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ABSTRACT

Across many marketing settings, sellers and buyers rely on the certification of quality to help foster the exchange of goods and services. However, quality certification is inaccurate and costly in many cases. We further investigate the relationship between quality certification and seller profits with an analytic model and an economic experiment. In particular, we assess whether certification enhances or detracts from seller profits and whether the results depend upon the cost and/or the noisiness of the certification. Our results demonstrate that quality certification can indeed benefit sellers, but only when the certification is sufficiently accurate.

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1. Introduction

In many marketing contexts, there is asymmetric information between sellers and buyers such that the seller often has more information about the product than the buyer. For example, car dealerships, realtors, stockbrokers and collectibles resellers commonly know the quality (or the condition) of the products being sold, while the buyer does not. One common mechanism used to alleviate this asymmetry is certification, where sellers can voluntarily pay an expert to certify the quality of their products. For instance, sellers of collectibles frequently pay grading services to have their products certified, which is quite common with sports trading cards, coins and autographed memorabilia. However, it is not obvious how much certification helps sellers. Consequently, our research focuses on whether sellers benefit from certification services and if the accuracy of the certification matters. More importantly, we address the question of whether some accuracy is better than none.

The classic theoretical literature has shown that sellers voluntarily engage in quality disclosure if the quality is verifiable by customers (Grossman 1981; Grossman and Hart 1980; Milgrom 1981). According to these studies, sellers provide verifiable quality disclosure in order to differentiate their products from others since rational consumers will infer that the seller's product has the worst possible quality if one does not credibly disclose its quality.[4] These studies have argued that full disclosure is forthcoming and there is no need for mandatory disclosure (Dranove and Jin 2010), as sellers would voluntarily provide verifiable quality disclosure to buyers whenever possible.

[4] As this type of verifiable quality disclosure starts from the seller with the highest quality and goes down to sellers with lower quality, Viscusi (1978) has called this an "unraveling process."

However, in many marketing settings, the seller's quality disclosure is not readily verifiable. Nelson (1974) has labeled the attributes that customers cannot evaluate before purchase as "experience" attributes while Darby and Karni (1973) have identified attributes that cannot be evaluated even after purchase as "credence" attributes. The collectible memorabilia and used car product markets may be classified as having experience or credence attributes, as most buyers cannot accurately evaluate the quality of those products by themselves before or even after purchase. Therefore, certification is of greater importance for these products and sellers may need to evaluate whether certification may improve their profits.

To further complicate the seller's decision to certify the quality of a product, we need to acknowledge that certification is costly and may not be accurate. The classic literature on verifiable quality disclosure mentioned above assumes perfect accuracy in the quality disclosure of sellers. However, actual quality certifications often provide faulty information to buyers due to several factors, including noise in the data generating process and the conflict of interest of the parties involved (Dranove and Jin 2010). For example, Edelman (2009) examined SiteAdvisor's measurement data of various websites' safety and found that TRUSTe-certified websites are actually more than twice as likely to be untrustworthy as uncertified sites. Feinstein (1989) investigated the result of more than 1,000 Nuclear Regulatory Commission (NRC) inspections of nuclear power plants over three years and found that NRC inspectors' rates of detecting violations differ significantly, due to the incompetency of certifiers. Other studies have investigated the issue of inaccurate quality information provided by professional certifiers in the financial advisory industry (Hong and Kubik 2003; Lim 2001; Michaely and Womack 1999) and third-party reviewers in marketing (Kim, Chung, and Lim 2018). This is why certifiers of used cars, such as Carfax, warn buyers about possible errors or omissions of information at the bottom of every report they provide.[5]

In addition, sellers frequently consider costs when deciding whether to disclose the quality of a product. The classic literature on verifiable quality disclosure assumes that the cost of disclosure is either zero or negligible (Grossman 1981; Grossman and Hart 1980; Milgrom 1981), but certification firms often charge substantial fees for certification. For instance, Becket Grading Services requires a payment of $15 to have a baseball card graded,[6] while PSA's grading service fees range from $7 to $1500 depending on the dollar value of the collectible item submitted for certification. Accordingly, Viscusi (1978) shows that some sellers with lower-quality products would not engage in verifiable quality disclosure as the cost of information disclosure exceeds the benefit, and Verrecchia (1983) finds that the disclosure cost provides noise in interpreting a firm's disclosure effort, which creates an equilibrium threshold level of disclosure.

Therefore, how inaccurate and costly certification affects sellers and buyers has not been determined. We examine how verifiable quality disclosure through certification affects seller profits and other market outcomes, focusing on the accuracy and the cost of such disclosure. More specifically, we analyze the effect of errors in quality disclosure on seller profits and other market outcomes. Through our analysis, we investigate if sellers are better off in a market where verifiable quality disclosure is available compared to other markets where quality disclosure cannot be verified. Suppose that providing verifiable quality disclosure to buyers can be shown to increase seller profits in spite of its errors and cost, then there would be a sufficient incentive

[5] All Carfax reports contain the following statement: "Carfax depends on its sources for the accuracy and reliability of its information. Therefore, no responsibility is assumed by Carfax or its agents for errors or omissions in this report."
[6] http://www.beckett.com/grading/faq

for sellers in a credence or experience goods market to voluntarily establish such instruments when an appropriate instrument to make verifiable quality disclosure is not already available.[7] Although there are alternative types of verifiable quality disclosure mechanisms such as warranty and licensing, this study focuses on third-party quality certification, as it is the most appropriate form of verifiable quality disclosure in a market where customers cannot easily evaluate the product quality.[8]

Based on this understanding, we develop an analytic model assuming a market where a monopolistic seller sells a product to a buyer who cannot evaluate the quality of the product. The seller can decide whether to use the quality certification or not, and the risk-neutral buyer decides whether to purchase the product or not depending on the seller's suggested price and the type of information disclosure. In this market, the certification can be noisy and can result in an incorrect assessment of the product. Additionally, the seller has to pay a certain fee to use the certification. By observing how the seller and the buyer react to noisy certification, we analyze how certification costs and certification accuracy affect market outcomes such as seller profits and buyer surplus. To our surprise, the equilibria show that it is less profitable for sellers to have any form of certification and that it is more profitable to exist in a market with no certification at all. According to this result, the introduction of a mechanism of verifiable information disclosure to the market under information asymmetry is not desirable from the seller's standpoint.

Next, we re-analyze the model by relaxing the assumption of customers' risk-neutrality, as the information provided by certification can be more valuable to loss-averse buyers and increase their willingness to pay. After considering the loss-aversion of customers, we find that it

[7] For example, trustworthy quality disclosure services such as Carfax are still not available in used car markets in many other countries.
[8] Regarding experience or credence attributes, warranty may not function well, as customers may not be able to detect product flaws in the first place.

is most profitable for sellers to have an accurate certification mechanism in the market. However, having an inaccurate certification mechanism is actually worse than having no certification mechanism at all. Therefore, it would appear that the adage of "some information is better than none" is unwarranted in our study.

Finally, we run an incentive-based economic experiment to test whether the predictions of our analytic models are consistent with actual seller and buyer behavior. As our theory presents two competing predictions that depend upon the loss-aversion level of the buyers, we are able to assess which framework's predictions are likely to be observed in practice through our experiment. In addition, our experiment allows for tight control over the market environment. Hence, we are able to assess market outcomes and we can also determine when sellers can benefit from certification. Finally, we are able to allow for cheap talk in our experiments, where the seller can state the quality or the condition of the product being sold.

Our experimental results show substantial support for the loss-aversion model of buyer behavior as opposed to the risk-neutral model. Hence, we can conclude that inaccurate certification is indeed worse than no certification in terms of seller profits, and accurate certification maximizes seller profits. Moreover, for reasonable levels of buyer loss-aversion, we demonstrate that inaccurate certification is highly undesirable and can even harm sellers. Consequently, sellers should proceed with caution if the certification may be less than accurate, as it may backfire on sellers. Furthermore, we believe our results provide meaningful implications for the literature on information disclosure by showing how the accuracy of certification and its costs affects market outcomes, and that the combination of game theory and economic experiments enhance theory development and applicability to real-world settings.

This paper proceeds as follows. In Section 2, we develop an analytic model to show how noisy certification affects market outcomes, which is based on the assumption of buyers being risk-neutral. In Section 3, we introduce buyers' loss-aversion to the original model and generate new model predictions. Section 4 describes the experimental procedures of the economic experiment, and Section 5 presents the findings of the experiment. This paper concludes with the discussion of the contributions and managerial implications of the results in Section 6. All of the proofs are provided in Appendix A, while Appendix B contains the experimental instructions.

2. Quality Certification with Risk-Neutral Buyers

Consider a game between a monopolistic seller and mass one of price-taking buyers with unit demand. The seller offers a product of quality v. The quality is private information and is unobserved by buyers. We assume that the quality is distributed uniformly on $[0,V]$, and without loss of generality we can normalize V to be equal to 1. The seller's cost is equal to 0. Both buyers and the seller are assumed to be risk-neutral. In the next section we will relax this assumption.

