The Monopolist's Blues*

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Abstract

We consider the problem of trade between a price setting party who has private information about the quality of a good and a price taker who may also have private information. We restrict attention to the case in which, under full information, it is efficient to trade only a subset of all qualities. In particular, we assume that trading a low (high) quality is inefficient when the seller (buyer) sets the price. We show that there is a unique equilibrium outcome passing Cho and Kreps (1987) "Never a Weak Best Response". The refined outcome is always characterized by no trade, although trade would be mutually beneficial in some state of nature. This occurs: 1. Even if the price taker has more precise information than the price setting party, and 2. Even when the information received by both parties is almost perfect. Both results imply that there are inefficiencies due to price setting that are not present in standard markets with adverse selection. We find that the price setting party can always increase her profits through ex-ante delegation of the price choice to an uninformed third party. We discuss applications to professional bodies and the market for unskilled labor.

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1 Introduction

Since Akerlof's seminal work, a number of studies have pointed out that posted prices may be used to separate high quality goods from lemons. The adverse selection problem would be thus mitigated by the use of prices as a signaling device. A standard assumption in this literature is that, under full information, there are gains from trading each of the qualities of the good potentially offered by the sellers. This assumption is certainly valid in many applications. It is also motivated by the need for a clear benchmark when assessing the inefficiencies produced by asymmetric information. However, for certain goods and services, the idea that there are positive gains from trade irrespectively of quality sounds far less appealing. It is conceivable that the value to a patient of a diagnosis made by a skilled doctor greatly exceed the doctor's cost of making the diagnosis. However, the value to the same patient of a diagnosis made by a quack might be zero or even negative, while the quack still incurs a cost when making the diagnosis. Similarly, the value to a client of the assistance of an incompetent lawyer is much lower than the cost that the lawyer incurs to study the court case, while the opposite is probably true in the case of a talented lawyer. As these examples show, gains from trade might be negative for a good or service of very poor quality. Gains from trade might also be negative when the quality of the good or service to be traded is very high. For example, consider an employer who wants to hire a worker for a job that does not require any particular skill. It is reasonable to assume that for unskilled workers the (opportunity) cost of supplying labor is exceeded by the benefits that firms derive from hiring them. The same might not be true for high ability workers.

This paper shows that allowing for negative gains from trade in particular states of nature results in an extreme equilibrium outcome. We consider the problem of trade between a price setting party who has private information about the good and a price taker who is imperfectly informed but may have access to some private information as well. Precisely, both the price setting party and the price taker observe a private signal about the quality of the good. We focus on the case in which it is efficient to trade only goods of certain qualities among all possible qualities. In particular, we assume that it is inefficient to trade the quality that yields the lowest (opportunity) cost or the highest benefit from trade to the price setting party. In the case of a price setting seller, this happens when the seller's evaluation for the lowest quality is higher than the buyer's evaluation. Symmetrically, when the buyer sets the price, this happens when the buyer's evaluation for the highest quality is below the seller's evaluation.

We show that whenever the price setting party has private information and the price taker's information is not perfect there is a unique equilibrium outcome which survives Cho and Kreps (1987) "Never a Weak Best Response" (NWBR). Remarkably, in the refined outcome, trade always collapses.

The result is general to the extent that it holds independently of: a. The precision of the information available to the parties, b. The relative precision of the information of one party vis-á-vis the other. For instance, when the seller sets the price, trade collapses even if the buyer's information is extremely precise or if it is extremely precise relative to the seller's information. It is sufficient that the buyer is imperfectly informed and that the seller has some information not directly available to the buyer but potentially revealable through the price choice.[1]

In order to understand the role of price setting, a comparison with a framework in which agents take the price as given may be useful. Consider a standard lemon market populated by a seller and a buyer. Assume that both are price takers but everything else is as in our setting: the seller's (opportunity) cost of selling a low quality good exceeds buyer's evaluation. The opposite is true for a good of high quality. When the probability that the good is of high quality is positive, market breakdown may only occur if information is sufficiently imprecise. As agents' information improves, one can always find prices at which the probability of trade is positive. By contrast, when the seller is price setting, the amount of trade in the refined equilibrium is always zero independently of the quality of information (provided that information is not perfect). The use of prices as signals, far from alleviating the adverse selection problem, might exacerbate it.

The intuition behind the result stems from two observations. The first is that full separation through prices is never incentive compatible. Consider the case of a price-setting seller and a price-taking buyer and assume that gains from trading are negative for sufficiently low qualities. The only way in which the buyer could give the seller incentives to fully reveal her information through prices is by buying at low prices with a higher probability than at high prices. However, this relationship between price and probability to trade cannot hold when the seller observes a sufficiently bad realization of her private signal. Prices which reveal the bad realization and induce the buyer to buy are always below the minimum price at which the seller is willing to sell.

The second observation relates to the signaling role of prices out of the equilibrium path. It is well known that beliefs satisfying NWBR allow for this type of signaling. The effect of these "out of equilibrium" signals is to destroy any type of pooling that may sustain trade in equilibrium. To gather intuition, consider the previous example and suppose that the seller announces the same equilibrium price for two different realizations of her signal, say good and bad. In the candidate equilibrium, the seller profits less from trading when her signal is good than when is bad. The incentive to deviate from the equilibrium price and announce a higher price is thus affected by the signal realization. According to NWBR, buyer's beliefs should take this difference in incentives into account when observing a deviation. This in turn ensures that, upon receiving a good signal, the seller wants to deviate to a higher price. Any equilibrium

[1]The market breakdown outcome is also quite robust. For instance, it is not affected by perturbations of the the payoffs as those used by Ellingsen (1997).

in which trade is sustained by pooling is accordingly destroyed.

The signaling role of prices might thus destroy trade, even though trade would be the efficient outcome in some state of nature. An important implication is that the price setting party would be always better off by committing ex-ante to strategies that are not contingent on her private information. This suggests a possible mechanism to restore trade. Assume that the price setting party is able to fully delegate the choice of the price to an uninformed third party, an intermediary, acting at his behest. This delegation provides a commitment device to trade at prices that do not depend on the private information of the price setting party. For example, a doctor could benefit from his professional association setting fees for him. Since the professional association sets fees for a large number of doctors, the fees do not reveal any information about the ability of a specific doctor.[2]

As observed by Matthews (1991), economists have traditionally viewed professional bodies as associations enforcing cartel prices in order to prevent competition among members. While restricting competition is something that these bodies probably do, there could be other equally important reasons for their existence. Indeed, while producers benefit from the formation of cartels in virtually every market, price-setting associations of producers are not present in every market. Our analysis offers a complementary explanation that may shed light on why this price setting role of professional bodies is more valuable in some markets than in others. According to our model, delegation of the price setting task to an intermediary, such as an association of producers, is more valuable when the buyer is not perfectly informed and evaluates a low quality good or service less than the seller. This may explain why deregulation attempts usually encounter stiffer resistance in particular services such as health care, for instance, than in others. Examples and applications are discussed in section 5. There, we also discuss how the model provides a possible rationale for firms to commit to a uniform wage policy in markets for unskilled labor.

This paper contributes to two different but related strands of the literature. The first is the literature on the signaling role of prices in markets with imperfect information. The second is the literature on the effect of information on trade.

