < \underline{V}$. It is sufficient to show that along any sequence of vanishing acquisition costs, the ex ante probability the buyer remains uninformed on the equilibrium path is bounded below by

$$1-\overline{\psi} = F(z^*)\left[\frac{\underline{V}-z^*}{\overline{\overline{V}}-z^*}\right] \geq F\left(\frac{\underline{c}+\underline{V}}{2}\right)\left[\frac{\underline{V}-\frac{\underline{c}+\underline{V}}{2}}{\overline{\overline{V}}-\frac{\underline{c}+\underline{V}}{2}}\right] > 0.$$

Fix any $\widetilde{\phi} \in (0,1)$ that is close to 1. Choose any sequence of strictly positive acquisition costs $\{(b_n, s_n)\}$ converging to $(0,0)$. For each n, let E_n be an equilibrium for acquisition costs (b_n, s_n). Using the first part of this proposition there exists N such that for all $n \geq N$, the seller acquires information with probability $\phi_n \geq \widetilde{\phi}$ in equilibria E_n. Fix $n \geq N$. We will show that the ex ante probability that buyer remains *uninformed* on the equilibrium path in equilibrium E_n is bounded below by

$$\widetilde{\phi}F\left(z^*\right)\left[\frac{\underline{V}-z^*}{\overline{V}-z^*}\right] \tag{5}$$

and as $\widetilde{\phi}$ can be chosen arbitrarily close to 1, the probability the buyer remains uninformed on the equilibrium path in E_n is bounded below by $1-\overline{\psi}$ which would complete the proof. Let $(\phi_n, p_{NA}, p(c), \psi_n(p), \sigma^I(p,c), \sigma^U(p))$ be the equilibrium strategy profile of the seller and the buyer in equilibrium E_n. Consider the interval $[\underline{c}, z^*)$ and the price $p(c)$ charged by the informed seller of type $c \in [\underline{c}, z^*)$. It is clear that (5) holds if the following inequality holds

$$\psi(p(c)) \leq \frac{\overline{V}-\underline{V}}{\overline{V}-z^*} < 1 \text{ for all } c \in [\underline{c}, z^*)\,. \tag{6}$$

To establish (6), confine attention to types $c \in K = \{c \in [\underline{c}, z^*] : \psi(p(c)) > 0\}$. Note that an informed seller of type $c \in K$ can make a profit of $\underline{V} - c$ if he sets price $p(c) = \underline{V}$. Fix any $c \in K$. There are two possibilities:

(a) In equilibrium, the informed seller of type c only sells to the uninformed buyer by setting $p(c)$. The profit obtained by such a seller is then

$$(1-\psi_n(p(c)))(p(c)-c) \leq (1-\psi_n(p(c)))(\overline{V}-c)$$

and as this should be larger than $\underline{V} - c$, we should have

$$\psi(p(c)) \leq \frac{\overline{V}-\underline{V}}{\overline{V}-c} < \frac{\overline{V}-\underline{V}}{\overline{V}-z^*}$$

so that inequality (6) holds.

(b) In equilibrium, the informed seller of type c sells to an informed buyer with strictly positive probability. As $\psi(p(c)) > 0$, for the buyer to gain by acquiring information after observing price $p(c)$ and incurring a strictly positive acquisition cost there must be a set C of multiple informed seller types that pool to charge the same price $p(c)$. Moreoer, $p(c) < V(c')$ for some $c' \in C$. Now, there are two sub-cases:

(b.i) $p(c) \geq E[\ V(\widetilde{c}) \| \widetilde{c} \in C]$: Here, as $p(c) < V(c')$, there must be some $c'' \in C$ such that $p(c) > V(c'')$.

(b.ii) $p(c) < E[\ V(\widetilde{c}) \| \widetilde{c} \in C]$: Here the buyer would buy for sure if she did not acquire information (after observing price $p(c)$). So there must exist $c'' \in C$ such that the buyer strictly gains if she does not buy after finding the seller's true type is c'' $\in C$ and in particular, $p(c) > V(c'')$.

Thus in both sub-cases (b.i) and (b.ii) there exists $c'' \in C$ where $p(c) > V(c'')$. As V is strictly increasing, $p(c) > V(\widetilde{c})$ for all $\widetilde{c} \in C, \widetilde{c} \leq c''$ and so without loss of generality, we can choose $c'' \leq c < \frac{\underline{c}+\underline{V}}{2}$. The informed seller of type c'' sells only when the buyer is uninformed, i.e., with probability $1-\psi(p(c))$ and as this seller must earn at least $\underline{V} - c''$ we must have:

$$[1-\psi(p(c))][p(c)-c''] \geq \underline{V} - c''$$

and as $p(c) \leq \overline{V}$ we have

$$[1-\psi(p(c))][\overline{V}-c''] \geq \underline{V} - c''$$

and as $c'' < z^*$ we have

$$\psi(p(c)) < \frac{\overline{V}-\underline{V}}{\overline{V}-z^*}$$

Thus, (6) holds in all cases, which concludes the proof.

Proof of Proposition 2

The proof is by contradiction. Suppose, to the contrary, there exists an efficient equilibrium E_0 at $b = s = 0$ which is a limiting equilibrium where the seller extracts full surplus. Let $(\phi, p_{NA}, p(c), \psi(p), \sigma^I(p,c), \sigma^U(p))$ be the strategy profile in E_0.