A certification technology provides a noisy assessment of the product's quality at cost c. The precision of the certification technology is captured by parameter α. When the product's quality is v, with probability α the certification results in a correct assessment, $s=v$, and with probability $1-\alpha$ it results in a noisy assessment, $s \sim U[0,1]$. Thus, when $\alpha=1$ the certification is 100 percent accurate, and when $\alpha=0$ it is pure noise. In the experimental part of the paper three scenarios are considered: first, a benchmark when the certification is not available; second, when it is available and $\alpha=1$; third, when the certification is available and $\alpha=1/2$.

The timing is as follows. First, if the certification is available, the seller chooses whether to certify the product or not. Second, if the seller chooses to certify, he decides whether to reveal the certification outcome or not. Third, the seller sets the price, p, to offer to buyers. Finally, buyers observe the price along with the results of the certification (if the seller made it public) and make their purchasing decision.

Agents' payoffs are as follows. When a buyer purchases the product, his utility is $U_b=Ev-p$, where Ev is a buyer's quality expectation and p is the price. Buyer's utility from not purchasing the product is equal to 0. The seller's payoff is equal to $U_s=Pr(sale)\ p$ if the seller does not certify, and to $U_s=Pr(sale)\ p-c$ if the seller does certify. In what follows, we assume that buyers will purchase if they are indifferent between purchasing or not. Similarly, if the seller is indifferent between certifying (disclosing) or not, the seller certifies (discloses).

2.1 No certification environment

Without certification, the buyers' willingness to pay for the product is equal to 1/2, which is the expected value of seller's quality, v. The monopolistic seller then will set $p=1/2$ and will earn profit of 1/2. The buyers' expected utility is 0.

2.2 Certification is available, $\alpha=1$.

We solve the game using backward induction. At the last (purchasing) stage, buyers purchase the product if and only if the price is less than or equal to their beliefs about expected quality. Given buyers' behavior, the seller will set the price equal to the expected quality. Since the certification outcome is certain, at the disclosure stage the seller will always disclose the outcome. This is because the seller would not pay the certification cost at the first stage if he was not willing to reveal the certification outcome at the second stage.

Now we study the first (certification) stage. If a seller with quality v certifies, he will set the price $p=v$ and will earn the profit of v-c. Let $E(v|ND)$ be buyers' beliefs if no certification outcome is disclosed, which means that the seller did not obtain certification. Then a non-certifying seller will set the price $p=E(v|ND)$ and will earn the profit of $E(v|ND)$.

There are three possibilities: all types certify; nobody certifies; some but not all types certify. The first scenario is possible only when $c=0$, since otherwise $v=0$ will not certify. The second scenario occurs if type $v=1$ does not certify. In this case, the non-certification profit of

E(v|ND)=1/2 should be greater than the certification profit of *1-c*. This happens whenever *c>1/2*. In this case, the seller does not certify and charges price *p=1/2* regardless of quality. Finally, consider the last scenario. There must be a type indifferent between certifying or not. Let his quality be *x*. Since the certification profit is an increasing function of quality, all types above (below) *x* will (will not) certify. Thus *E(v|ND)=x/2* and it should be equal to the certification profit of *x-c*. The quality of the indifferent type, therefore, is equal to *x=2c*. Types with quality below *2c* do not certify, charge price *p=E(v\ND)=c* and earn profit *c*. Types with quality above *2c* charge price *p=v* and earn profit *v-c*. Given the analysis above, it is now straightforward to calculate the aggregated seller's profit in each of the three cases.

Proposition 1. *Assume that* $\alpha = 1$. *Then*

i) if c=0 all types certify and the aggregated seller's profit is 1/2.

ii) if c>1/2 then no one certifies and the aggregated seller's profit is 1/2.

iii) if c∈(0,1/2] then types with v<2c do not certify and types with v≥2c certify. The aggregated seller's profit is 1/2-c(1-2c). It is less than 1/2 unless c=1/2.

As it follows from Proposition 1, unless the certification cost is zero or so high that no type certifies, the environment with precise certification results in lower, on average, profit for the seller. The result is on the aggregated level, which is the focus of our analysis. On the individual level, types with higher quality will benefit from a possibility of certification while types with lower quality will not.

2.3 Certification is available, α<1.

The analysis in this section applies for any value of α<1, so we do not consider the case of α=1/2 separately. When α<1, then the certification outcome is a random variable with support equal to

[0,1]. It makes this setting different from the setting with $\alpha=1$. In particular, there can no longer be equilibrium where some types do not certify.

To understand this intuition, consider a candidate for an equilibrium where types with quality below x do not certify and types with quality above x do. Then, the average quality of the certifying types is $\frac{1+x}{2}$. Based on this seller's strategy, buyers' beliefs conditional on the observed certification outcome s are:

(2.1) $\mathrm{E}(v|s) = \frac{1+x}{2} \ \ if\ s < x$; and

(2.2) $\mathrm{E}(v|s) = \frac{(1-x)(1-\alpha)}{(1-x)(1-\alpha)+\alpha} \cdot \frac{1+x}{2} + \frac{\alpha}{(1-x)(1-\alpha)+\alpha} s \ \ if\ s \geq x.$

Notice that differently from the case of $\alpha=1$, even though no type below x certifies, with positive probability one can have the certification outcome below x. Given the seller's certification strategy, conditional on observing outcome $s<x$, no matter how a priori unlikely it is, buyers will conclude that the certification outcome was noisy and will not update their prior, i.e., $\mathrm{E}(v|s) = \frac{1+x}{2}$.

As an example, consider the case of α being arbitrarily close to 1. Then a type with quality below x (for example, quality $v=0$), will have incentives to deviate and certify. The certification outcome is almost certain to be correct so that $s=0$. However, buyers will interpret it as a mistake of the certification and will have beliefs $(1+x)/2$. Then the profit of the zero-quality seller from certifying is arbitrarily close to $(1+x)/2-c$, while the profit from non-certifying is $x/2$. As long as $c<1/2$, type 0 will find it profitable to deviate and certify. Therefore, our candidate strategy is not an equilibrium, no matter how close α is to 1.

We now develop the formal analysis of the setting with imprecise certification. As before, we use backward induction. At the last (purchasing) stage, buyers purchase the product if and only if the price is less than or equal to the expected quality. Given buyers' strategy, the seller will set the price exactly equal to the expected quality. The analysis of the first two stages (deciding whether to disclose the certification outcome or not, and whether to certify or not) is done in Proposition 2. Its proof is in the Appendix.

Proposition 2. *Assume that* $\alpha < 1$. *Then*

i) in equilibrium, if it exists, all types certify and disclose certification results for any s*;*

ii) expected profit of type v *is* $\alpha^2 v + \frac{1}{2}(1-\alpha^2) - c$. *Aggregated profit is* $1/2 - c$*;*

iii) such an equilibrium exists if $c \leq \frac{1}{2} - \frac{1}{2}\alpha^2$.

It follows from Proposition 2 that when α=1/2, the aggregated seller's profit is lower than that in the environment with no certification, and is lower than when α=1.

Thus, it follows from our analysis in this section that if buyers are risk-neutral, then the no-certification environment is more profitable than an environment with certification as long as the certification cost is positive and there are types that certify. Intuitively, when buyers are risk-neutral, removing the quality uncertainty does not, on average, increase buyers' willingness to pay; therefore, the certification may be useless from the aggregate perspective. On individual level, of course, paying certification cost is not necessary wasteful, as it benefits types with higher quality.

3. Quality Certification with Loss-Averse Buyers

Propositions 1 and 2 have shown that, when buyers are risk-neutral, costly certification can only hurt the aggregate profit. This is because the seller's profit is equal to the buyers' willingness to pay minus any certification cost. When buyers are risk-neutral, the law of iterated expectations ensures that the availability of certification technology does not affect buyers' ex-ante willingness to pay, which is why from the ex-ante point of view paying the certification cost is nothing but a waste for the seller.

Arguably, however, the risk-neutral case overlooks an important role of the certification, which is that, when sufficiently precise, it can provide buyers with accurate information about the product's quality. When buyers are not risk-neutral, such information can increase buyers' willingness to pay. This increase can outweigh the cost of certification and increase the seller's ex-ante profit.

In this section, we analyze what happens if we depart from the risk-neutrality assumption. Specifically, we assume that buyers are loss-averse, and their reference point is endogenously determined by buyers' beliefs about expected quality.[9] Let f denote density of buyers' beliefs about product quality, let $E_f v$ be expected quality given f, and let v be the actual quality of the purchased product. Then if the product's price is p and $E_f v > v$ buyer's utility is $U_b(v, E_f v, p) = E_f v - p$. The purchased quality is higher than buyers' expectations and they do not experience any loss. If, however, $E_f v < v$ then the buyer's utility is

$$U_b(v, E_f v, p) = E_f v - p + b(v - E_f v),$$

[9] Among a variety of reference-dependent models with endogenous reference points (e.g., Gul 1991; Köszegi and Rabin 2006; Shalev 2000), this reference-dependent model "*has proven quite popular in applications, as the reference point is neither stochastic nor recursively defined, but is simply the expected consumption utility of the lottery*" (Masatlioglu and Raymond 2016, p. 2765).

where b measures the degree of buyers' loss-aversion, and $v – E_f v$ is buyer's loss. The case of b=0 coincides with the risk-neutral case. When $b>0$ buyers are loss-averse, and higher values of b correspond to be buyers being more sensitive to losses.