Within the first strand, important contributions including Milgrom and Roberts (1986), Laffont and Maskin (1987), Bagwell and Riordan (1991) Bagwell (1991), Overgard (1987) and Ellingsen (1997) have focused on the case of monopoly. In particular, Bagwell (1991) finds that, with a downward sloping demand, the only equilibrium which satisfies the Intuitive Criterion (Cho and Kreps 1987) is a separating equilib-

[2]The rationale for delegation here is different from the standard case in which the principal commits by giving incentives different from his own to a delegate decision maker, as for instance in Fershtman and Judd (1987) and in Persson and Tabellini (1993), or by hiring a delegate decision maker with particular preferences, as in Schelling (1960). Here, the price setting party commits not to reveal information by hiring a delegate decision maker who has no private information or whose action cannot reflect the information of the price setting party.

rium in which the high quality is traded at a higher price but the amount sold is lower than the amount sold when the quality is low. Ellingsen (1997), who uses a setup more directly comparable with the one developed here, considers a model with one seller and one buyer with inelastic demand. He finds that there is a unique equilibrium which survives D1 (Cho and Kreps 1987) and is fully separating. Finally, Voorneveld and Weibull (2005) characterize all equilibria in a model with a perfectly informed seller and a buyer who observes a private signal. All these models assume that a positive amount of trade is efficient independently of the monopolist's quality. In other words, under full information, there are positive gains from trading each of the qualities of the good. Moreover, none of the mentioned papers considers the case of a seller with imperfect information or the case of a price setting buyer.[3]

Within the second strand of literature, Levin (2001) considers a model in which both buyer and seller are price taker. He finds that the relationship between information asymmetries and trade is not monotonic. Kessler (2001), in a competitive market, finds similar results by varying the fraction of informed sellers. We show, in a price setting contest, that there is a discontinuity of the refined equilibrium in the precision of information available. When the price setting party has perfect information, the amount of trade drops from the full information level to zero as soon as the price taker's information becomes noisy.[4] Finally, in an informed-principal framework, Ottaviani and Prat (2001) show that the principal always benefits from committing to directly reveal the information that can be guessed through the contract he offers and destroying the rest. In our setup, in which direct revelation is not possible, the monopolist is always better off by committing to a "contract" that does not reveal any information.

The paper is organized as follows. Section two considers the case of a price-setting seller. Section three extends the results to the case of a price-setting buyer. Section four illustrates the benefits of delegation. Section five discusses examples and applications. Section six concludes.

2 The Price-Setting Seller Model

A seller (S) is endowed with one unit of a good. The quality q of the good can be either high (H) or low (L). A buyer (B) has inelastic demand and consumes either one unit or nothing. The timing of the game is as follows. At stage 0 Nature draws

[3]Wilson (1980) considers the case of price setting buyers in a market populated by many agents. However, differently from our setup, the price taking sellers are perfectly informed.

[4]Mailath et al (1993) use a similar discontinuity argument to criticize the use of refinements based on forward induction. While we do not have strong views on the issue, we believe that the use of a forward induction refinement makes our results more directly comparable with the existing literature on the signaling role of prices (see for example Milgrom and Roberts (1986), Bagwell and Riordan (1991) Bagwell (1991), and Ellingsen (1997)).

$q \in \{H, L\}$ from a Bernoulli distribution with $\Pr(q = H) = \lambda$ and $\Pr(q = L) = 1 - \lambda$. At stage 1, either S or both S and B exogenously receive some private information about the quality of the good (see below). At stage 2, S announces a price p at which he is willing to trade. The price announced by S is assumed to be a take-it-or-leave-it offer. At stage 3, B observes p and chooses whether to buy or not. Finally, at stage 4, payoffs are realized.

As for the information available to S and B, we first consider the *extreme case* in which S is perfectly informed while B only relies on prior information and on the information conveyed by the price. We then turn attention to the *general case* in which both S and B receive a private signal, s_S and s_B respectively.

Seller S values a high quality good v_H and a low quality good $v_L < v_H$. Alternatively, v_q, $q = L, H$, can be viewed as the cost of producing a good of quality q (provided that production occurs conditional on trade). B values a high quality good u_H and a low quality good $u_L < u_H$. We assume $u_H > v_H$ and $u_L < v_L$ such that there is a potential gain from trading the high quality and a potential loss from trading the low quality. The last assumption is an aspect in which this model departs from the existing literature. As discussed in the introduction, one can think of several examples in which this assumption is appropriate, including professional advise by physicians, engineers, psychologists, etc.

The equilibrium concept we use is Perfect Bayesian Equilibrium (PBE). We give the definition for the general case. Denote with $\mu(s_S|p, s_B)$ the belief function giving B's probability assessment that S has observed a signal realization s_S given p and s_B. A PBE for the general case is a strategy profile for S and B and a belief function $\mu^*(s_S|p, s_B)$ which satisfy the usual conditions: 1) S's best reply, 2) B's best reply, 3) consistency of $\mu^*(s_S|p, s_B)$ for all p that are announced with positive probability in equilibrium. In order to avoid the common "unsent message" problem, we refine the PBE concept with Cho and Kreps (1987) version of "Never a Weak Best Response" (NWBR). Intuitively, for any p that is announced with probability zero in equilibrium, if the set of B's best responses for which a seller observing s_S weakly benefits from announcing p (relative to his equilibrium payoff) is contained in the set for which a seller observing $s'_S > s_S$ strictly benefits, then B, upon observing p, assigns probability zero to s_S.

Before characterizing the equilibrium, it is worth considering the first best benchmark. With full information trade only occurs if the seller is of type H. Thus, total expected surplus is $W^{FI} = \lambda[u_H - v_H]$. Since S is able to extract all the surplus from B under full information, S's profits are equal to W^{FI}.

2.1 The extreme case: S is perfectly informed and B has no private information

This section illustrates how the market breaks down in the extreme case in which the seller has perfect information and the buyer combines prior information with information conveyed by the price. In the next section we consider the general case in which both B and S receive a private signal.

Let $\mu(q|p)$ denote B's beliefs on the quality of the good upon observing p. The application of NWBR is straightforward in this case. Consider a deviation p. If the set of B's mixed best responses for which type H strictly benefits (relative to his equilibrium payoff) contains the set for which type L weakly benefits, then $\mu^*(L|p) = 0$.

Proposition 1. *There is a unique NWBR-refined equilibrium outcome, and this is such that no trade occurs.*

The proof uses two arguments. First, there is no separating equilibrium in which trade occurs. Intuitively, type L can only trade by mimicking type H so that separation is never incentive compatible. Second, no pooling or hybrid equilibrium survives NWBR. If a price p is announced by both types, a type H seller always prefers to deviate to a price higher than p in order to signal his type. The intuition here is that trading at p is relatively more costly for type H since $v_H > v_L$. The potential gain from a deviation $p' > p$, relative to the equilibrium payoff, is higher for type H than for type L. It follows that type H is "more seemly" to benefit from the deviation. Hence, B should believe that the deviation comes from type H. This in turn implies that it is always profitable to deviate to some p', thus destroying any pooling or hybrid equilibria.

Differently from Akerlof (1970), the market breakdown is not induced by a downward pressure on the price due to adverse selection. Here, the market breakdown is caused by an upward pressure on the price driven by signaling concerns. The main effects at work can be metaphorically described as an "upward race". Given pooling, type H increases his price to differentiate himself from type L. Given separation, type L increases his price to mimic type H. When the price reaches u_H, no further upward deviation is possible, since B would never buy at higher prices. However, if both types announce $p = u_H$, B replies by not buying. Hence, the only refined equilibrium is one in which the market breaks down. Clearly, this equilibrium is sustained by off-equilibrium beliefs which give a weight large enough to type L. This is robust to NWBR since both types make zero surplus. It follows that both types have the same incentive to deviate to any $p > v_H$.