We begin by arguing that E_0 must be a fully separating equilibrium where the seller acquires information for sure ($\phi = 1$), charges $p(c) = V(c)$ almost surely, the buyer acquires information with strictly positive probability and buys for sure at almost every price $p(c)$ charged by (informed) seller of type c.

To see that $\phi = 1$ note that if the seller were uninformed with strictly positive probability in E_0, then (i) if the uninformed seller charges a price that is strictly higher than $\underline{V}$, the buyer will have a strict incentive to acquire information and not buy for realizations of c close to $\underline{c}$ so that trade does not occur with strictly positive probability which contradicts efficiency, and (ii) if the price charged by the uninformed seller is no higher than $\underline{V}$, the uninformed seller cannot extract full surplus with probability one.

Let $\mathbf{P} = \{p : p = p_0(c), c \in [\underline{c}, \overline{c}]\}$ be the set of equilibrium prices. Efficiency requires that the buyer buys at price $p \in \mathbf{P}$ with probability one. As the seller extracts full surplus,

$$p = E[V(c) \| p(c) = p] \tag{7}$$

for (almost) all $p \in \mathbf{P}$. We now argue that this must be a fully separating equilibrium. Suppose, to the contrary, that a set S of strictly positive measure of seller types pool to charge some price $p' \in \mathbf{P}$, then as $V(.)$ is strictly increasing, (7) implies for types c close to the lowest types in S, $p' > V(c)$ so that given $b = 0$, the buyer has a strict incentive to acquire information after observing price p'. This in turn implies that seller types in $\{c : V(c) < p'\}$, a set of strictly positive measure, cannot sell at all violating efficiency. Thus, full extraction of surplus by the seller in E_0 implies that with probability one, $p(c) = V(c)$ with trade occurring almost surely at every such price. However, a lower quality type will then have a strict incentive to imitate (higher) prices unless the buyer acquires information with strictly positive probability after observing the higher price. Thus, $\psi(p(c)) > 0$ almost surely on $[\underline{c}, \overline{c}]$.Choose $c_0 \in (\underline{c}, \overline{c}]$ such that

$$\psi_0 = \psi(p(c_0)) > 0.$$

In the rest of the proof we argue that for strictly positive acquisition costs close enough to zero, there must be an equilibrium $\widetilde{E}$ close enough to E_0 where the seller is informed with probability close to one and the buyer acquires information with strictly positive probability when she observes $p(c_0)$. As information acquisition is costly, $p(c_0)$ must be a pooling price with the informed buyer not buying the lowest realizations of c in $\{c : \widetilde{p}(c) = \widetilde{p}(c_0)\}$. Tthis creates, however, an incentive for these lowest quality types in the pool to deviate to a lower price (charged by slightly lower types in this equilibrium) where they can sell with probability close to one.

Choose $c_1 < c_0$ close enough to c_0 such that

$$V(c_1) - V(c_0)[1 - \psi_0] > c_0\psi_0. \tag{8}$$

Given ψ_0, c_0 and c_1 choose $\epsilon > 0$ sufficiently small such that

$$2\epsilon < \min\{V(c_0) - V(c_1), c_0 - c_1, \psi_0\}. \tag{9}$$

Further as (8) holds, we choose $\epsilon > 0$ small enough so that

$$[V(c_1) - \epsilon][1 - \epsilon] - [V(c_0) + \epsilon][1 - (\psi_0 - \epsilon)] > c_0(\psi_0 - 2\epsilon). \tag{10}$$

As E_0 is a limiting equilibrium, there must exist an equilibrium $\widetilde{E}$ with strategy profile $(\widetilde{\phi}, \widetilde{p}_{NA}, \widetilde{p}(c), \widetilde{\psi}(p), \widetilde{\sigma}^I(p,c), \widetilde{\sigma}^U(p))$ for strictly positive acquisition costs $b > 0, s > 0$ arbitrarily small that is sufficiently close to E_0 so that *all* of the following hold in equilibrium $\widetilde{E}$:

(i) The probability that the seller acquires information in equilibrium $\widetilde{E}$ is close enough to 1 and in particular, at least as large as $1 - \epsilon$;

(ii) Prices $\widetilde{p}(c_1), \widetilde{p}(c_0)$ set by the informed seller of types c_1, c_0 in equilibrium $\widetilde{E}$ are close enough to the prices set by these types in equilibrium E_0 and in particular,

$$\widetilde{p}(c_i) \in (p(c_i) - \epsilon, p(c_i) + \epsilon) = (V(c_i) - \epsilon, V(c_i) + \epsilon), \quad i = 0, 1.$$

(iii) The set of seller types charging $\widetilde{p}(c_1)$ and $\widetilde{p}(c_0)$ in equilibrium $\widetilde{E}$ are close enough to c_1 and c_0 respectively:

$$\{c : \widetilde{p}(c) = \widetilde{p}(c_1)\} \subset (c_1 - \epsilon, c_1 + \epsilon), \{c : \widetilde{p}(c) = \widetilde{p}(c_0)\} \subset (c_0 - \epsilon, c_0 + \epsilon). \tag{11}$$