Given $f(v)$, buyer's expected surplus from purchasing is

$$U_b(f,p) = E_f v - p - b \cdot \int \left(E_f v - v\right) \cdot \mathbf{1}_{v<E_f v} \cdot f(v)dv.$$

Buyers will purchase the product if and only if $U_b(f,p) \geq 0$. Thus, given beliefs f, buyers' willingness to pay is $E_f v - b \cdot \int \left(E_f v - v\right) \cdot \mathbf{1}_{v<E_f v} \cdot f(v)dv$. In equilibrium, buyers' beliefs f should be correct.

Below, we solve the model with loss-averse buyers for each of the three scenarios used in the experimental part of the paper: no certification, 100 percent accurate certification (α=1), and 50 percent accurate certification (α=0.5).

3.1 Certification is not available

When certification is not available and the seller's quality is $v \sim U[0,1]$, the buyers' willingness to pay and the seller's expected profit are equal to

$$\int_0^{1/2} \left(v - b\left(\frac{1}{2} - v\right)\right) dv + \int_{1/2}^{1} v dv = \frac{1}{2} - \frac{1}{8}b. \tag{3.1}$$

3.2 Certification is available, α=1.

As in the case of risk-neutral buyers, the decision to disclose is trivial. Since, conditional on certifying, the certification outcome is equal to seller's quality with probability 1, it is never optimal to pay the certification cost and then not disclose the outcome. We now focus on the certification decision.

Let x be the quality of the seller indifferent between certifying and not. If seller's quality is $v > x$, then buyers' willingness to pay is v, and the seller's profit is v-c. If $v < x$, then the buyers' posterior is that the seller's quality is $U[0,x]$ and buyer's willingness to pay is

$$\frac{1}{x}\int_0^{x/2}\left(v-b\left(\frac{x}{2}-v\right)\right)dv+\int_{x/2}^{x}vdv=\frac{1}{8}x(4-b).$$

The seller is indifferent between certifying and not if

$$\frac{1}{8}x(4-b)=x-c$$

so that $x=\frac{8c}{4+b}$. Thus, if

$$\frac{8c}{4+b}<1,$$

or equivalently when $c<\frac{1}{2}+\frac{b}{8}$, some types, i.e., those with high quality, will choose to certify. Notice that, differently from the risk-neutral case, the seller can be willing to pay the certification costs even if it is greater than 1/2. This is because reducing the quality uncertainty is valuable for buyers, thereby increasing their willingness to pay, which in turn increases the seller's profit. The aggregated profit is

$$\int_0^x \frac{1}{8}x(4-b)dv+\int_x^1(v-c)dv=\frac{64(1/2-b/8)c^2}{(4+b)^2}+\frac{1}{2}-\frac{32c^2}{(4+b)^2}-c\left(1-\frac{8c}{4+b}\right). \qquad (3.2)$$

To see whether this equilibrium is more or less profitable than the equilibrium without certification, we compare the certification profit (3.2) and the no-certification profit (3.1). Solving

$$\frac{64(1/2-b/8)c^2}{(4+b)^2}+\frac{1}{2}-\frac{32c^2}{(4+b)^2}-c\left(1-\frac{8c}{4+b}\right)=\frac{1}{2}-\frac{1}{8}b,$$

we get two roots:

$$c_1=\frac{1}{32}b^2+\frac{1}{8}b \text{ and } c_2=\frac{1}{2}+\frac{1}{8}b.$$

When $c \in [c_1,c_2]$, the no-certification profit is higher. When $c < c_1$, the aggregate profit with certification is higher. That is, when buyers are loss-averse and certification cost is not too high, the equilibria with certification are more profitable: the risk-reduction benefits of certification outweigh its cost.[10] When $c > \frac{1}{2}+\frac{b}{8}$, no one certifies and the two equilibria are equivalent. We summarize this result in Proposition 3 below.

Proposition 3. *Assume that* $\alpha = 1$. *Let* $c_1=\frac{1}{32}b^2+\frac{1}{8}b$ and $c_2=\frac{1}{2}+\frac{1}{8}b$. *The seller's aggregated profit is given by (3.2), and*

i) when $c<c_1$ *the aggregated profit in the environment with certification is higher;*

ii) when $c \in [c_1,c_2]$ *the aggregated profit in the environment with certification is lower;*

iii) when $c>c_2$ *both environments generate the same aggregated profit.*

3.3 Certification is available, α=1/2.

[10] To get an idea of how $[c_1,c_2]$ varies with b, notice that when b=0 it is [0,1/2] as before; when b=1 it is [5/32,5/8]; and when b=2 it is [3/8,3/4].

Now we consider the case of $\alpha=1/2$. Due to non-linearity of buyers' utility, this case is the most complicated analytically, and, in general, gives rise to a multiplicity of equilibria. Instead of characterizing all possible equilibria, which is beyond the scope of this paper, we will focus on an equilibrium where, just as in the risk-neutral case, all types certify and all outcomes are disclosed. We will derive conditions that guarantee that such an equilibrium exists and then will show that buyers' loss-aversion changes, as compared to the previous section, relative profitability of the three experimental environments: the one with no certification, the one with 100 percent accurate certification, and the one with 50 percent accurate certification.

Let C be the set of all sellers who choose to certify and D be the set of all certification outcomes that are disclosed. We are interested in an equilibrium in which $C=D=[0,1]$, i.e., all types certify and disclose certification outcome. Let $p(v|s)$ be buyer's willingness to pay conditional on certification outcome s, and $E(v|s)$ be the expected quality given certification outcome s. With probability 1/2, the certification is incorrect so that the posterior quality is U[0,1], and with probability 1/2, the certification is correct so that the posterior quality is s. Thus,

$$\mathrm{E}(v|s) = \frac{1}{2} \cdot \frac{1}{2} + \frac{1}{2} s = \frac{1+2s}{4}.$$

To calculate the buyers' willingness to pay, we need to consider two cases. The first case is where buyers do not experience loss when the certification is correct, i.e., the certification outcome s is equal to v, and $E(v|s) < s$. The second case is when buyers do experience loss when the certification is correct.

Consider the first case. It is easy to see that $E(v|s) < s$ if and only if $s \geq 1/2$. Thus, if $s \geq 1/2$, then buyers do not experience loss when the certification is correct. However, they still experience loss when the certification is wrong. Incorrect certification happens with posterior probability 1/2, and then the seller's quality is U[0,1]. The expected loss is

$$\frac{1}{2}\int_0^{\mathrm{E}(v|s)} b\big(v - \mathrm{E}(v|s)\big)dv = -\frac{b}{64}(2s+1)^2.$$

The buyers' willingness to pay when $s \geq 1/2$ is expected quality minus expected loss:

$$p(v|s) = \frac{1+2s}{4} - \frac{b}{64}(2s+1)^2 \tag{3.3}$$

Now consider the second case. When $s<1/2$, so that $s<\mathrm{E}(v|s)$, buyers experience loss even if the certification is correct, and this is in addition to the expected loss from incorrect certification outcomes. The buyers' willingness to pay then is (3.3) minus the loss when the certification is correct, which is

$$\mathrm{b}\frac{1}{2}\big(s - \mathrm{E}(v|s=v)\big) = \frac{b}{8}(2s-1).$$

Thus

$$p(v|s) = \frac{1+2s}{4} - \frac{b}{64}(2s+1)^2 + \frac{b}{8}(2s-1), \tag{3.4}$$

when $s<1/2$. Combining these two equations, we have:

$$p(v|s) = \begin{cases} \dfrac{1+2s}{4} - \dfrac{b}{64}(2s+1)^2, & s \geq 1/2 \\ \dfrac{1+2s}{4} - \dfrac{b}{64}(2s+1)^2 + \dfrac{b}{8}(2s-1), & s < 1/2 \end{cases}$$

We can use the expression for $p(v|s)$ derived above to calculate the seller's expected profit. First, if the seller's quality is $v \geq 1/2$ and the certification is correct, then the expected profit is given by (3.3), where $s=v$. If the certification is correct and $v<1/2$, then the expected profit is given by (3.4), where $s=v$. Finally, if the certification is incorrect, then the expected profit is

$$\int_0^{1/2}(3.4)ds+\int_{1/2}^{1}(3.3)ds.$$

Combining the two, we get that the seller's expected profit without the certification cost is:

$$\mathrm{E}\pi(v)=\frac{1}{2}(3.6)|_{s=v}+\frac{1}{2}\left(\int_0^{\frac{1}{2}}(3.6)ds+\int_{\frac{1}{2}}^{1}(3.5)ds\right)$$

$$=\frac{3}{8}+\frac{1}{4}\mathrm{v}-\frac{1}{32}bv^2+\frac{3}{32}\mathrm{bv}-\frac{23}{192}\mathrm{b} \qquad (3.5)$$

if $v<1/2$, and

$$\mathrm{E}\pi(v)=\frac{1}{2}(3.5)|_{s=v}+\frac{1}{2}\left(\int_0^{\frac{1}{2}}(3.6)ds+\int_{\frac{1}{2}}^{1}(3.5)ds\right)$$

$$=\frac{3}{8}+\frac{1}{4}\mathrm{v}-\frac{1}{32}bv^2-\frac{1}{32}\mathrm{bv}-\frac{11}{192}\mathrm{b} \qquad (3.6)$$

if $v\geq 1/2$.