It is immediate to show that NWBR-refined outcome survives (unobserved) small perturbations of the buyer's evaluation, as in Ellingsen (1997). This suggests that the market breakdown result is not a consequence of the inelasticity of demand.

2.2 The general case: both S and B observe a private signal

In this section we consider the general case in which both S and B observe a private signal about the quality of the good. The timing of the game is as follows. At stage 0, Nature draws $q \in \{H, L\}$. At stage 1, both S and B observe a private signal (s_S and s_B respectively). At stage 2, S announces a price p. At stage 3, B observes p and decides whether to buy or not. Finally, at stage 4, payoffs are realized.

The signals $s_B \in [\underline{s}_B, \overline{s}_B]$ and $s_S \in [\underline{s}_S, \overline{s}_S]$ received by B and S are assumed to be independently drawn conditional on quality q. The density function for s_B is denoted with $f(s_B|q)$ and the cumulative with $F(s_B|q)$. The density function for s_S is denoted with $g(s_S|q)$ and the cumulative with $G(s_S|q)$. We impose standard restrictions on $f(.|q)$ and $g(.|q)$:

Assumption 1. *$f(.|q)$ and $g(.|q)$:*

1. *are continuous with full support;*
2. *satisfy the Monotonic Likelihood Ratio Property, i.e.*

$$\frac{f(s_B|H)}{f(s_B|L)} \text{ is increasing in } s_B \tag{1}$$

$$\frac{g(s_S|H)}{g(s_S|L)} \text{ is increasing in } s_S \tag{2}$$

and the above ratios have full support $(0, \infty)$.

The main result of this section is the following.

Proposition 2. *Assume that $f(.|q)$ is non-degenerate and satisfies assumption 1. Then in both of the two following cases:*

1. *$g(.|q)$ is non-degenerate and satisfies assumption 1,*
2. *S is perfectly informed so that $g(.|q)$ is degenerate,*

there is a unique NWBR-refined equilibrium outcome, and this is such that no trade occurs.

In order to understand the intuition, it is worth analyzing the extent of the result. The results of proposition 1 not only apply to the case in which S receives a more precise signal than B, but also to the case in which B observes a more precise signal than S. Since proposition 2 holds for all non-degenerate distributions of B's signal, the only robust equilibrium is such that no trade ever occurs, even when B has better information. In other words, in order to have trade collapsing, it does not matter whether the seller is more informed than the buyer. It is sufficient that the seller have some private information which could be potentially disclosed through the price choice. It follows that the impossibility of trade is more pervasive than in a standard adverse selection model in which agents are price-takers. The ability of the seller to convey information through prices amplifies the effect of adverse selection rather than reducing it.

As in the previous section, the result relies on the impossibility of separating equilibria and on the fact that pooling and hybrid do not pass NWBR. We sketch the argument for the case in which $g(.|q)$ is non-degenerate. In this case, S's evaluation is a function of his signal s_S. It can be shown that if S weakly prefers to announce p to $p' < p$ when he has a low evaluation of the good, then he strictly prefers to announce p when he has a high evaluation. Intuitively, this sorting condition ensures that higher prices correspond to higher valuations of S. B decides to buy only if the realization of his signal s_B is above a certain threshold which depends on the price announced by S. In a separating equilibrium, lower prices have two opposite effects on B's willingness to buy. They reduce B's threshold since he has to pay less for the good (direct effect), and increase B's threshold since they signal that S has a low evaluation (signaling effect). For a separating equilibrium to be viable, the direct effect should always prevail. The probability to sell must be decreasing in the price in order to provide incentives for S to announce low prices when his evaluation is low. However, for low enough realizations of S's signal, the price should drop below v_L to ensure that the probability with which B buys does not go to zero, since $v_L > u_L$. This cannot happen since S always loses from any $p < v_L$. Hence, the signaling effect prevails and no separating is possible.

Let us now focus on pooling and hybrid. In these equilibria, the same price p is announced for different evaluations of S. The sorting condition implies that, for any B's response, a seller with a given evaluation prefers to deviate to a higher price whenever a seller with a lower evaluation weakly prefers to deviate. Intuitively, B, upon observing a deviation to a higher price, infers that the deviation comes from the type of seller who gains more from deviating, relative to his equilibrium payoff (NWBR). This is always the type with the highest signal among the signals for which S announces p. Clearly, these out of equilibrium beliefs provide S with a strong incentive to raise the price.

These results point out an intrinsic instability of the equilibrium: as soon as the information is perturbed, the equilibrium outcome radically changes. To see this, consider the case in which the precision of the private signals is almost perfect so that the game approximates the full information game. Since proposition 2 holds for all non-degenerate distributions, the amount of trade is discontinuous with respect to the precision of the signals. Whenever a negligible amount of noise is introduced, the amount of trade drops from the full information level to zero. In particular, since proposition 2 holds even if S has perfect information, it is sufficient a small perturbation of B's information for trade to collapse entirely.

3 The Price-Setting Buyer Model

This section considers the case in which B sets the price. We maintain the assumption that $v_H > v_L$ and $u_H > u_L$, but we now assume that potential gains from trading the low quality are positive and potential gains from trading the high quality are negative. It is shown that this game is symmetric to the one in which the S sets the price: whenever $u_L > v_L$ and $u_H < v_H$, all results found in the previous section apply.

The timing of the game is as follows. At stage 0, Nature draws $q \in \{H, L\}$. At stage 1, either B or both S and B exogenously receive some private information about the quality of the good. At stage 2, B announces a price p at which he is willing to trade. At stage 3, S observes p and chooses whether to sell or not. Finally, at stage 4, payoffs are realized.

Proposition 3. *When B sets the price the results are symmetric to those of propositions 1 and 2. In particular, if $g(.|q)$ is non-degenerate and satisfies assumption 1, in both of the following cases:*

1. *$f(.|q)$ is non-degenerate and satisfies assumption 1,*
2. *B is perfectly informed so that $f(.|q)$ is degenerate,*

there is a unique NWBR-refined equilibrium outcome and is such that no trade occurs.

The proof relies on a symmetry argument. The game in which B sets the price and $u_H < v_H$ is symmetric to the game in which S sets the price and $u_L < v_L$. Hence, the same results apply.

The intuition is again that separating equilibria are not possible. In a separating equilibrium, B should announce a higher price whenever he has a higher evaluation. As before, lower prices have both a negative (direct) effect and a positive (signaling) effect on S's willingness to trade. In order to give incentive to B to reveal his evaluation through the price, the direct effect should always prevail. This does not happen when B observes very high realizations of his signal and thus has a high valuation. The price that B should announce to make S willing to sell should jump above u_H which is always dominated for B. Hence, for evaluations high enough, B would pretend that his evaluation is low by announcing a low price.

As for pooling and hybrid equilibria, they never pass NWBR. In pooling and hybrid, the same price is announced for different evaluations. The lower the signal received by B, the higher is the incentive to deviate to a lower price. NWBR implies that S's off-equilibrium beliefs take this into account. This in turn makes the deviation profitable for B. Intuitively, B wants to lower the price when his evaluation is low in order to differentiate himself. On the other hand, he wants to lower the price when his evaluation is high to mimic a low evaluation buyer. This ensures that the price eventually reaches v_L at which no trade occurs.