(iv) The buyer's information acquisition probability $\widetilde{\psi}(\widetilde{p}(c_0))$ after observing price $\widetilde{p}(c_0)$ set by the uninformed seller of type c_0 in equilibrium $\widetilde{E}$ is close enough to the acquisition probability of the buyer when he observes $p(c_0)$ in equilibrium E_0

$$\widetilde{\psi}(\widetilde{p}(c_0)) \geq \psi(p(c_0)) - \epsilon = \psi_0 - \epsilon > 0. \tag{12}$$

(v) The informed seller of type c_1 charging price $\widetilde{p}(c_1)$ in equilibrium $\widetilde{E}$ sells with probability at least as large as $1 - \epsilon$

Note that

$$\widetilde{p}(c_1) \leq V(c_1) + \epsilon < V(c_0) - \epsilon < \widetilde{p}(c_0)$$

To show that the lowest realizations of c in $\{c : \widetilde{p}(c) = \widetilde{p}(c_0)\}$ have an incentive to deviate consider an informed seller in this set who does not sell to an informed buyer. Using (12), the profit earned by this seller is at most

$$[\widetilde{p}(c_0) - c'][1 - \widetilde{\psi}(\widetilde{p}(c_0))] \leq [V(c_0) + \epsilon - c'][1 - (\psi_0 - \epsilon)].$$

If type c' deviates to charge the lower price $\widetilde{p}(c_1)$, he would sell for sure when the buyer is informed (as, using (9) and (11), c' is a strictly higher quality than every quality type that charges $\widetilde{p}(c_1)$ in equilibrium $\widetilde{E}$) and with the same probability as type c_1 if the buyer is uninformed, so that his expected deviation profit is at least

$$[\widetilde{p}(c_1) - c'][1-\epsilon] \geq [V(c_1) - \epsilon - c'][1-\epsilon].$$

Thus, the deviation is strictly gainful if

$$[V(c_1) - \epsilon - c'][1-\epsilon] > [V(c_0) + \epsilon - c'][1 - (\psi_0 - \epsilon)],$$

which (using (9), (10) and $c' < c_0$) holds, completing the proof.

Proof of Proposition 3

We show that the equilibrium E_0^* for the case $b = s = 0$ outlined in the main text (following the statement of Proposition 3) can be sustained as a limiting equilibrium as information acquisition costs vanish. Consider b, s small enough. Choose $h > 0$ arbitrarily small. As before, define $c_0(h) = \underline{c}$ and $c_1(h) = V(c_0(h)))$. Next, define $c_2(h) = V(c_1(h))) + h = p_2(h)$ and more generally, for $i \geq 1$ define

$$c_i(h) = \min\{V(c_{i-1}(h)) + h, \overline{c}\}$$

and let $T(h) = \min\{i : V(c_{i-1}(h)) + h \geq \overline{c}\}$. For $i = 1, ...T(h)$ define prices

$$p_i(h) = V(c_{i-1}(h)) + h.$$

Consider an equilibrium where the seller acquires information for sure and the seller types in $[c_{i-1}(h), c_i(h))$ pool to offer price $p_i(h)$. Note that $p_i(h) = c_i(h)$ for $i = 1, ...T(h) - 1$ and $p_{T(h)} \geq c_{T(h)} = \overline{c}$.

Note that for $i \geq 2$, $p_i(h) = V(c_{i-1}(h)) + h > V(c)$ for $c \in [c_{i-1}(h), V^{-1}(p_i(h)))$, while $p_i(h) = V(c_{i-1}(h)) + h \leq V(c)$ for $c \in [V^{-1}(p_i(h)), c_i)$. Define for $i \geq 2$,the buyer's gain from information acquisition when faced with price p_i

$$G_i = E[(p_i(h) - V(c)) \parallel c \in [c_{i-1}(h), V^{-1}(p_i(h))] > 0.$$

Choose

$$b < \min\{G_i : i = 2, ...T\}.$$

The equilibrium strategies are as follows. The buyer acquires information with probability zero when he observes price $p_1(h)$ and acquires information with probability one when he observes prices $p_2(h), ...p_{T(h)}(h)$. The buyer buys with probability one at price $p_1(h)$ and at prices $p_i(h)$ for $i \geq 2$ he buys if and only if $c \in (\ V^{-1}(p_i(h)), c_i)$. Thus for $i \geq 2$, seller of type $c \in [c_{i-1}(h), V^{-1}(p_i(h))]$ does not sell at all (the only inefficiency in this equilibrium). If buyer observes any out-of-equilibrium price he believes $c = \underline{c}$ for sure. If he observes such a price he buys only if the price is strictly below $V(\underline{c})$ (which is $\leq p_i(h)$ for all i.) There is no incentive for any seller of type $c \in [c_{i-1}(h), c_i(h))$ to deviate to a higher equilibrium price $p_k(h)$ for $k > i$ as the buyer will be informed and will not buy (as $p_k(h) = V(c_{k-1}(h)) + h \geq V(c_i(h)) > V(c)$). Note that even though the seller of type $c \in [c_{i-1}(h), V^{-1}(p_i(h))]$ does not sell at all, he cannot gain by deviating to price $p_{i-1}(h) = c_{i-1}(h)$. Given the out-of-equilibrium belief and the buyer's strategy, the seller has no incentive to deviate to any other price as he would have to charge a price strictly below $p_1(h)$ to sell. Finally, it is easy to check that given the beliefs of the buyer, the seller cannot gain by deviating to not acquiring information if h is small enough. As $h \to 0$, $c_i(h) \to c_i, p_i(h) \to p_i = V(c_{i-1})$ and so the interval $[c_{i-1}(h), V^{-1}(p_i(h))] = [c_{i-1}(h), V^{-1}(V(c_{i-1}(h)) + h))]$ converges to a point with probability zero (continuous distribution). Thus, the efficient equilibrium E_0^* for $b = 0, s = 0$ outlined in the main text is a limiting equilibrium.