Now we will find conditions to guarantee that C=D=[0,1]. The seller will choose to use certification technology if expected profit after certification is greater than certification cost. Thus, a sufficient condition to guarantee that C=[0,1] is:

$$\mathrm{E}\pi(v)\geq \mathrm{c} \text{ for all v in } [0,1]. \qquad (3.7)$$

From (3.5) and (3.6), one can easily see that $\mathrm{E}\pi(v)$ is a concave quadratic function on interval [0,1/2] and on interval [1/2,1]. Thus, a necessary and sufficient condition for (3.7) is

$$\begin{cases} E\pi(0) = \frac{3}{8} - \frac{23}{192} b \geq c \\ E\pi\left(\frac{1}{2}\right) = \frac{1}{2} - \frac{31}{384} b \geq c \\ E\pi(1) = \frac{5}{8} - \frac{23}{192} b \geq c \end{cases}$$

Solving the inequalities above, we see that b must be such that $b \leq \left(\frac{3}{8} - c\right)\frac{192}{23}$.

Next, we examine conditions that ensure that D=[0,1]. The seller is not going to sell at a price below the product's cost, which is zero. Thus all outcomes are disclosed if and only if

$$\mathrm{p(v|s)} \geq 0 \text{ for all s in } [0,1]. \tag{3.8}$$

This means that the seller will choose to disclose certification result when the buyer's willingness to pay is positive. Given that $p(v|s)$ is a concave quadratic function on both [0,1/2] and [1/2,1], a necessary and sufficient condition for (3.8) is:

$$p(v|0) = \frac{1}{4} - \frac{9}{64} b \geq 0$$
$$p(v|1) = \frac{1}{2} - \frac{1}{16} b \geq 0$$
$$p(v|\frac{1}{2}) = \frac{3}{4} - \frac{9}{64} b \geq 0$$

Solving the inequalities above, we have $\mathrm{b} \leq 16/9$. Thus, for a given certification cost c, equilibrium in which all types choose to certify and reveal certification outcome exists when:

$$\mathrm{b} \leq \min\left\{\frac{16}{9}, \left(\frac{3}{8} - c\right)\frac{192}{23}\right\}.$$

Finally, one can use (3.5) and (3.6) to calculate the aggregated profit:

$$\int_0^{1/2} (3.5)dv + \int_{1/2}^1 (3.6)dv = \frac{1}{2} - \frac{19}{192} b - c.$$

Proposition 4 summarizes the arguments above:

Proposition 4. *Assume that* $\alpha = 1/2$*. Then if*

$$\mathrm{b} \leq \min\left\{\frac{16}{9}, \left(\frac{3}{8} - c\right)\frac{192}{23}\right\},$$

it is an equilibrium for all types to certify and disclose the certification outcome. The aggregated profit is equal to $\frac{1}{2} - \frac{19}{192}b - c$*. It is greater than the profit in the environment without certification iff* $c < \frac{5}{192}b$*.*

3.4 Theory and predictions. Case of c=1/9.

In this section we compare the profitability of the three settings—no certification, 100 percent accurate certification (α=1) and 50 percent accurate certification (α=1/2)—given the parameters' values that are used in the experimental analysis. In the experiment, the product quality is drawn from the uniform distribution [0,180] and the certification cost will be set equal to 20. After normalizing the upper quality level to 1, the certification cost corresponds to the normalized cost value of 1/9.

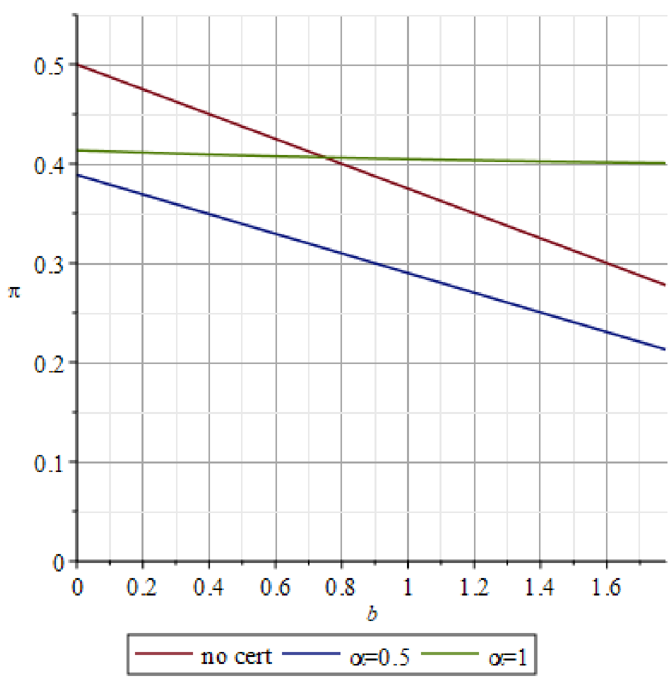
In the environment without certification the aggregated profit is equal to $1/2 - 1/8b$. In the case of α=1 and c=1/9, the quality of the seller indifferent between certifying and not is given by $\frac{8}{9}\frac{1}{4+b}$, and the aggregated profit is equal to

$$\frac{1}{162}\frac{63b^2 + 504b + 1072}{(4+b)^2}.$$

In the case of α=1⁄2 and c=1/9, in order to have an equilibrium as defined in Section 3.3, the value of b should be less than or equal to 16/9, which is approximately 1.78.[11] The aggregated profit in this case is $1/2-19/192b-1/9$.

We plot the seller's profits in each of the three cases on Figure 1. When c=1⁄9 the 50 percent-accurate certification is always dominated by 100 percent accurate certification. When b is sufficiently small (b < 0.75) the no-certification environment is the most profitable one. This is an extension of our result that for risk-neutral buyers the no-certification case is the most profitable. By continuity, if buyers are only slightly loss-averse, the no-certification environment also dominates.

Figure 1: Aggregated profits when c=1/9.



[11] In the United States, where we conducted our experiments, the median value of the degree of loss-aversion is equal to 1.7 (Wang, Rieger, and Hens 2017, Table 1).

As buyers become more loss-averse (b > 0.75), 100 percent accurate certification becomes the most profitable while 50 percent accurate certification remains the least profitable. With sufficiently loss-averse buyers, 100 percent accurate certification increases buyers' willingness to pay enough to offset the certification cost, thereby increasing the seller's ex-ante profit. At the same time, when the certification is only 50 percent accurate, having 50 percent probability of noisy certification outcome suppresses willingness to pay for loss-averse buyers, which translates into lower profits. Thus, with sufficiently loss-averse buyers, having accurate certification technology is better than having none, but having inaccurate certification technology is worse than having none.

Finally, it should be noted that two factors contribute to the fact that the environment with 50 percent accurate certification is dominated by the no-certification environment. The first factor, as discussed above, is that it introduces extra uncertainty, and the second one is certification cost. When, for example, c=0, then the environment with 50 percent accurate certification is more profitable than the environment with no certification for any $b<16/9$. That is, ignoring the certification cost, the 50 percent accurate certification is sufficiently valuable to increase buyers' willingness to pay as compared to the no-certification environment. However, when c=1/9, the increase is not high enough to offset the certification cost.

4. Experiment

Although our theoretical model makes strong predictions about how certification and the accuracy of certification affect seller profits, this relationship depends upon the loss-aversion of the buyer. Thus, without an empirical investigation, it is impossible for us to determine which outcome is most likely to arise in real-world settings. For this reason, we test the results of the theory using an incentive-based economic experiment. Our focus is to test how certification impacts the exchange between the seller and the buyer along with its profit implications.

The extant marketing literature using incentive-based, economics experiments has focused on the strategic decision making of firms in promotion decisions (Amaldoss and He 2009; Yuan, Gómez, and Rao 2013), duopoly pricing (Amaldoss and He 2013; Amaldoss and Shin 2011; Zhou, Mela, and Amaldoss 2015), distribution channel coordination (Cui and Mallucci 2016; Ho, Lim, and Cui 2010; Ho and Zhang 2008; Lim and Ho 2007; Özer, Subramanian, and Wang 2018), salesforce management (Chen, Ham, and Lim 2011; Chen and Lim 2013, 2017; Lim and Chen 2014; Lim and Ham 2014), and third-party reviews (Kim, Chung, and Lim 2018). Similarly, the literature has studied strategic consumer decision making in the context of conspicuous consumption (Amaldoss and Jain 2005a, 2005b, 2010) and auction bidding behavior (Amaldoss and Jain 2008; Ding et al. 2005). Instead of focusing separately on sellers and buyers as much of the literature has done, our experiment captures the strategic interaction that takes place between sellers and buyers.

4.1 Experimental design

Our experimental method offers several advantages that are especially helpful in understanding what happens in these exchanges.

First, we can fully investigate the degree of information disclosure of sellers because we observe the true quality of the products during the experiment. Understanding the true quality of experience or credence goods is usually very hard with other observational data unless experts can examine the quality of those products, as done by Jin and Kato (2006). Therefore, unlike many empirical studies on information disclosure, this study can clearly distinguish whether the seller fully discloses quality, providing some important implications regarding sellers' behavior and buyer surplus under information asymmetry.

Second, we can allow for sellers to engage in cheap talk about the quality of the product. Even though sellers may not certify their products, they usually add a statement claiming the quality or condition of their product when selling the product. This practice is very common on eBay, Craigslist and other listing websites. Hence, we allow sellers to engage in cheap talk even when they do not use certification. If cheap talk is highly informative, then costly certification would not be necessary. On the other hand, if the talk is not just cheap but worthless, then the results will be different.