In the next section we show that if the buyer committed to a price higher than v_L before observing his signal, trade would occur with probability bounded away from zero. Section 5 uses this intuition to explain why employers in the market for unskilled jobs could benefit from committing to an equal wage policy. In other words, the employer can increase its profits by committing to offer the same wage to all workers with similar duties independently of the worker-specific information received. Trade unions may thus act as a commitment device for the employer.

4 Delegation of Price Decisions to an Uninformed Party

The previous sections show that, when the party setting the price has private information, market breakdown is a pervasive phenomenon. If one believes that NWBR is a sensible refinement, then our analysis suggests that absence of trade is the most reasonable outcome. Even if one considers NWBR an excessively strong refinement which may sometimes eliminate reasonable equilibria, our results still show that the equilibrium with no trade cannot be dismissed as the product of peculiar off-equilibrium beliefs.

Either way, it is interesting to ask whether mechanisms can be put into place to prevent trade from completely collapsing. A natural mechanism is repeated interaction. However, repeated interaction might not be feasible in some circumstances. A different (partial) solution would be giving the right to set the price to the buyer when his evaluation for the low quality is lower than the seller's, and to the seller when his evaluation for the high quality exceeds that of the buyer. However, this would require parties to voluntarily renounce to their price setting power in favor of their counterparty.

A more sensible mechanism from the price-setting party viewpoint, is to commit ex-ante to a pricing policy that is independent of his information. In this way, the price-setting party can avoid to reveal his information through prices and a positive amount of trade is restored. A possible way to commit is to delegate pricing decisions to an uninformed third party acting in the interest of the price setting party. In the next section, we provide examples in which this type of mechanism is at work.

For simplicity, we consider the case in which S is price setting, $v_L > u_L$, and $v_H < u_H$. The same results apply to the case in which B is price setting, $v_L < u_L$, and $v_H > u_H$. Assume now that S is able to delegate the price choice to an uninformed agent D. This agent chooses p^D in order to maximize S's ex-ante expected profits. We assume that S is bound to sell at the price announced by D. The next result illustrates the benefits of delegation.

Proposition 4. *Under delegation the expected amount of trade, S's expected profits, and expected total surplus are bounded away from zero.*

The proof relies on the fact that D, by announcing some price $p^D \in (v_H, u_H)$ is always able to achieve a positive probability of trade. Intuitively, S is always willing to trade at p^D. As for B, he is willing to trade at p^D for high realizations of his signal. The surplus is lower than the first best level since B can make two types of errors: buying when $q = L$ (type I) and not buying when $q = H$ (type II). The reason why total expected surplus is positive is that B chooses a threshold value on his signal to optimally exploit the trade-off between the two types of errors. Therefore, B's losses never outweigh his gains in expectations.

In general, the surplus under delegation is less than the first best. However, for the case of two qualities, the surplus under delegation converges to the first best as the precision of B's signal goes to infinity. Intuitively, as B's information becomes perfect, the probabilities to commit both type I and type II errors converge to zero. This result however does not hold in general if we consider more than two qualities. Consider the case of potential gains from trading more than one quality and assume that D can announce only one price. To gather intuition, suppose there are three qualities (L, M, H) such that $v_H > v_M > v_L$ and $u_H > u_M > u_L$. Assume that gains from trading quality M are positive, i.e. $u_M > v_M$. Under full information trade would occur at two different prices in this case. If D can announce only one price, the upper bound of the surplus generated by trade is lower than the first best.

5 Examples and Applications

In this section we discuss a possible example in which the seller delegates the choice of the price to third parties: professional bodies. We also discuss an application of the price setting buyer model which provides a possible rationale for trade unions in the market for unskilled jobs.

5.1 Professional Bodies

Professional services provide a number of examples of situations in which the value of a low quality service is higher for the seller than for the buyer. Practitioners bear a positive cost to provide a low quality service whereas the utility for the customer may be zero or even negative, as in the case of a physician making a wrong diagnosis or a dentist using non-sterile instruments. In many countries, however, practitioners do not set fees directly. A professional association or the government often set fees in their stead. In many cases, they are even forbidden to advertise their fees. Independently of whether fee scales are considered as mandatory or just "recommended" by the professional association, the members tend to consider them as binding.[5] Since the professional body typically sets the fees for a large number of members, these convey no information about the quality of a specific practitioner.

Economists have traditionally viewed professional bodies as associations enforcing cartel prices in order to prevent competition among members (Matthews 1991). We do not deny that this is a sensible explanation for the existence of professional bodies. Our results provide a complementary explanation which can shed light on some features of professional bodies that are not fully explained by the traditional view. For instance, our results may explain why this price setting function of professional associations has survived in service markets such as health but not in other markets such as interior design or decoration. Moreover, they may explain why some professional associations set maximum fees.[6] These are clearly of no help in preventing undercutting. By contrast, in our model, a maximum price between buyer and seller evaluation for the high quality could produce a positive amount of trade.

5.2 The Market for Unskilled Labor

Consider the problem of an employer (buyer) who wants to hire a worker (seller) for an unskilled job. The worker's ability can be either high or low. The worker has private but imperfect information about his ability. The firm also obtains private information through selection procedures, references, etc. Hence, both the worker and the firm observe a private signal relative to the worker's ability. Given that the job does not require any particular training or skill, it is reasonable to assume that the cost of taking up the job to a high ability worker (including forgone opportunities) exceeds the benefit to the firm, while the benefit exceeds the cost if the worker is low ability. If the employer is price setting, our results suggest that it would be mutually beneficial if the employer committed to a wage *before* collecting any information about the candidate. Committing to a wage between v_L and u_L always ensures a positive probability of trade. This commitment would prevent the employer from deviating to lower wages in order to signal that he has a low evaluation of the worker's ability. For most unskilled jobs, wages are negotiated by trade unions for all workers. Typically,

[5]Shinnick and Stephen (2000), citing the Monopolies and Mergers Commission, report "... although disciplinary action could not be taken specifically for breach of a recommended scale, the fact that the fees charged were not in accordance with the scale might in some circumstances be quoted in support of a charge of breach of some other rule .... such that the established practitioner would not depart more readily from a 'recommended' scale than from a mandatory scale."

[6]For instance, the Professional Board for Psychology in South Africa sets "Ethical Tariffs" that provide a ceiling to the rates chargeable by the members.

a stated objective of trade unions is equal treatment for all workers doing the same type of job. Interestingly, our results suggest that also the employer could benefit from being constrained to offering equal wage treatment to all workers.

6 Conclusions

We considered a model of monopoly/monopsony with two-sided private information. Our results showed that, under empirically relevant assumptions, the only NWBR-refined equilibrium outcome involves complete market breakdown. We also found that a positive amount of trade can be restored if the price-setting party delegates the choice of the price to an uninformed agent. The model can be extended in several ways. First, it would be interesting to investigate under what conditions trade would occur in a model in which the action space is not restricted to the price choice. The price setting party may have other ways to signal quality in addition to the price (e.g. advertising). Second, the assumption that the price set by the delegated decision maker reflect only publicly available information is reasonable in some applications, such as professional bodies for instance, but not in others. Since in our model this assumption is necessary to produce a positive amount of trade, it is interesting to assess under what conditions trade is possible when the delegated decision maker has private information. In particular, we would like to explore whether a conflict of interests between the delegated decision maker and the price setting party may produce a positive amount of trade in equilibrium even when the first has private information.