Proof of Proposition 4

We begin by showing that as information acquisition costs converge to zero, the seller's acquisition probability must converge to 1. This part of the proof is very similar to the proof of the first part of Proposition 1. Suppose to the contrary there exists a sequence of strictly positive acquisition costs $\{(b_n, s_n)\}$ converging to $(0, 0)$ and for each n, an equilibrium E_n for acquisition costs (b_n, s_n) such that ϕ_n, the probability with which the seller acquires information in equilibrium E_n, is bounded above by $\overline{\phi} < 1$. We will show that for n large enough so that the acquisition costs are smaller than some strictly positive bounds, the seller has an incentive to deviate. We begin by outlining these bounds. Fix ϵ, $0 < \epsilon < \underline{V} - \underline{c}$. Then, $\underline{c} < \underline{V} - \epsilon$ and $\int_{\underline{c}}^{\underline{V}-\epsilon} (\underline{V} - \epsilon - c) dF(c) > 0$. Define $\underline{\pi}_A > 0, \sigma_0 > 0$

$$\underline{\pi}_A = \frac{1}{2} \int_{\underline{c}}^{\underline{V}-\epsilon} (\underline{V} - \epsilon - c) dF(c), \ \sigma_0 = \frac{\underline{\pi}_A}{\overline{V} - \overline{c}} \tag{13}$$

Next define $s' > 0, s'' > 0$ by $b' > 0, , \overline{s} > 0$ by,

$$s' = \sigma_0 \int_{\frac{\underline{V}+\overline{c}}{2}}^{\overline{c}} \left(c - \frac{\underline{V}+\overline{c}}{2} \right) dF(c), \;\; s'' = \int_{\underline{c}}^{\widetilde{c}} (V(c) - c) dF(c) \tag{14}$$

Let $\overline{s} > 0$ be defined by

$$\overline{s} = \min\{\underline{\pi}_A, s', s'') \tag{15}$$

Finally, let $b' > 0$ be defined by

$$b' = (1 - \overline{\phi})\sigma_0 \int_{\underline{c}}^{V^{-1}\left(\frac{\underline{V}+\overline{c}}{2}\right)} \left(\frac{\underline{V}+\overline{c}}{2} - V(c) \right) dF(c) \tag{16}$$

Fix n large enough so that

$$s_n \in (0, \overline{s}), b_n \in (0, b')$$

In what follows, we consider the equilibrium E_n. Let $(\phi_n, p_{NA}, p(c), \psi, \sigma^I(p, c), \sigma^U(p))$ be the equilibrium strategy profile of the seller and the buyer. The uninformed seller chooses price p_{NA} and sells with probability $\sigma(p_{NA}) = \psi(p_{NA})F(V^{-1}(p_{NA})) + (1 - \psi(p_{NA}))\sigma^U(p_{NA})$. The ex ante expected profit the seller makes by not acquiring information equals $\sigma(p_{NA})(p_{NA} - c^e)$ where $c^e = E(c)$. As the seller does not acquire information with probability bounded below by $1 - \overline{\phi} > 0$, the ex ante expected profit of the uninformed seller is at least as large as what the seller can obtain by being informed (net of acquisition cost).

We will show that the net expected profit of the seller when he acquires information is bounded below by $\underline{\pi}_A$ and $\sigma(p_{NA})$, the probability with which the seller sells when he does not acquire information is bounded below by σ_0. Observe that (regardless of belief about quality) the buyer necessarily buys for sure at any price $p < \underline{V}$. If the seller, after acquiring information, follows a specific pricing strategy where $p(c) = \underline{V} - \epsilon$ for $c \leq \underline{V} - \epsilon$ and $p(c) = c$ for $c > \underline{V} - \epsilon$ then he can earn net expected profit at least as large as

$$\int_{\underline{c}}^{\underline{V}-\epsilon} (\underline{V} - \epsilon - c) dF(c) - s_n = 2\underline{\pi}_A - s_n > \underline{\pi}_A$$

(where $\underline{\pi}_A$ is as defined in (13)) and thus $\underline{\pi}_A$ is a strictly positive lower bound on the net expected profit earned by the seller in equilibrium after acquiring information. Thus, $\sigma(p_{NA})(p_{NA} - c^e) > \underline{\pi}_A > 0$ which requires $p_{NA} \in (c^e, \overline{V}]$ and further,

$$\sigma(p_{NA}) > \frac{\underline{\pi}_A}{p_{NA} - c^e} \geq \frac{\underline{\pi}_A}{\overline{V} - c^e} = \sigma_0 \text{ (using (13))}$$

If $p_{NA} \leq \frac{\underline{V}+\overline{c}}{2}$, then the non-acquiring seller has an incentive to avoid the loss he makes if his true type turns out to be larger than p_{NA}. This expected loss is equal to

$$\begin{aligned} \sigma(p_{NA}) \int_{\frac{\underline{V}+\overline{c}}{2}}^{\overline{c}} (c - p_{NA}) dF(c) &> \sigma_0 \int_{\frac{\underline{V}+\overline{c}}{2}}^{\overline{c}} \left(c - \frac{\underline{V}+\overline{c}}{2} \right) dF(c) \\ &= s' \text{ (defined in (14))} \end{aligned}$$

As $s_n < \overline{s} \leq s'$, where $\overline{s}$ is as defined above, the seller is strictly better off deviating and acquiring information for sure.