Third, we can consider three market environments for our experimental treatments. In particular, we consider a market without certification, a market with a 50 percent accuracy certification and a market with a 100 percent accuracy certification. These three treatments enable us to assess how the seller's profits vary in these three markets. More specifically, we can assess whether the risk-neutral predictions or the loss-averse model predictions are supported experimentally. As stated previously, if buyers are risk-neutral, we would expect certification to be a fruitless endeavor. However, if buyers are loss-averse, the 100 percent accurate certification may improve seller profits, while the 50 percent certification may harm sellers.

4.2 Procedure

The participants consisted of 58 undergraduate students at a research university in the U.S. The participants were given a course credit for participating in the experiments, and cash payments were provided at the end of the experiment sessions according to their performance (i.e., their earnings in the experiment). We conducted three experimental sessions in total, using a within-subject design, and had 18 to 20 subjects in each session. We rotated the three treatments within a session to minimize order and carryover effects. More specifically, the first session started with no certification and ended with 50 percent certification, the second session started with 50 percent certification and ended with 100 percent certification, and the third session started with 100 percent certification and ended with no certification. Each treatment consisted of 15 decision rounds. Each subject participated in 45 decision rounds altogether, providing 2,610 observations of buyer and seller decisions from 1,305 transactions in total.

For each decision round, we randomly and anonymously assigned the subjects into the roles of buyers and sellers, matched them in a pair and observed their decisions to maximize their profits under various certification types. The matching procedure was repeated every round, and the participants were re-matched with another player for each of the 45 decision rounds. The experiments were implemented using the z-Tree software (Fischbacher 2007). Before starting the decisions, we helped the participants understand the procedure by reading the instructions out loud and answering their questions. We also provided two practice decision rounds for every treatment (i.e., six practice rounds in total for each participant) so that participants could get used to the decision-making procedure and their payoff structure before beginning the actual experiments.

Accordingly, the parameters were chosen to be reasonable and to also allow for varying predictions based on whether buyers are risk-neutral or loss-averse. In particular, we set the maximum quality level of the product as 180 (i.e., $V = 180$), and the cost of certification as 20 (i.e., $c = \frac{1}{9}V$), as explained in the previous section. The final cash rewards for the participants were calculated by converting the sum of their points for the 45 decision rounds at a rate of $1.00 per 100 points.

The game started with the seller offering an item to the matched buyer and ended with the buyer choosing whether to purchase the item. Before offering an item, the seller first observed its randomly assigned true value between 0 to 180, where each number between 0 and 180 had an equal chance of being drawn by the computer program. After observing the true value of the item, the seller chose whether to certify the value when the certification was available, or just announce the value without certification (cheap talk). The cost of certification (20) was incurred when the seller certified the value. However, as suggested in the theory, the seller might not show the certification to the buyer, even after getting certified value, and might simply announce the value. The seller then chose the price of the item that would be offered to the buyer between 0 and 180 in decimals up to two places. Upon receiving the information about the price and either the certified value or the announced value of the item, the buyer chose whether to purchase the item at the price offered by the seller or not. The buyer did not know the true value before purchase but would only observe either the certified or announced value, and the certified value could be either equal to the true value or not, depending on the types of certification (i.e., according to whether the certification is 100% or 50% accurate).

4.3 Payoff calculation

The seller's points in each round were calculated as follows. If the seller chose to certify and the buyer purchased the item, then the seller's points were equal to *price – 20* (certification cost). If the seller chose to certify and the buyer did not purchase the item, then the seller's points were equal to *-20,* which was lower than zero. If the seller chose not to use certification and the buyer purchased the item, then the seller's points would be equal to the *price*. If the seller chose not to use certification and the buyer did not purchase the item, then the seller's points were equal to *zero*. Therefore, the seller's points increased with a higher price as long as the buyer purchased the product. However, the seller would need to balance both the margin on the item being offered along with the likelihood that the item is actually purchased.

The buyer's points in each round were calculated as follows. If the buyer purchased the item, then the buyer's points were equal to the *true value – price*. Note that the true value, not certified or announced value, determined the buyer's points. If the buyer did not purchase the item, then the buyer's points were equal to *zero*. In this way, we assume that buyers obtain the benefits of the true value of the product as opposed to its certified value except in those scenarios where the certified value is indeed equal to the true value of the product. The full description of the game and procedure can be found in the instructions in Appendix B.

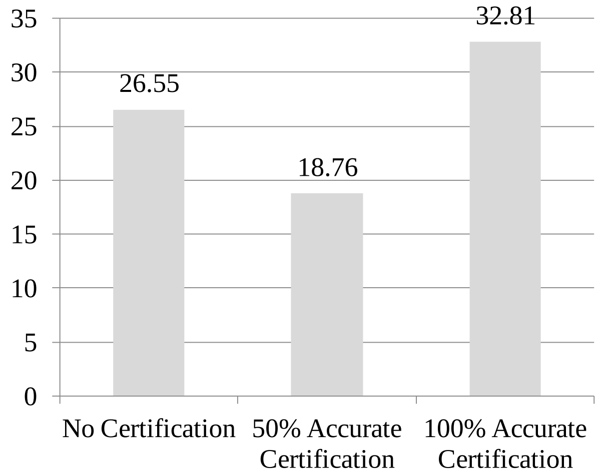
5. Results of Experiment

The experimental analysis provides us with 2,610 observations of buyer and seller decisions in 1,305 individual transaction rounds in total (i.e., in each round, we observed both the buyer's and the seller's decisions at the same time). We now analyze the pattern of seller profit and the factors affecting it, along with buyer surplus, from the behaviors of sellers and buyers observed from the experiment. As the participants in the study make multiple decisions, we cluster the standard errors at the subject level in all of the following statistical analyses to control for potential within-subject correlation.

5.1 Primary observations

We first observe the sellers' average profits across three different conditions of certification. The results show that sellers have earned 26.55, 18.76 and 32.81 on average when there is no certification, when the certification has 50 percent accuracy, and when the certification has 100 percent accuracy, respectively. This result is also presented in Figure 2. However, the predicted profit levels under risk-neutrality would be 90, 74.4 and 70 when there is no certification, 50 percent accurate and 100 percent accurate certification, respectively. Hence, the departure from the risk-neutral model predictions appears distinct.

Figure 2: Average profit of sellers across three conditions.



The ordinary least squares (OLS) regression of seller's profit on certification types shows that the observed impact on seller profit is significant, as seller profit is significantly higher with no certification than with 50 percent certification (p=0.004), and significantly higher with 100 percent certification than with no certification (p=0.043), as is shown in Table 1.

Empirical Result 1: *Seller profits are the highest with 100 percent certification accuracy and the lowest with 50 percent certification accuracy.*

Table 1: Regression of Seller's Profit on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*t*-stat.	*p*-value
Constant (Base=No Certification)	26.55	1.894	14.02	0.000
50% Accurate Certification	-7.79	2.614	-2.98	0.004
100% Accurate Certification	6.26	3.024	2.07	0.043

Therefore, these results described in Figure 2 and Table 1 are consistent with the model results from Section 3, which assumes loss-averse buyers, as opposed to Section 2, which assumes risk-neutrality. More specifically, in both the model predictions in Section 3 and the experimental results, the seller profit with 50 percent accuracy certification was the lowest, and the seller profit with 100 percent accuracy certification was higher than the profit with no certification. Therefore, our results would suggest that inaccurate information is *not* better than no information.

5.2 Profit margins conditional on purchase

Next, we attempt to compare the profit across three treatments conditional on whether a buyer makes purchase or not, in order to figure out what may be driving the profit variation observed above. The regression results are shown in Table 2. We obtain some interesting observations about the patterns in seller profits here.

First, when buyers do not purchase, the seller profit is the highest with no certification (p=0.000), but the profits from 100 percent certification and 50 percent certification do not differ from each other (p=0.320) (i.e., profit from no certification > {profit from 50 percent certification = profit from 100 percent certification}). This is consistent with the explanation from the model; as sellers still have to pay the certification cost even when buyers do not purchase the product, the profit would certainly be higher with no certification than with certification, if there is no purchase.

Second, when buyers do purchase, seller profit does not differ between the 100 percent accuracy case and the no certification case (p=0.853). However, seller profit in the 100 percent accuracy case is greater than in the 50 percent accuracy case (p=0.036), and profit in the no certification case is marginally higher than the 50 percent accuracy case (p=0.086) (i.e., {profit from 100 percent certification = profit from no certification} > profit from 50 percent certification). The results indicate that even though the seller incurs the certification costs in the 100 percent accuracy certification case, the margins are no different than when there are no certification costs. Hence, the seller is able to extract a relatively high margin in the 100 percent certification case even though certification is costly. However, since the margin is lower in the 50 percent accuracy certification case than in the 100 percent one, sellers do not seem to be able to extract the same margin from buyers' purchase when the certification is inaccurate.