A Appendix

A.1 Proof of Proposition 1

The proposition is proved in three steps. We first prove that there is no separating equilibrium in which trade occurs. Then we prove that no NWBR-refined equilibrium in which trade occurs can involve any type of pooling. Finally, we prove that outcome involving market breakdown is a NWBR-refined equilibrium.

Lemma 1. *There is no fully separating equilibrium in which trade occurs.*

Let P_L and P_H be the set of prices announced in equilibrium by type L and H respectively. If $P_L \cap P_H = \oslash$, type L is never able to trade. However, type L would benefit from trading at any $p \in P_H$ if p is optimal for type H. Hence, type L would always try to mimic type H.

Lemma 2. *No NWBR-refined equilibrium in which trade occurs can be a pooling or a hybrid equilibrium.*

Consider a pooling/hybrid equilibrium with trade. Let $\hat{p}$ be some price at which pooling occurs. Suppose that type H announces $\hat{p}$ with probability β_H (possibly 1) and type L announces $\hat{p}$ with probability β_L (possibly 1). Then B's expected utility at $\hat{p}$ is:

$$\frac{\lambda\beta_H}{\lambda\beta_H + (1-\lambda)\beta_L}u_H + \frac{(1-\lambda)\beta_L}{\lambda\beta_H + (1-\lambda)\beta_L}u_L - \hat{p} \tag{A.1}$$

Let $\hat{\alpha}$ be the (possibly 1) probability with which B buys at $\hat{p}$. Payoff at $\hat{p}$ for H is:

$$\hat{\alpha}(\hat{p} - v_H) \tag{A.2}$$

payoff for L is:

$$\hat{\alpha}(\hat{p} - v_L) \tag{A.3}$$

Consider a deviation p and assume that the buyer, upon observing p, buys with probability α. Then type L is eliminated according to NWBR if, for all α such that

$$\alpha(p - v_L) \geq \hat{\alpha}(\hat{p} - v_L), \tag{A.4}$$

the following holds:

$$\alpha(p - v_H) > \hat{\alpha}(\hat{p} - v_H) \tag{A.5}$$

Consider an upward deviation $p > \hat{p}$ and suppose that (A.4) holds. It is easy to verify that the following is true:

$$\frac{\alpha}{\hat{\alpha}} \geq \frac{\hat{p} - v_L}{p - v_L} > \frac{\hat{p} - v_H}{p - v_H} \tag{A.6}$$

The first inequality comes from (A.4) while the second comes from $p > \hat{p}$. Note that the above expression implies that (A.5) is satisfied. Therefore, the low quality can be always eliminated from the deviation. But then, unless $\hat{p} = u_H$, the high quality has always incentive to deviate. On the other hand $\hat{p} = u_H$ cannot be an equilibrium so long as $\beta_L > 0$.

Lemma 3. *There is a NWBR-refined equilibrium in which no trade occurs.*

Consider a situation in which S always announces $p = u_H$ and B never buys. This is clearly an equilibrium. It is also robust to NWBR since, for a deviation $p \geq v_H$, the set of B's best responses that make type L willing to deviate coincides with the set of best responses that make type H willing to deviate. Therefore, type L cannot be eliminated.

A.2 Proof of Proposition 2

We start by giving the proof for the case in which S is perfectly informed and B observes a private signal (case 2 in proposition 2). Then we turn to the case in which both B and S observe private signals (case 1 in proposition 2).

A.2.1 S is perfectly informed and B observes a private signal

We start by showing that no separating equilibrium in which trade occurs exists. Then we show that no pooling or hybrid equilibrium in which trade occurs passes NWBR.

Lemma 4. *There is no separating equilibrium in which trade occurs.*

Proof. The proof given for the case in which B has only prior information also applies to this case. This follows from the fact that in a perfectly separating equilibrium, B always discards his exogenous signal. He already obtains perfect information by looking at the prices. But then, in a separating equilibrium, the low quality could not be traded and a low quality seller would always try to mimic the high quality. Hence, no separation is possible. □

Lemma 5. *No pooling-hybrid equilibrium in which trade occurs survives NWBR.*

Proof. Suppose as before that pooling occurs at $\hat{p} < u_H$. A high quality seller announces $\hat{p}$ with probability β_H and a low quality seller announces $\hat{p}$ with probability β_L (possibly 1). B observes price $\hat{p}$ and receives a signal s (we omit the B subscript from the signal). B's expected utility from buying at $\hat{p}$ is:

$$\frac{\lambda\beta_H f(s|H)}{\lambda\beta_H f(s|H) + (1-\lambda)\beta_L f(s|L)} u_H + \frac{(1-\lambda)\beta_L f(s|L)}{\lambda\beta_H f(s|H) + (1-\lambda)\beta_L f(s|L)} u_L - \hat{p} \qquad \text{(A.7)}$$

Expected utility is nonnegative if:

$$\frac{f(s|H)}{f(s|L)} \geq \frac{(1-\lambda)\beta_L}{\lambda\beta_H}\frac{\hat{p}-u_L}{u_H-\hat{p}} \tag{A.8}$$

Notice that the LHS is an increasing function of s and the RHS is positive. Given the full support assumption, there always exist a threshold $s^* \in [\underline{s}, \overline{s}]$ such that B buys if $s > s^*$ and does not buy if $s < s^*$. Hence, B uses a threshold strategy s^*. S's payoff is:

$$[1-F(s^*|H)](\hat{p}-v_H) \tag{A.9}$$

when he is of type H and:

$$[1-F(s^*|L)](\hat{p}-v_L) \tag{A.10}$$

when he is of type L. Suppose now that B observes a deviation $p > \hat{p}$. Upon observing p, B uses a a threshold s^D (see Benabou and Tirole 2003 on this way to use NWBR). According to NWBR, type L can be eliminated from the deviation if the set of values for s^D that make him weakly benefit from the deviation is contained in the set of values that make type H strictly benefit. Type L would (weakly) benefit whenever:

$$[1-F(s^D|L)](p-v_L) \geq [1-F(s^*|L)](\hat{p}-v_L) \tag{A.11}$$

The low quality is eliminated if, whenever (A.11) holds, the following also holds:

$$[1-F(s^D|H)](p-v_H) > [1-F(s^*|H)](\hat{p}-v_H) \tag{A.12}$$

Note that (A.12) is always true whenever $s^D \leq s^*$ since type H would get a higher price and a *lower* threshold (which implies a higher probability to sell). Assume then $s^D > s^*$. As before, the following is true for $p > \hat{p}$:

$$\frac{1-F(s^D|L)}{1-F(s^*|L)} \geq \frac{\hat{p}-v_L}{p-v_L} > \frac{\hat{p}-v_H}{p-v_H} \tag{A.13}$$

The first inequality comes from (A.11) and the second comes from $p > \hat{p}$. All that remains to show to prove that (A.12) holds and type L can be eliminated is that:

$$\frac{1-F(s^D|H)}{1-F(s^*|H)} \geq \frac{1-F(s^D|L)}{1-F(s^*|L)} \tag{A.14}$$

Rewrite the above as:

$$(1-F(s^D|H))(1-F(s^*|L)) - (1-F(s^*|H))(1-F(s^D|L)) \geq 0 \tag{A.15}$$

Note that the limit of the above expression for $s^D \to s^*$ is 0. The limit for s^D going to $\overline{s}$ is zero as well. Consider the derivative with respect to s^D

$$-f(s^D|H)(1-F(s^*|L)) + f(s^D|L)(1-F(s^*|H)) \tag{A.16}$$

From the above expression, the LHS of equation (A.15) is increasing whenever:

$$\frac{f(s^D|H)}{f(s^D|L)} < \frac{1-F(s^*|L)}{1-F(s^*|H)} \tag{A.17}$$

and is decreasing whenever the reverse inequality holds. Given the MLRP (which implies that $\frac{f(s^D|H)}{f(s^D|L)}$ is an increasing function), the LHS of inequality (A.15) must be an increasing-decreasing function (i.e. increasing for small values of s^D and decreasing beyond a threshold). Since the LHS of inequality (A.15) is an increasing-decreasing function which converges to zero as s^D moves toward the bounds of $(s^*, \overline{s})$, it follows that it cannot be negative in $(s^*, \overline{s})$. Hence, the low type can be always eliminated. Since type L can be eliminated, for deviations to $p < u_H$, B would always buy with probability one. But then, it is always optimal for S to deviate to prices $p \in (\hat{p}, u_H)$. □

Lemma 6. *There always exists a NWBR-refined equilibrium in which trade does not occur.*

The proof is identical to that of lemma 3. Both type H and type L announce u_H and B selects a threshold equal to $\overline{s}$.