It remains to consider the possibility that $p_{NA} > \frac{\underline{V}+\overline{c}}{2}$. First, consider the case where the buyer acquires information with probability $\psi < 1$. We argue that in such an equilibrium the buyer will deviate to $\psi = 1$ in order to avoid the loss of surplus in the state where she buys at price p_{NA} and true quality $c < V^{-1}(p_{NA})$; this expected loss of surplus for an uninformed buyer (relative to an informed buyer) is at least as large as

$$\frac{(1-\phi_n)\sigma(p_{NA})}{\phi_n x + (1-\phi_n)} \int_{\underline{c}}^{V^{-1}(p_{NA})} (p_{NA} - V(c)) dF(c),$$

where x is the probability the seller chooses p_{NA} when he is informed. As $p_{NA} > \frac{\underline{V}+\overline{c}}{2}, \phi_n \leq \overline{\phi}$

$$\begin{aligned} & \frac{(1-\phi_n)\sigma(p_{NA})}{\phi_n x + (1-\phi_n)} \int_{\underline{c}}^{V^{-1}(p_{NA})} (p_{NA} - V(c)) dF(c) \\ > \; & (1-\overline{\phi})\sigma_0 \int_{\underline{c}}^{V^{-1}\left(\frac{\underline{V}+\overline{c}}{2}\right)} \left(\frac{\underline{V}+\overline{c}}{2} - V(c) \right) dF(c) \\ = \; & b' \text{ (as defined in (16))} \end{aligned}$$

As $b_n < b'$, the buyer is strictly better off deviating to acquiring information for sure. Next, suppose that $p_{NA} > \frac{\underline{V}+\overline{c}}{2}$ and $\psi = 1$. In the state where the seller sets price p_{NA}, the buyer buys if, and only if, $c > V^{-1}(p_{NA})$ so that the uninformed seller makes an expected profit equal to $\int_{V^{-1}(p_{NA})}^{\overline{c}} (p_{NA} - c) dF(c)$. It is easy to check that the uninformed seller is strictly better off acquiring information and then selling for sure at price slightly below $V(c)$ for $c < V^{-1}(p_{NA})$ (while continuing to set a price p_{NA} for $c \geq V^{-1}(p_{NA})$ as on the candidate equilibrium path) if

$$\begin{aligned} s_n &< \int_{\underline{c}}^{V^{-1}(p_{NA})} (V(c) - c)dF(c) \\ &= s'' \text{ (defined in (14))} \end{aligned}$$

and this holds as $s_n < \overline{s} \leq s''$. This concludes the proof of the first part of the proposition.

We now establish the second part of the proposition i.e., the buyer's information acquisition probability is bounded above by $\widetilde{\psi}$ as information acquisition costs vanish. Choose $\epsilon > 0$ arbitrarily small. Let $\widetilde{\psi}_\epsilon = \max\{\psi^0(1+\epsilon), \psi^1\}$.As ϵ is arbitrary and $\widetilde{\psi}_\epsilon \to \widetilde{\psi}$ when $\epsilon \to 0$, this will complete the proof. Let $\widehat{s} > 0$ be defined by

$$\widehat{s} = \min \left\{ \begin{array}{c} \psi^0(1+\epsilon)(V^e - c^e) - \left(\frac{\underline{V}+V^e}{2} - c^e\right), \\ \psi^0(1+\epsilon) \int_{\underline{c}}^{V^{-1}(\frac{\underline{V}+V^e}{2})} (V(c) - c)dF(c) \end{array} \right\}$$

Choose any sequence of information acquisition costs $\{(b_n, s_n)\}$ converging to $(0,0)$; let E_n be an equilibrium for costs (b_n, s_n) and let ψ_n be the buyer's information acquisition probability in equilibrium E_n. There exists N such that for all $n \geq N$, $s_n < \widehat{s}$. We will show that $\psi_n \leq \widetilde{\psi}_\epsilon$ for all $n \geq N$.

To see this, suppose to the contrary there exists $n \geq N$ such that $\psi_n > \widetilde{\psi}_\epsilon$. In what follows, fix such n. Let $(\phi, p_{NA}, p(c), \psi_n, \sigma^I(p,c), \sigma^U(p))$ be the equilibrium strategy profile in E_n.