Empirical Result 2: *The seller's margin in the 100 percent accuracy certification treatment and the no certification treatment conditional on the buyer's purchase are higher than that in the 50 percent accuracy certification treatment, but margins do not differ between the 100 percent accuracy certification treatment and the no certification treatment.*

Table 2: Regression of Seller's Profit on Certification Types Conditional on Purchase

	Coefficient	Standard Errors	*t*-stat.	*p*-value
Conditional on No Purchase (#obs. = 686)				
Constant (Base=50% Accurate Certification)	-8.59	0.826	-10.41	0.000
No Certification	8.59	0.826	10.41	0.000
100% Accurate Certification	1.11	1.105	1.00	0.320
Conditional on Purchase (#obs. = 619)				
Constant (Base=50% Accurate Certification)	55.38	3.054	18.13	0.000
No Certification	7.05	4.040	1.74	0.086
100% Accurate Certification	7.82	3.645	2.15	0.036

5.3 Purchase probability

Given that profits are determined not only by the margin, but also by the purchase frequency, we consider how the treatments affect the buyer's purchase probability. We first run a logistic regression of the purchase probability on the certification types, and the result is displayed in Table 3. The results show that the purchase probability in the 100 percent certification case is significantly higher than in other cases (p=0.000), while the purchase probability between no certification and 50 percent certification is not different (p=0.944). Therefore, buyers are much more likely to make purchases when there is 100 percent accurate certification than when there is 50 percent accurate certification or no certification. Alternatively, buyers' purchase incidences do not differ when the certification is 50 percent accurate and when the certification is not available.

Empirical Result 3: *The buyer's purchase probability is the highest in the 100 percent accurate certification case, but does not differ when there is no certification or the accuracy of the certification is 50 percent.*

Based on these results, we can explain why the 100 percent accuracy certification has the highest seller profits and why the 50 percent accuracy certification has the lowest profits. For the 100 percent certification case, both the margins conditional on purchase and the purchase frequency are the highest. Consequently, certification seems to ensure confidence in the value of the product, and this drives buyers to place a higher value on the product and ensures that buyers are more likely to purchase the product. For the 50 percent accuracy certification case, the margins conditional on purchase are marginally lower from the no certification treatment, and the likelihood that the buyer purchases is not different either. Accordingly, when buyers do not purchase, the profit from the 50 percent case is lower than the profit from the no certification case, which is mainly driven by the certification costs. This causes the 50 percent accuracy certification treatment to have the lowest profits.[12]

[12] The seller's profits may also be determined by the frequency of certification or its use. The proportion of sellers using certification is 50 percent in the 50 percent accuracy certification treatment and 66 percent in the 100 percent accuracy certification treatment. This difference is significant with a logistic regression (0.65, z=3.18, p=0.000). When we combine this finding with the margins obtained with certification in 5.4, we can help explain why inaccurate certification is ineffective.

Table 3: Logistic Regression of Purchase Probability on Certification Types

	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=No Certification)	-0.30	0.140	-2.15	0.032
50% Accurate Certification	0.01	0.135	0.07	0.944
100% Accurate Certification	0.58	0.162	3.60	0.000

obs. = 1,305

5.4 Factors affecting behavior within a treatment

Our explanation above has been at the treatment level. However, the seller decisions within the treatment may impact buyer behavior. Consequently, we consider these factors below.

No certification case. We first run a logistic regression of purchase probability on the seller decisions when there is no certification. Here, the seller will only announce the value of the product and the suggested price. As is shown in Table 4, the purchase probability is significantly affected by the suggested price (p=0.000), where a lower price raises the buyer's likelihood of purchase. The claimed value does not have a significant effect (p=0.242) on the purchase probability. However, the claimed value could concurrently impact the seller's margin. We regress seller profits on the claimed value conditional on a purchase and find that for every unit increase in the claimed value the seller's profits increase by 0.54 (t=7.67, p=0.000). This result suggests that the exaggeration of the claimed values can raise margins. Interestingly, sellers lie 81 percent of the time and they exaggerate their values on average by 179 percent. Therefore, a lower price raises a buyer's purchase probability because the purchase risk is lower, but a higher claimed value raises the margins on a purchase or their willingness to pay. Even so, the benefits of cheap talk are limited because it does not work in raising the buyer's likelihood to purchase.

Empirical Result 4: *When certification is not available, a lower price increases the buyer's purchase probability, while a higher claimed value raises the buyer's willingness to pay*.

50 percent certification case. For the purchase probability, we add a term indicating whether the seller has shown the certification and the interaction term between whether the seller has shown the certification and the claimed value. In this treatment, the claimed value can either be supported by the certification or not. If it is not supported by the certification, then the claimed value is merely the verbal communication of the value. Therefore, the interaction term should clearly distinguish whether the value depends on whether it is supported by the certification. As shown in Table 4, the purchase probability is significantly affected by suggested price (p=0.000) and the interaction term (p=0.008). However, the claimed value (p=0.512) and whether certification is used by the seller (p=0.764) do not influence the purchase behavior. Therefore, certification, even when it is only 50 percent accurate, can raise the buyer's purchase probability as buyers place confidence in the certified value of the product.

Relatedly, we examine how the value and whether or not it is claimed can influence seller margins conditional on a purchase. To do so, we regress seller profits conditional on a purchase on the claimed value. Regardless of whether the claimed value is supported by the certification, the claimed value increases seller margins. When the claimed value is not supported by the certification, a unit increase in the value increases seller profits by 0.64 (t=10.31, p=0.000), and when the value is supported by the certification, a unit increase in the value increases seller profits by 0.65 (t=16.37, p=0.000). As we saw in the no certification treatment, sellers lie 88 percent of the time and exaggerate the true value by 235 percent on average. A higher certified value not only raises the seller's margins, but it increases the buyer's likelihood of purchase.

Consequently, certification is important for a loss-averse buyer because it can substantially reduce the risks associated with purchasing the product.

Empirical Result 5: *When certification is 50 percent accurate, a higher certified value raises both the buyer's purchase probability and the buyer's willingness to pay.*

100 percent certification case. As we have done in the previous two treatments, we assess behavior within the 100 percent certification treatment. From Table 4, we observe that the purchase probability is significantly affected by the claimed value (p=0.024), suggested price (p=0.000), whether certification is used by the seller (p=0.016), and the certified value (p=0.018). Buyers will purchase more frequently when the claimed value is higher, the price is lower, and the seller certifies the value. What is interesting about 100 percent case is that, unlike 50 percent accuracy case, cheap talk is effective in raising the buyer's purchase probability. However, when comparing the effects of the claimed value and whether it is certified, our results indicate that certification leads to a higher purchase probability than a non-certified claimed value. This is because the effect of the certified claimed value is equal to 1.48 + 0.02× *claimed value*, but the noncertified claimed value is only equal to 0.02× *claimed value*.

We also know from the theoretical model that sellers will not certify if the true value is less than 40 because it is too costly. We observe that sellers certify only 23 percent of the time when the value is equal to or below this threshold and certify 76 percent of the time when the value is above the value threshold of 40. Consequently, buyers may anticipate that sellers may not certify if the value is lower and are influenced by the seller's cheap talk. We also regress the seller's profit on the claimed value conditional on purchase and find that a unit increase in the claimed value raises profits by 0.65 (t=10.53, p=0.000) when it is not certified and by 0.78 (t=23.42, p=0.000) when the value is certified. As we observed in the previous treatments, sellers lie 88 percent of the time and exaggerate by 289 percent. Even so, the effect of certification is stronger than no certification (p=0.003). Consequently, certification is more effective in improving the buyer's purchase probability and their willingness to pay.

Empirical Result 6: *When certification is 100 percent accurate, a higher certified value raises both the buyer's purchase probability and the buyer's willingness to pay and is more impactful than cheap talk.*

Table 4: Logistic Regression of the Purchase Probability on Seller Decisions

	Coefficient	Standard Errors	*z*-stat.	*p*-value
No Certification (#obs. = 435)				
Constant	0.72	0.322	2.25	0.025
Claimed value	0.004	0.003	1.17	0.242
Suggested price	-0.02	0.005	-3.95	0.000
50% Certification (#obs. = 435)				
Constant	0.55	0.395	1.40	0.162
Claimed value	0.003	0.005	0.66	0.512
Suggested price	-0.02	0.007	-3.58	0.000
Use of certification	-0.16	0.533	0.30	0.764
Use of certification * claimed value	0.01	0.006	2.65	0.008
100% Certification (#obs. = 435)				
Constant	-0.33	0.434	-0.75	0.451
Claimed value	0.02	0.007	2.25	0.024
Suggested price	-0.04	0.010	-4.04	0.000
Use of certification	1.48	0.613	2.42	0.016

Use of certification * claimed value	0.02	0.007	2.36	0.018

5.5 Buyer surplus

Although our exposition has focused on seller profits, it is important to also consider how the buyer is affected by the certification treatments. We observe buyers' average surplus across three different treatments as 6.92, 9.82 and 13.54 when there is no certification, the certification has 50 percent accuracy, and the certification has 100 percent accuracy, respectively. We run an OLS regression of buyer's profit on certification types and find that the above-mentioned impact of certification types on buyer profit is marginally significant. Surplus is marginally higher with 50 percent certification than with no certification (p=0.082), and marginally higher with 100 percent certification than with 50 percent certification (p=0.078). Hence, buyers are better off with certification even if it is noisy because it reduces the risk associated with the purchase. Nonetheless, sellers can still be worse off when the certification is noisy, as we observed in the 50 percent accuracy certification treatment.