A.2.2 Both S and B receive a private signal

We start by proving that B follows a threshold strategy. Then we show that a sorting condition holds. Given the sorting condition, no separation is possible. We then show that no pooling/hybrid passes NWBR. Finally, we show that there is a NWBR-refined equilibrium involving no trade.

Lemma 7. *B's payoff is monotonically increasing in his signal s_B, i.e. B follows a threshold strategy.*

Suppose that S announces price p for some set of signal realizations $\Sigma(p)$. Since s_S is, conditionally on q, independent of s_B, the price p also is independent on s_B conditionally on q. Hence, it is easy to show that:

$$\Pr(q|s_B, p) = \frac{f(s_B|q)\Pr(p|q)\Pr(q)}{\sum_{q\in\{H,L\}} f(s_B|q)\Pr(p|q)\Pr(q)} \tag{A.18}$$

B's expected payoff from buying at p is therefore:

$$\frac{\lambda f(s_B|H)\Pr(p|H)}{\lambda f(s_B|H)\Pr(p|H) + (1-\lambda)f(s_B|L)\Pr(p|L)}u_H + \\ + \frac{(1-\lambda)f(s_B|L)\Pr(p|L)}{\lambda f(s_B|H)\Pr(p|H) + (1-\lambda)f(s_B|L)\Pr(p|L)}u_L - p \tag{A.19}$$

B's payoff is nonnegative if:

$$\frac{f(s_B|H)}{f(s_B|L)} \geq \frac{1-\lambda}{\lambda}\frac{p-u_L}{u_H-p}\frac{\Pr(p|L)}{\Pr(p|H)} \tag{A.20}$$

From the MLRP, the LHS is an increasing function of s_B. Given the full support assumption, there always exists a threshold $s_B^* \in [\underline{s}_B, \overline{s}_B]$. Hence, B follows a threshold strategy.

Lemma 8. *(Sorting) Let s_S and $s'_S < s_S$ be two realization of S's signal. Let also p and $p' < p$ be two prices. Whenever type s'_S weakly prefers p to p', then type s_S strictly prefers p to p'.*

Consider S's payoff when S chooses to sell and has received a signal s_S:

$$[\Pr(H, s_B > s_B^*|s_S) + \Pr(L, s_B > s_B^*|s_S)]p + \Pr(H, s_B < s_B^*|s_S)v_H + \\ + \Pr(L, s_B < s_B^*|s_S)v_L \tag{A.21}$$

The payoff when S decides not to sell is:

$$\Pr(H|s_S)v_H + \Pr(L|s_S)v_L \tag{A.22}$$

It is easy to show that $\Pr(q, s_B > s_B^*|s_S) = (1 - F(s_B^*|q))\Pr(q|s_S)$ Therefore, the expected net payoff is:

$$[(1 - F(s_B^*|H))\Pr(H|s_S) + (1 - F(s_B^*|L))\Pr(L|s_S)]p + \\ +F(s_B^*|H)\Pr(H|s_S)v_H + F(s_B^*|L)\Pr(L|s_S)v_L - \Pr(H|s_S)v_H - \Pr(L|s_S)v_L = \\ = (1 - F(s_B^*|H))\Pr(H|s_S)(p - v_H) + (1 - F(s_B^*|L))\Pr(L|s_S)(p - v_L) \tag{A.23}$$

Let s_S and $s'_S < s_S$ be two realizations of S's signal. Let also p and $p' < p$ be two prices. In order to have sorting, whenever type s'_S weakly prefers p to p', then type s_S strictly prefers p to p'. Type s'_S weakly prefers p when:

$$(1 - F(s_B^*(p)|H))\Pr(H|s'_S)(p - v_H) + (1 - F(s_B^*(p)|L))\Pr(L|s'_S)(p - v_L) \geq \\ (1 - F(s_B^*(p')|H))\Pr(H|s'_S)(p' - v_H) + (1 - F(s_B^*(p')|L))\Pr(L|s'_S)(p' - v_L) \tag{A.24}$$

where $s_B^*(p)$ and $s_B^*(p')$ are B's thresholds when B observes prices p and p' respectively. Type s_S strictly prefers p when

$$(1 - F(s_B^*(p)|H))\Pr(H|s_S)(p - v_H) + (1 - F(s_B^*(p)|L))\Pr(L|s_S)(p - v_L) > \\ (1 - F(s_B^*(p')|H))\Pr(H|s_S)(p' - v_H) + (1 - F(s_B^*(p')|L))\Pr(L|s_S)(p' - v_L) \tag{A.25}$$

For $s_B^*(p) \leq s_B^*(p')$, condition A.24 trivially holds. Suppose then that $s_B^*(p) > s_B^*(p')$. By using $\Pr(L|s_S) = 1 - \Pr(H|s_S)$, conditions (A.24) and (A.25) can be rewritten as:

$$A \geq \Pr(H|s'_S)[A + C] \tag{A.26}$$

$$A > \Pr(H|s_S)[A + C] \tag{A.27}$$

where:

$$A = [1 - F(s_B^*(p)|L)](p - v_L) - [1 - F(s_B^*(p')|L)](p' - v_L) \tag{A.28}$$
$$C = [1 - F(s_B^*(p')|H)](p' - v_H) - [1 - F(s_B^*(p)|H)](p - v_H) \tag{A.29}$$

We distinguish between two cases: $A < 0$ (Case 1) and $A \geq 0$ (Case 2). *Case 1:* $A < 0$. If A is negative, then, from condition (A.26), $A + C$ is also negative. One can then rewrite (A.24) as:

$$\Pr(H|s_S) \geq \frac{A}{A + C} \tag{A.30}$$

and (A.25) as:

$$\Pr(H|s'_S) > \frac{A}{A + C} \tag{A.31}$$

Since, from the MLRP, $\Pr(H|s'_S) > \Pr(H|s_S)$, condition (A.31) is always verified.
Case b: $A \geq 0$. In this case, it is easy to verify that:

$$\frac{1 - F(s_B^*(p)|L)}{1 - F(s_B^*(p')|L)} \geq \frac{p' - v_L}{p - v_L} > \frac{p' - v_H}{p - v_H} \tag{A.32}$$

where the first inequality comes from $A \geq 0$ and the second from $p > p'$. As shown in the proof of lemma 5, the MLRP implies that the following holds:

$$\frac{1 - F(s_B^*(p)|H)}{1 - F(s_B^*(p')|H)} \geq \frac{1 - F(s_B^*(p)|L)}{1 - F(s_B^*(p')|L)} \tag{A.33}$$

which, together with (A.32) implies $C < 0$. But then, it is possible to rewrite (A.26) and (A.27) as:

$$\frac{\Pr(H|s'_S)}{\Pr(L|s'_S)} \geq \frac{A}{C} \tag{A.34}$$

and

$$\frac{\Pr(H|s_S)}{\Pr(L|s_S)} > \frac{A}{C} \tag{A.35}$$

respectively. Since the LHS of (A.35) is always positive, the above inequality always holds.