We begin by showing that $\phi = 1$ i.e., the seller must be acquiring information with probability one in this equilibrium. Suppose to the contrary $\phi < 1$. If the uninformed seller charges $p_{NA} \geq \frac{\underline{V}+V^e}{2}$ in equilibrium then he cannot sell to the informed buyer when $c < V^{-1}(\frac{\underline{V}+V^e}{2})$; if he deviates to acquiring information, continues to charge p_{NA} when $c \geq V^{-1}(\frac{\underline{V}+V^e}{2})$ and when $c < V^{-1}(\frac{\underline{V}+V^e}{2})$, sells to the informed buyer by charging $V(c)$, his net gain in expected profit is

$$\begin{aligned}
& \psi_n \int_{\underline{c}}^{V^{-1}(\frac{\underline{V}+V^e}{2})} (V(c)-c)dF(c) \\
> \;& \psi^0(1+\epsilon) \int_{\underline{c}}^{V^{-1}(\frac{\underline{V}+V^e}{2})} (V(c)-c)dF(c), \text{ as } \psi_n > \widetilde{\psi}_\epsilon \geq \psi^0(1+\epsilon) \\
\geq \;& \widehat{s} > s_n
\end{aligned}$$

so that the seller strictly gains by acquiring information for sure. On the other hand, if the uninformed seller charges $p_{NA} < \frac{\underline{V}+V^e}{2}$ in equilibrium, his equilibrium profit is at most

$$\int_{\underline{c}}^{\overline{c}} (\frac{\underline{V}+V^e}{2} - c)dF(c) = \left[\frac{\underline{V}+V^e}{2} - c^e\right]$$

while if he deviate to acquiring information and selling to (at least) the informed buyer at price $V(c)$ for every c, his expected deviation profit is at least

$$\psi_n \int_{\underline{c}}^{\overline{c}} (V(c)-c)dF(c) = \psi_n(V^e - c^e)$$

so that the net gain in expected profit by acquiring information is at least as large as

$$\begin{aligned}
& \psi_n(V^e - c^e) - \left[\frac{\underline{V}+V^e}{2} - c^e\right] \\
> \;& \psi_0(1+\epsilon)(V^e - c^e) - \left[\frac{\underline{V}+V^e}{2} - c^e\right] \\
\geq \;& \widehat{s} > s_n
\end{aligned}$$

and therefore, the seller strictly gains by acquiring information for sure. We have now established that $\phi = 1$ in equilibrium E_n.

As the buyer acquires information with probability $\psi_n > \widetilde{\psi}_\epsilon > 0$, there must be prices on the equilibrium path such that an uninformed buyer gains at least b_n by acquiring information. This implies there must be at least one price $\widehat{p}$ at which different types of sellers pool and at which informed and uninformed buyers would make different decisions: either (i) the uninformed buyer buys with positive probability, but there are types $c' \in \{\widehat{c} : p(\widehat{c}) = \widehat{p}\}$ such that $\widehat{p} > V(c')$ so that an informed buyer would not buy, or (ii) the uninformed buyer does not buy, but there are types for which the price is smaller than the buyer's valuation so that an informed buyer would buy; this too implies there are types $c' \in \{\widehat{c} : p(\widehat{c}) = \widehat{p}\}$ such that $\widehat{p} > V(c)$ so that an informed buyer would not buy. Consider any such type c' that does not sell to the informed buyer; the profit earned by this seller type is at most $(1-\psi_n)(\widehat{p}-c')$. Type c' can always earn profit $\psi_n(V(c') - c')$ by deviating to price $V(c')$ and selling only to the informed buyer. To rule out this deviation, we must have

$$(1-\psi_n)(\widehat{p}-c') \geq \psi_n(V(c') - c')$$

and as $\widehat{p} \leq \overline{V}$, we have

$$\begin{aligned}\psi_n &\leq \frac{(\overline{V} - c')}{(\overline{V} - c') + (V(c') - c')} \\ &\leq \psi^1\end{aligned}$$

which contradicts $\psi_n > \widetilde{\psi}_\epsilon \geq \psi^1$. This concludes the proof.

Proof of Proposition 5. In the main text, we have described an equilibrium E_0 for $b = s = 0$ where (i) the seller acquires information for sure, (ii) the buyer acquires information with probability $\psi_0 = \frac{\overline{V}-V}{\overline{V}-\underline{c}}$ and (iii) the seller with quality c charges price equal to $V(c)$ and sells with probability one To establish the proposition it is sufficient to show the following: there exists $\widehat{s} > 0$ and for any $\epsilon > 0$ small enough, $b(\epsilon) > 0$ such that for $s = \widehat{s}, b = b(\epsilon)$ there is an equilibrium where the seller acquires information for sure, the buyer acquires information with probability $\psi(\epsilon) \in (0, 1)$ and for all realizations of $c \in [\underline{c} + \epsilon, \overline{c} - \epsilon]$ the seller charges price equal to the buyer's valuation $V(c)$, trades with probability one and extracts full surplus ; further $b(\epsilon) \to 0$, $\psi(\epsilon) \to \psi_0$ when $\epsilon \to 0$. The proposition then follows by considering any strictly positive sequence $\{\epsilon_n\}$ converging to zero where ϵ_n are small enough, and then noting that an equilibrium as described above exists for $\epsilon = \epsilon_n$ and that these equilibria are identical to the equilibrium in E_0 except for price and trading probability for quality realizations below $\underline{c} + \epsilon_n$ and those above $\overline{c} - \epsilon_n$, a set that vanishes (in Lebesque and probability measure) as $n \to \infty$.