Empirical Result 7: *Buyer surplus is marginally the highest with 100 percent certification accuracy, followed by the 50 percent certification accuracy and the lowest with no certification.*

Table 5: Regression of Buyer's Profit on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*t*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	9.82	1.53	6.42	0.000
No Certification	-3.80	2.14	-1.77	0.082
100% Accurate Certification	3.72	2.07	1.80	0.078

5.6 Summary

First, we find that seller profits are the highest with 100 percent certification and the lowest with 50 percent certification, which suggests that accurate certification benefits sellers, but inaccurate certification can actually harm sellers. This result is consistent with the model predictions from Section 3 with loss-averse buyers and suggests that the observed pattern can be explained by the degree of loss aversion that was estimated from the data (b). Second, certification is highly effective because it raises both the buyer’s purchase probability and the buyer’s willingness to pay. This behavior is consistent with how buyers with loss-aversion respond to a risk-reduction mechanism, such as certification. Third, although cheap talk is believed by the buyer, the product value is highly exaggerated in the data and leads to the lowest surplus for the buyer. Moreover, certification is much more effective in raising the buyer’s purchase probability and willingness to pay.

6. Conclusion

Although the literature has shown that sellers will voluntarily disclose quality information using quality certifications under information asymmetry, what happens with inaccurate and costly certification has not been clearly investigated despite the fact that quality certification is often not accurate in real-world market exchanges. We are ultimately interested in asking whether some information is better than none when sellers sell their products and certification carries a fee. More formally, this study investigates the effect of noisy certification on market outcomes through analytic models and economic experiments.

Our first model with risk-neutral buyers predicts that having no certification in the market is more profitable for sellers than having a certification of any type when certification is costly. Therefore, according to this result, a mechanism of verifiable information disclosure in a market under information asymmetry only hurts seller profit. However, our second model with loss-averse buyers has predicted that having an accurate certification mechanism is the most profitable for sellers, while having inaccurate certification is actually less profitable than having no certification mechanism at all. Our competing predictions depend upon the risk preferences of the buyers.

We then conduct an economic experiment where sellers and buyers strategically interact with each other to maximize their profits. We observe that the seller profit is actually the highest with 100 percent certification and the lowest with 50 percent certification, suggesting that the model with loss-averse buyers is more consistent with real market outcomes. Certification works to raise the buyer's willingness to pay and also the likelihood of purchase, which is consistent with the loss-aversion model predictions. The findings from the analytic model and the experimental analysis concur that inaccurate certification does not help sellers as much as accurate certification does, and is even worse than no certification mechanism. This finding is somewhat counterintuitive, as the conventional wisdom indicates that certification should ultimately help sellers. However, noise in the certification mechanism can be highly detrimental for sellers.

We also demonstrate that cheap talk as a truth revelation device is insufficient and there is merit in maintaining an accurate certification system. The product value when it is merely stated by the seller is often exaggerated. Buyers who purchase can suffer a substantial loss in surplus because the value is lower than stated. In the experiments, the treatment with the lowest buyer surplus is the no certification treatment and the highest is the perfectly accurate certification treatment. Therefore, the emphasis should not be on whether certification exists, but rather on the accuracy of the certification because it raises the social welfare of both the seller and the buyer.

We expect that future research may extend the findings from this study and provide more evidence regarding the effects of noisy certification on various market outcomes by exploring some observational market data. As this paper focuses on a monopoly case, we expect that future studies can also extend the findings of this paper to the duopoly or other competitive settings such as those set out by Board (2009) and Guo and Zhao (2009). Changing the information environment could also lead to different results. Although the seller has more information than the buyer in our setting, buyers may have more information or the information set may be equivalent in other market settings. Therefore, the results may change depending on the information set of the players. Furthermore, although our aim was to be conservative in how the noise affects the market by keeping the inaccuracy random, the noise may be directionally biased, which could have ramifications on the results. Finally, it may be important to study the threshold accuracy levels that may be necessary for certification to be successful.

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Appendix A. Proofs

Proposition 2. *Assume that* $\alpha < 1$. *Then*

i) in equilibrium, if it exists, all types certify and disclose certification results for any s*;*

ii) expected profit of type v *is* $\alpha^2 v + \frac{1}{2}(1 - \alpha^2) - c$. *Aggregated profit is* $1/2 - c$*;*

iii) such an equilibrium exists if $c \leq \frac{1}{2} - \frac{1}{2}\alpha^2$.

Proof: *i*) Let C be a set of all types who chose to certify. Let $E(v|ND)$ be an average quality of types that did not disclose any certification results, whether because they did not certify or because they certified but chose not to disclose. Let $E(v|s)$ be an average seller's quality given the certification outcome s. If the seller discloses s, then, as discussed in the main part of the paper, the seller will set price $p = E(v|s)$ and will earn profit of $E(v|s)$.

If the seller decided to use the certification technology and the outcome is s, the seller will reveal the outcome if and only if $E(v|s) \geq E(v|ND)$. Thus, if the certification outcome is s, then either all types, regardless of their quality, disclose it, or none do. We will use $d(s)$ to denote the disclosure strategy. It is equal to 1 if the seller discloses outcome s and to 0 otherwise.

One can show that any $s \in C$ is disclosed. Assume some $s^0 \in C$ is not disclosed. Take type $v = s^0$. Since $v \in C$, this type has certified and his expected profit is equal to

$$E\pi(s^0) = \alpha E(v|ND) + (1 - \alpha)\int_0^1 [E(v|s)d(s) + E(v|ND)(1 - d(s))]ds - c.$$

The first term comes from the fact that with probability α the certification is accurate so that $s = v^0$. This outcome is not disclosed and, therefore, the buyer's willingness to pay is $E(v|ND)$. The second term comes from the fact that with probability $1 - \alpha$ the certification outcome is noise and is disclosed according to $d(s)$.

Take a type $v' \notin C$. This type then can certify and achieve a payoff of at least $E\pi(s^0)$. To do that the type with quality v' should not disclose if $s = v'$, which happens with probability α, and will earn $E(v|ND)$. For any other outcome, the type should disclose according to $d(s)$. If type $v = s^0$ found it optimal to certify, then so should type with quality v', which is a contradiction to $v' \notin C$. Intuitively, what differentiates a given type is the probability of α of getting correct certification outcome $s = v$. Thus, not revealing the outcome that coincides with one's own quality means one only reveals noisy outcomes which then can be imitated by any type.

Next we show that any $s \notin C$ is disclosed as well. If it is disclosed, buyers understand that the certification outcome is noise, and therefore $E(v|s) = E(v|v \in C)$. If $E(v|v \in C) \geq E(v|ND)$, then it is optimal to disclose signal s. It is straightforward to establish that $E(v|v \in C) < E(v|ND)$ cannot happen in equilibrium. Indeed, take type v^1 such that $v^1 \in C$ and $v^1 \leq E(v|v \in C)$. As established above, it should be optimal to reveal outcome $s = v^1$. Furthermore, $E(v|s = v^1) \leq E(v|v \in C)$. This is because buyers believe that the certification's outcome is either correct, and then the expected quality is v_1 and $v_1 \leq E(v|v \in C)$, or it is noise, and then the expected quality is $E(v|v \in C)$. Given that $E(v|s = v^1)$ is the weighted average of the two, it implies that $E(v|s = v^1) \leq E(v|v \in C)$. Since type v^1 certifies it means that $v^1 \in C$, and, therefore, s= v^1 is disclosed. Thus, $E(v|ND) \leq E(v|s = v^1)$, which combined with $E(v|s = v^1) \leq E(v|v \in C)$ implies that $E(v|v \in C) \geq E(v|ND)$. Thus, any signal $s \notin C$ is disclosed as well.

So far we established that if $C \subset [0,1]$ then any certification outcome is revealed. Therefore,

$$E(v|s) = \frac{(1-\alpha)\Pr(C)}{(1-\alpha)\Pr(C) + \alpha} E(v|v \in C) + \frac{\alpha}{(1-\alpha)\Pr(C) + \alpha} s, \tag{A1.1}$$

if $s \in C$. Here $\Pr(C)$ is the probability of an outcome being in set C conditional on it being noisy, and $(1-\alpha)Pr(C)$ is the joint probability of an outcome being noisy and in set C. Probability of outcome being accurate is α. The weights on $E(v|v \in C)$ and s are then posterior probabilities of noisy and accurate outcomes. If $s \notin C$ then $E\pi(v|s) = E(v|v \in C)$.