Lemma 9. *There is no separating equilibrium in which trade occurs.*

A separating equilibrium is a one-to-one map $p(.)$ from the set of realizations of S's signal, s_S, into the set of prices. Given lemma 8, the function $p(.)$ is monotonically increasing in s_S. Upon observing a particular price p, B is able to retrieve s_S. B's expected utility from buying at p is:

$$\frac{\lambda f(s_B|H)g(s_S(p)|H)}{\lambda f(s_B|H)g(s_S(p)|H)+(1-\lambda)f(s_B|L)g(s_S(p)|L)}u_H + \\ +\frac{(1-\lambda)f(s_B|L)g(s_S(p)|L)}{\lambda f(s_B|H)g(s_S(p)|H)+(1-\lambda)f(s_B|L)g(s_S(p)|L)}u_L - p \tag{A.36}$$

where $s_S(.)$ is the inverse of $p(.)$. Payoff is nonnegative if:

$$\frac{f(s_B|H)}{f(s_B|L)} \geq \frac{1-\lambda}{\lambda}\frac{p-u_L}{u_H-p}\frac{g(s_S(p)|L)}{g(s_S(p)|H)} \tag{A.37}$$

Rewrite the RHS as a function of s_S:

$$\frac{f(s_B|H)}{f(s_B|L)} \geq \frac{1-\lambda}{\lambda}\frac{p(s_S)-u_L}{u_H-p(s_S)}\frac{g(s_S|L)}{g(s_S|H)} \tag{A.38}$$

Note that $g(s_S|L)/g(s_S|H)$ is decreasing is s_S. Let s_S and $s'_S > s_S$ be two possible signal realizations of S. From the sorting condition the price announced by s'_S must exceed that announced by s_S. Hence, there are two effects of a price increase on the threshold: 1) the direct effect ($[p-u_L]/[u_H-p]$ increases), 2) the signaling effect ($g(s_S|L)/g(s_S|H)$ decreases). For a separating equilibrium to be viable, the direct effect should always prevail. In other words, the threshold must be always increasing in p (or increasing in s_S). We show that this cannot happen. Consider the limit for $s_S \to \underline{s}_S$. Since $g(s_S|H)/g(s_S|L)$ is monotonically increasing and has full support $(0,\infty)$, the inverse ratio $g(s_S|L)/g(s_S|H)$ must diverge to infinity for $s_S \to \underline{s}_S$. On the other hand, the direct effect is bounded away from zero by $[v_L-u_L]/[u_H-v_L]$ since S would never announce a price below v_L. It follows that for low realizations of s_S the signaling effect always prevails and therefore no separation is possible.

Lemma 10. *No pooling-hybrid equilibrium in which trade occurs survives NWBR.*

Denote with $\Sigma(\hat{p})$ the set of realizations for which S announces price $\hat{p}$ with positive probability. In any pooling-hybrid equilibrium in which trade occurs there always exists some $\hat{p} < u_H$ such that $\Sigma(\hat{p})$ is non-singleton. Let $s_S < \tilde{s}_S \equiv \sup\Sigma(\hat{p})$ be a realization of S's signal and consider a deviation $p > \hat{p}$. We first show that all $s_S \in \Sigma(\hat{p})$ can be eliminated according to NWBR except for $\tilde{s}_S$. Then we show that also $s_S < \tilde{s}_S$, $s_S \notin \Sigma(\hat{p})$ can be eliminated. Finally, we show that there always exist $p > \hat{p}$ such that the probability to sell at p is not smaller than the probability to sell at $\hat{p}$ given B's refined beliefs (which implies that it is always optimal to deviate to p). Consider first the case $s_S \in \Sigma(\hat{p})$. As already shown, the expected payoff for S when s_S is realized is:

$$\Pr(H|s_S)[1-F(s^*_B|H)](\hat{p}-v_H)+\Pr(L|s_S)[1-F(s^*_B|L)](\hat{p}-v_L) \tag{A.39}$$

Consider a deviation $p > \hat{p}$. Upon observing p, B uses threshold s_B^D. Type s_S would (weakly) benefit from the deviation if:

$$\begin{aligned}\Pr(H|s_S)[1-F(s_B^D|H)](p-v_H)+\Pr(L|s_S)[1-F(s_B^D|L)](p-v_L)\geq\\ \Pr(H|s_S)[1-F(s_B^*|H)](\hat{p}-v_H)+\Pr(L|s_S)[1-F(s_B^*|L)](\hat{p}-v_L)\end{aligned} \quad (A.40)$$

According to NWBR, type s_S is eliminated if the set of all s_B^D that make him weakly benefit from the deviation is strictly contained in the set of s_B^D that make some other type s'_S strictly benefit. We can thus eliminate s_S if, for all s_B^D such that (A.40) holds, a seller receiving signal $\tilde{s}_S$ strictly benefits from the deviation. This happens if

$$\begin{aligned}\Pr(H|\tilde{s}_S)[1-F(s_B^D|H)](p-v_H)+\Pr(L|\tilde{s}_S)[1-F(s_B^D|L)](p-v_L)>\\ \Pr(H|\tilde{s}_S)[1-F(s_B^*|H)](\hat{p}-v_H)+\Pr(L|\tilde{s}_S)[1-F(s_B^*|L)](\hat{p}-v_L)\end{aligned} \quad (A.41)$$

However, from lemma 8 the above inequality is always verified for $p > \hat{p}$ and $\tilde{s}_S > s_S$. Therefore, type s_S can be eliminated.

We now show that all $s_S \notin \Sigma(\hat{p})$ such that $s_S < \tilde{s}_S$ can also be eliminated. Consider then $s_S \notin \Sigma(\hat{p})$, $s_S < \tilde{s}_S$. In equilibrium, s_S announces some price p' to which B replies with a threshold s'_B. From incentive compatibility of type s_S it follows that:

$$\begin{aligned}\Pr(H|s_S)[1-F(s'_B|H)](p'-v_H)+\Pr(L|s_S)[1-F(s'_B|L)](p'-v_L)\geq\\ \Pr(H|s_S)[1-F(s_B^*|H)](\hat{p}-v_H)+\Pr(L|s_S)[1-F(s_B^*|L)](\hat{p}-v_L)\end{aligned} \quad (A.42)$$

type s_S weakly benefits from a deviation to p when:

$$\begin{aligned}\Pr(H|s_S)[1-F(s_B^D|H)](p-v_H)+\Pr(L|s_S)[1-F(s_B^D|L)](p-v_L)\geq\\ \Pr(H|s_S)[1-F(s'_B|H)](p'-v_H)+\Pr(L|s_S)[1-F(s'_B|L)](p'-v_L)\end{aligned} \quad (A.43)$$

Hence, in order to eliminate s_S, it is sufficient to show that $\tilde{s}_S$ strictly benefits for any s_B^D such that:

$$\begin{aligned}\Pr(H|s_S)[1-F(s_B^D|H)](p-v_H)+\Pr(L|s_S)[1-F(s_B^D|L)](p-v_L)\geq\\ \Pr(H|s_S)[1-F(s_B^*|H)](\hat{p}-v_H)+\Pr(L|s_S)[1-F(s_B^*|L)](\hat{p}-v_L)\end{aligned} \quad (A.44)$$

but this, again, is implied by lemma 8.