From assumption A3 we can fix $\epsilon > 0$ sufficiently small such that $\underline{V} < \overline{c} - \epsilon$ and

$$\frac{V(\overline{c} - \epsilon) - V(\underline{c})}{V(\overline{c} - \epsilon) - \underline{c}} < \frac{V(\overline{c} - \epsilon) - \overline{c}}{\overline{V} - \overline{c}}. \tag{17}$$

Let $\widetilde{p} = V(\overline{c} - \epsilon)$. For any $b > 0$ with

$$b < \int_{\underline{c}}^{\overline{c}-\epsilon} (\widetilde{p} - V(c))dF(c)$$

there exists $h(b) \in (0, \epsilon)$ such that

$$b = \int_{\underline{c}}^{\underline{c}+h(b)} (\widetilde{p} - V(c))dF(c). \tag{18}$$

It is easy to check that $h(b) \to 0$ as $b \to 0$ and that $h(b)$ is strictly increasing in b. Next, given ϵ, choose b small enough (and therefore, $h(b)$ small enough) so that the following conditions hold:

$$\widetilde{p} = V(\overline{c} - \epsilon) \leq E\left[V(c) \| c \in [\underline{c}, \underline{c} + h(b)) \cup (\overline{c} - \epsilon, \overline{c}]\right] \tag{19}$$

and

$$\frac{\widetilde{p} - V(\underline{c} + h(b))}{\widetilde{p} - (\underline{c} + h(b))} < \frac{\widetilde{p} - \overline{c}}{V(\overline{c}) - \overline{c}}. \tag{20}$$

Note that as $b, h(b) \to 0$ and the distribution of c is continuous with full support on $[\underline{c}, \overline{c}]$,

$$E\left[V(c) \| c \in [\underline{c}, \underline{c} + h(b)) \cup (\overline{c} - \epsilon, \overline{c}]\right] \to E\left[V(c) \| c \in (\overline{c} - \epsilon, \overline{c}]\right] > V(\overline{c} - \epsilon) = \widetilde{p}$$

so that the inequality in (19) must hold for $b, h(b)$ small enough. Further, the inequality in (17) implies that (20) must hold for b, and therefore $h(b)$, small enough.

Next, we claim the following inequality holds

$$\frac{\widetilde{p} - (\underline{c} + h(b))}{[\widetilde{p} - (\underline{c} + h(b))] + [V(\underline{c} + h(b)) - ((\underline{c} + h(b))]} > \frac{\widetilde{p} - V(\underline{c} + h(b))}{\widetilde{p} - (\underline{c} + h(b))}. \tag{21}$$

To see this, observe that (21) can be written as

$$\frac{V(\underline{c} + h(b)) - ((\underline{c} + h(b))}{\widetilde{p} - (\underline{c} + h(b))} < \frac{V(\underline{c} + h(b)) - (\underline{c} + h(b))}{\widetilde{p} - V(\underline{c} + h(b))},$$

which holds as $V(\underline{c}+h(b)) > (\underline{c}+h(b))$. Let

$$\psi(\epsilon) = \frac{\widetilde{p} - V(\underline{c}+h(b))}{\widetilde{p} - (\underline{c}+h(b))} \in (0,1). \tag{22}$$

Using (20) and (21)) we have

$$\begin{aligned} & \min\left\{\left(\frac{\widetilde{p} - (\underline{c}+h(b))}{[\widetilde{p} - (\underline{c}+h(b))] + [V(\underline{c}+h(b)) - ((\underline{c}+h(b))]}\right), \left(\frac{\widetilde{p} - \overline{c}}{\overline{V} - \overline{c}}\right)\right\} \qquad (23) \\ > \quad & \psi(\epsilon) = \frac{\widetilde{p} - V(\underline{c}+h(b))}{\widetilde{p} - (\underline{c}+h(b))} \end{aligned}$$

We now claim for $s > 0$ small enough there exists an equilibrium where the seller acquires information for sure, the buyer acquires information with probability $\psi(\epsilon)$, the seller's equilibrium pricing strategy is

$$\begin{aligned} p(c) &= V(c), \text{ for } c \in [\underline{c}+h(b), \overline{c}-\epsilon] \\ &= \widetilde{p}, \text{ for } c \in [\underline{c}, \underline{c}+h(b)) \cup (\overline{c}-\epsilon, \overline{c}] \end{aligned}$$

and only the uninformed buyer buys when $p = \widetilde{p}$ and $c \in [\underline{c}, \underline{c}+h(b))$ and otherwise, both the informed and uninformed buyer buy for sure. Out-of-equilibrium beliefs of the buyer assign probability one to the seller being of type $\underline{c}$ at any off path price. The uninformed buyer does not buy at any off path price unless the price is strictly below $\underline{V}$. The informed buyer buys (and buys for sure) if (and only if) the price is no larger than his valuation of actual quality.

We now verify that all incentive constraints needed for this equilibrium are satisfied. First, observe that the right-hand side of the inequality in (18) is the expected gain of the buyer if she becomes informed (as he can avoid buying at quality realizations for which the pooling price exceeds his valuation) and as this equals the cost of information acquisition, the buyer is indifferent between acquiring and not acquiring information. Second, note that the equilibrium pricing strategy for $c \in [\underline{c}+h(b), \overline{c}-\epsilon]$ fully reveals the seller's type and as the price is equal to buyer's valuation, it is optimal for the buyer to buy for sure (regardless of whether or not he is informed). Further, (19) implies that the expected valuation of the uninformed buyer after observing price $\widetilde{p}$ is at least as high as $\widetilde{p}$ and so it is optimal for the uninformed buyer to buy; for the informed buyer facing price $\widetilde{p}$, it is optimal to buy if, and only if, the true valuation does not exceed $\widetilde{p}$ which only holds for $c \in (\overline{c} - \epsilon, \overline{c}]$.

Next, we verify the seller has no incentive to deviate from his pricing strategy. First, consider a seller of type $c \in [\underline{c} + h(b), \overline{c} - \epsilon)$. Clearly, he has no incentive to deviate to a lower price. Moreover, he has no incentive to deviate from price $V(c)$ to the higher price $\widetilde{p}$ (where he would sell only to an uninformed buyer as an informed buyer would know his true quality) if

$$V(c) - c \geq (\widetilde{p} - c)(1 - \psi(\epsilon)) \text{ for all } c \in [\underline{c} + h(b), \overline{c} - \epsilon)$$

and as $V(c) - c$ is nondecreasing in c this holds if, and only if,

$$V(\underline{c} + h(b)) - (\underline{c} + h(b)) \geq [\widetilde{p} - (\underline{c} + h(b)](1 - \psi(\epsilon)),$$

which follows from (22).

Then, a seller of type $c \in [\underline{c}, \underline{c} + h(b))$ cannot gain by deviating from the pooling price $\widetilde{p}$ to a lower price $p(c') = V(c')$ for some $c' \in [\underline{c} + h(b), \overline{c} - \epsilon)$ as he can only sell to an uninformed buyer at the latter price. Further, such a seller does not gain by deviating to a lower price $V(c)$ (where he would be selling only to informed buyers, given the beliefs of an uninformed buyer) if:

$$(\widetilde{p} - c)(1 - \psi(\epsilon)) \;\geq (V(c) - c)\psi(\epsilon) \text{ for all } c \in [\underline{c}, \underline{c} + h(b))$$

and as $V(c) - c$ is non-decreasing this holds if, and only if,

$$(\widetilde{p} - (\underline{c} + h(b)))(1 - \psi(\epsilon)) \;\geq (V(\underline{c} + h(b)) - (\underline{c} + h(b)))\psi(\epsilon),$$

which follows from the (first) inequality in (23). A seller of type $c \in [\underline{c}, \underline{c} + h(b))$ can also not gain by deviating to $\underline{V}$ where he can sell with probability one if

$$(\widetilde{p} - c)(1 - \psi(\epsilon)) \;\geq \underline{V} - c \text{ for all } c \in [\underline{c}, \underline{c} + h(b)),$$

which holds, if and only if, it holds at $c = \underline{c}$, i.e.,

$$\psi(\epsilon) \leq \frac{\widetilde{p} - \underline{V}}{\widetilde{p} - \underline{c}}. \tag{24}$$

Given the definition of $\psi(\epsilon)$ in (22) this holds if

$$[\widetilde{p} - V(\underline{c} + h(b))]\,[\widetilde{p} - \underline{c}] \leq [\widetilde{p} - (\underline{c} + h(b))]\,[\widetilde{p} - \underline{V}]\,,$$

i.e.,

$$h(b)\,[\widetilde{p} - \underline{V}] \leq (\widetilde{p} - \underline{c})\,[V(\underline{c} + h(b)) - \underline{V}]\,,$$

which is true as $\widetilde{p} - \underline{V} \leq (\widetilde{p} - \underline{c})$ and $h(b) \leq V(\underline{c} + h(b)) - \underline{V}$ as $V(c) - c$ is non-decreasing.

A seller of type $c \in (\overline{c} - \epsilon, \overline{c}]$ has no incentive to deviate from pooling price $\widetilde{p}$ to a strictly higher price $V(c)$ where it sells only to informed buyer if

$$(\widetilde{p} - c) \geq (V(c) - c)\psi(\epsilon) \text{ for all } c \in (\overline{c} - \epsilon, \overline{c}]$$

which follows from the first inequality in (23).

A seller that deviates from acquiring to not acquiring information saves on the acquisition cost but given the beliefs and equilibrium incentive conditions, the uninformed seller cannot extract more surplus from the buyer compared to the informed seller for any quality realization. Further, he cannot sell to an informed buyer if the valuation of the realized quality is below any of the equilibrium prices that he may choose after deviation. One can check that given the equilibrium beliefs of the buyer, the seller's loss of ex ante expected profit by deviating to non-acquisition is bounded away from zero for a range of ϵ in a (right) neighborhood of zero so that we can choose a fixed $\widehat{s} > 0$ small enough for which the deviation by the seller to non-acquisition is never gainful.

Finally, note that as $\epsilon \to 0$

(a)

$$b(\epsilon), h(b(\epsilon)) \to 0$$

(b)

$$\psi(\epsilon) = \frac{V(\overline{c} - \epsilon) - V(\underline{c} + h(b(\epsilon)))}{V(\overline{c} - \epsilon) - (\underline{c} + h(b(\epsilon)))} \to \frac{V(\overline{c}) - V(\underline{c})}{V(\overline{c}) - \underline{c}} = \psi_0$$

This concludes the proof.