In summary, all realizations $s_S < \tilde{s}_S$ can be eliminated. It follows that B, upon observing p, should believe that the deviation comes from seller of type $\tilde{s}_S$ or above. This also holds when $p > \hat{p}$ is not a deviation, i.e. when there are types (realizations of s_S) which announce p with positive probability in equilibrium. In this case the sorting condition ensures that p is never announced by types $s_S < \tilde{s}_S$. We now show that, given B's refined beliefs, $\tilde{s}_S$ would strictly benefit from announcing some $p > \hat{p}$.

Assume $p = \hat{p} + \epsilon$ with $\epsilon > 0$. For ϵ small enough, the ex-ante probability (before observing s_B) with which B buys at p is greater than or equal to the probability with which B buys at $\hat{p}$. To show this, it is sufficient to show that, for all realizations s_B, the ex-post probability with which B buys is larger when S announces p. Given s_B, denote with $\mathcal{M}(\hat{p}, s_B)$ and with $\mathcal{M}(p, s_B)$ B's (refined) posterior belief that the good is H upon observing $\hat{p}$ and p respectively. Since all $s_S < \tilde{s}_S$ can be eliminated from p, it follows that $\mathcal{M}(p, s_B) > \mathcal{M}(\hat{p}, s_B)$. It is then easy to show that there is always $\epsilon > 0$ such that:

$$\mathcal{M}(\hat{p}+\epsilon, s_B)(u_H - \hat{p} - \epsilon) + (1 - \mathcal{M}(\hat{p}+\epsilon, s_B))(u_L - \hat{p} - \epsilon) > \mathcal{M}(\hat{p}, s_B)(u_H - \hat{p}) + (1 - \mathcal{M}(\hat{p}, s_B))(u_L - \hat{p}) \quad \text{(A.45)}$$

Hence, for ϵ small enough B's payoff is higher when buying at $\hat{p} + \epsilon$ rather than at $\hat{p}$. But then, the probability to buy cannot be lower at $\hat{p} + \epsilon$ than at $\hat{p}$. Hence, S would always benefit from increasing his price.

Lemma 11. *There is always a NWBR-refined equilibrium in which trade does not occur.*

Consider a situation in which S always announces $p = u_H$ and B never buys (i.e. $s_B^* = \overline{s}_B$). This is clearly an equilibrium. It is also robust to NWBR since, for any deviation $p \geq v_L$, the set of threshold values that make type s_S willing to deviate does not contain the set of best responses that make type $s'_S < s_S$ willing to deviate. Therefore, no signal realization can be eliminated.

A.3 Proof of proposition 3

In the game in which S sets the price, payoffs were given by:

$$\begin{array}{ccc} q & \text{Price Taker } (B) & \text{Price Setter } (S) \\ H & u_H - p & p - v_H \\ L & u_L - p & p - v_L \end{array} \quad \text{(A.46)}$$

with $u_H > u_L$, $v_H > v_L$, $u_H > v_H$, and $v_L > u_L$. Consider now the game in which B announces a price p and gains from trade are reversed: $v_H > u_H$ and $u_L > v_L$. In words, quality H generates negative gains from trade while quality L yields positive gains. We want to show that the two games are the same. Let $A \in \mathbb{R}$ be a number greater than v_H. Redefine B's action as $\tilde{p} = A - p$ and qualities as $\tilde{H} = L$, and $\tilde{L} = H$. Redefine also the evaluations as follows: $\tilde{v}_H = A - u_L$, $\tilde{v}_L = A - u_H$, $\tilde{u}_H = A - v_L$, $\tilde{u}_L = A - v_H$. Clearly, the conditions $\tilde{u}_H > \tilde{u}_L$, $\tilde{v}_H > \tilde{v}_L$, $\tilde{u}_H > \tilde{v}_H$, and $\tilde{v}_L > \tilde{u}_L$ hold. Also, it is easy to check that net payoffs are unaffected by these transformations. The net payoffs for the game in which B sets the price can thus be expressed as:

$$\begin{array}{ccc} q & \text{Price Taker } (S) & \text{Price Setter } (B) \\ \tilde{H} & \tilde{u}_H - \tilde{p} & \tilde{p} - \tilde{v}_H \\ \tilde{L} & \tilde{u}_L - \tilde{p} & \tilde{p} - \tilde{v}_L \end{array} \quad \text{(A.47)}$$

Hence, this is the same game as that in which S sets the price.

A.4 Proof of proposition 4

We start by showing that the amount of trade and S's profits are bounded away from zero. Assume that D announces a price p^D. B, who receives a signal s_B, chooses to buy at p^D if:

$$\frac{\lambda f(s_B|H)}{\lambda f(s_B|H) + (1-\lambda) f(s_B|L)} u_H + \frac{(1-\lambda) f(s_B|L)}{\lambda f(s_B|H) + (1-\lambda) f(s_B|L)} u_L - p^D \geq 0 \quad \text{(A.48)}$$

solving for $f(s_B|H)$ yields:

$$f(s_B|H) \geq \frac{1-\lambda}{\lambda} \frac{p^D - u_L}{u_H - p^D} f(s_B|L) \quad \text{(A.49)}$$

Given monotonicity, B uses a threshold strategy on his own signal: he chooses to buy at p^D if his signal s_B is a above a threshold s_B^*, where s_B^* solves:

$$\frac{f(s_B^*|H)}{f(s_B^*|L)} = \frac{1-\lambda}{\lambda} \frac{p^D - u_L}{u_H - p^D} \quad \text{(A.50)}$$

Profits for S are:

$$\lambda[p^D - v_H][1 - F(s_B^*|H)] + (1-\lambda)[p^D - v_L][1 - F(s_B^*|L)] \quad \text{(A.51)}$$

For $p^D > v(h)$, profits are positive unless the amount of trade is zero, i.e. $F(s_B^*|L) = F(s_B^*|H) = 1$. However, this occurs only if $s_B^* = \overline{s}_B$. From (A.50), this cannot happen for any $p^D < u_H$. Hence, for $p^D \in (v_H, u_H)$ both expected profits and expected amount of trade are bounded away from zero. We now show that expected total surplus is also bounded away from zero. Total surplus under delegation is:

$$\lambda[u_H - v_H][1 - F(s_B^*|H)] + (1-\lambda)[u_L - v_L][1 - F(s_B^*|L)] \quad \text{(A.52)}$$

where the second term is negative. Total surplus is positive when:

$$[1 - F(s_B^*|H)] > \frac{(1-\lambda)[u_L - v_L]}{\lambda[u_H - v_H]}[1 - F(s_B^*|L)] \quad \text{(A.53)}$$

Since inequality (A.49) must hold for every $s_B > s_B^*$, one can integrate both sides of the inequality between s_B^* and infinity:

$$[1 - F(s_B^*|H)] \geq \frac{1-\lambda}{\lambda} \frac{p^D - u_L}{u_H - p^D} [1 - F(s_B^*|L)] \tag{A.54}$$

Given (A.54), condition (A.53) always holds for $p^D \in (v_H, u_H)$. Since total surplus is positive, welfare under delegation is higher than welfare in the absence of delegation.

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