Take type v^0 such that $v^0 \in C$and $v^0 < E(v|v \in C)$. It is straightforward to use (A1.1) to calculate its expected profit:

$$E\pi(v^0) = \alpha E(v|s = v^0) + (1-\alpha)\int_0^1 E\,\pi(v|s)ds - c = \alpha E(v|s = v^0) + (1-\alpha)E(v|v \in C) - c.$$

By (A1.1), $E(v|s = v^0) < E(v|v \in C)$ and, therefore, $E\pi(v^0) < E(v|v \in C) - c$. Consider now $v^1 \notin C$. This type does not certify and gets an equilibrium payoff of $E(v|ND)$. However, it has a profitable deviation of certifying and disclosing all outcomes. Its expected profit from deviation is

$$E\pi(v^1) = \alpha E(v|v \in C) + (1-\alpha)E(v|v \in C) - c = E(v|v \in C) - c > E\pi(v^0) \geq E(v|ND).$$

Here we used the fact that if the certification is correct so that $s = v^1$ then buyers will interpret this outcome as $E(v|v \in C)$. The last inequality follows from the fact that type v^0 certifies. The fact that type v^1 has a profitable deviation is a contradiction to the fact that only types in C certify. Thus, in any equilibrium all types must certify.[13]

Now that we have established that $C = [0,1]$, we will consider the disclosure decision. Let D be the set of all certification outcomes that are disclosed in equilibrium. Conditional on $s \in D$, the expected quality is

$$E\pi(v|s) = \frac{(1-\alpha)\Pr(D)}{(1-\alpha)\Pr(D)+\alpha}\frac{1}{2} + \frac{\alpha}{(1-\alpha)\Pr(D)+\alpha}s,$$

where $1/2$ is the average quality given that everyone certifies. Conditional on non-certifying, the buyers' beliefs are $E(v|ND)$. Given s, sellers will disclose if and only $E\pi(v|s) \geq E(v|ND)$. It

[13] This argument depends on the fact that $\alpha < 1$. When $\alpha = 1$ type v^1 wouldn't have a profitable deviation since the only certification outcome is $s = v^1$, which buyers would interpret as the seller having qulaity of v^1. Also, having $v^0 \in C$and $v^0 < E(v|v \in C)$ requires that set *C* has at least two elements. In general, there can be equilibria where exactly one type certifies. In this equilibrium type *1/2+c* (assuming that c<1/2) will certify and any certification outcome will be interpreted as the seller having quality *1/2+c*. The expected profit then is equal to 1/2 regardless of whether the seller certifies or not. Since zero mass of sellers certify, the aggregated profit is also 1/2. We do not have special mention of such equilibria in the main text since they are excluded by our assumption that if sellers are indifferent, then they certify.

follows from the equation above that $E\pi(v|s)$ is an increasing function of s so that it is (not) optimal to reveal higher (lower) signals and, therefore, $D = [y, 1]$ for some y.

Then, on the one hand,

$$E(v|ND) = E\pi(v|s = y) = \frac{(1-\alpha)(1-y)}{(1-\alpha)(1-y)+\alpha}\frac{1}{2} + \frac{\alpha}{(1-\alpha)(1-y)+\alpha}y,$$

because the seller must be indifferent between disclosing signal y and not. On the other hand,

$$E(v|ND) = E(v|C = [0,1], s \in [0, y]) = (1-\alpha)\frac{1}{2} + \alpha\frac{y}{2}.$$

The two expressions above are equal only when $y = 0$. Thus, in equilibrium any signal must be disclosed. Intuitively, only low signals are not disclosed and low signals are more likely if the quality is low. Therefore, not disclosing *is* bad news. The type with threshold quality $v = y$ then will always strictly prefer to disclose so that the first expression is strictly greater, unless $y = 0$.

ii) Since all types certify and all outcomes are disclosed $E\pi(v|s) = (1-\alpha)\frac{1}{2} + \alpha s$, and

$$E\pi(v) = \alpha E\pi(v|s = v) + (1-\alpha)\int_0^1 E\,\pi(v|s)ds - c = \alpha((1-\alpha)\frac{1}{2} + \alpha v) + (1-\alpha)\frac{1}{2} - c,$$

which is equal to $\alpha^2 v + (1-\alpha^2)\frac{1}{2} - c$.

iii) Expected utility of type $v = 0$ is equal to $(1-\alpha^2)/2 - c$. For it to be non-negative it must be the case that $c \leq (1-\alpha^2)/2$. ∎

Appendix B. Instructions

<u>INSTRUCTIONS</u>

1. Introduction

This is an experiment in decision making. The instructions are simple – if you follow them carefully and make good decisions, you could earn a considerable amount of money which will be paid to you immediately following this experiment. What you earn partly depends on your decisions, partly on the decisions of others and partly on chance. Do not look at the decisions of others. Do not talk during the experiment. You will be warned if you violate this rule. If you violate this rule twice, we will cancel the experiment immediately and your earnings will be $0.

The participants in this experiment will participate in three parts with a total of 15 decision rounds in each part. In total, there will be 45 decision rounds that participants make. In each round, the computer will <u>randomly and anonymously</u> match the participants into pairs:1 Seller and 1 Buyer. This matching procedure will be repeated every round. That is, you will be rematched with one other player every round until all 45 rounds are complete. In this way, your roles may also change in each round. As will be described in detail below, your decision and the decision of the other players affect your earnings and vice versa. We will use a computer program to coordinate the experiment. The specific moves and decisions for each player are described below.

2. EXPERIMENT PART 1

<u>Step 1: Seller's Move and Points</u>

In each round, the Seller will offer an item to the Buyer and the Buyer will choose whether to purchase the item. The specific details of the decisions are shown below.

The Seller observes the Value of the item. The computer will randomly generate the Value between 0 and 180, where each number between 0 and 180 has an equal chance of being drawn. Note that the computer will randomly generate a new Value in each round and that the Values that have been drawn will not affect the Values that will be drawn in the future.

Upon observing the Value, the Seller chooses the following:

- *Choose the Value of the item that you will Announce to the Buyer (between 0 and 180 in integers)*
- *Choose the Price of the item that you will offer the item to the Buyer (between 0 and 180 in decimals up to two places)*

Note that the Announced Value of the item can be equal to the Value of the item, but it can also differ from the Value of the item.

The Seller's points in each round are equal to the following (note that there are no selling or transaction costs):

If the Buyer purchases the item:

Seller's Points = Price.

If the Buyer does not purchase the item:

Seller's Points = 0.

Therefore, the Seller's Points increase with a higher Price as long as the buyer purchases. However, the Seller will also need to consider if the Buyer will purchase (discussed further below).

<u>Step 2: Buyer's Move and Points</u>

Upon receiving the Announced Value of the item and the Price, the Buyer chooses the following:

- *Choose whether to purchase the item at the Price offered (Yes or No)*

Note that the Buyer does not observe the Value at this decision, but will observe the Announced Value that is chosen by the Seller. The Buyer will observe the Value only after purchasing the item when the Points are determined.

The Buyer's points in each round are equal to the following:

If the Buyer purchases the item:

Buyer's Points = Value – Price.

The Buyer does not know the Value at the time of purchase. However, the Value, as opposed to the Announced Value, is revealed after purchase and determines part of the Buyer's Points. The remaining part of the Buyer's Points are determined by the Price chosen by the Seller.

If the Buyer does not purchase the item:

Buyer's Points = 0.

<u>Step 3: Point Earnings</u>

After the Seller and the Buyer make their decisions, the computer program will determine the Points for each Player. Note that the Seller will always know the Value, but the Buyer will only observe the Value if the Buyer purchases the item. The Points will be totaled for the 15 Rounds in Part 1.

3. EXPERIMENT PART 2

Step 1: Seller's Move and Points

In each round, the Seller will offer an item to the Buyer and the Buyer will choose whether to purchase the item. The specific details of the decisions are shown below.

The Seller observes the Value of the item. The computer will randomly generate the Value between 0 and 180, where each number between 0 and 180 has an equal chance of being drawn. Note that the computer will randomly generate a new Value in each round and that the Values that have been drawn will not affect the Values that will be drawn in the future.

Upon observing the Value, the Seller chooses between the following:

- *Choose to Certify the Value of the item by incurring a cost of 20 (the Buyer will be shown the Value of the item)*

- *Choose to Announce the Value of the item to the Buyer (between 0 and 180 in integers)*

Note that the Certified Value that will be shown to the Buyer is equal to the Value that is observed by the Seller while the Announced Value of the item can be equal to the Value of the item, but it can also differ from the Value of the item. Also, note that the Certified Value comes at a cost of 20 which will be deducted from the Seller's Points if Certify is chosen.

After choosing between the Certified Value and the Announced Value, the Seller chooses the following:

- *Choose the Price of the item that you will offer the item to the Buyer (between 0 and 180 in decimals up to two places)*

The Seller's points in each round are equal to the following (note that the only costs are certification costs if the Seller chooses to Certify):

➢ If the Seller chooses to Certify and the Buyer purchases the item:

Seller's Points = Price – 20.

If the Seller chooses to Certify and the Buyer does not purchase the item:

Seller's Points = -20.

➢ If the Seller chooses to Announce and the Buyer purchases the item:

Seller's Points = Price.

If the Seller chooses to Announce and the Buyer does not purchase the item:

Seller's Points = 0.

Therefore, the Seller's Points increase with a higher Price as long as the buyer purchases. However, the Seller will also need to consider if the Buyer will purchase (discussed further below).

Step 2: Buyer's Move and Points

Upon receiving either the Certified Value or the Announced Value of the item and the Price, the Buyer chooses the following:

- *Choose whether to purchase the item at the Price offered (Yes or No)*

Note that the Buyer observes the Value if the Value is Certified, but will not observe the Value if the Value is Announced. In the latter case, the Buyer will observe the Announce Value that is chosen by the Seller and will observe the Value only after purchasing the item when the Points are determined.

The Buyer's points in each round are equal to the following:

If the Buyer purchases the item:

Buyer's Points = Value – Price.

If the Value is certified, the Buyer will know the Value of the item at the time of purchase. On the other hand, if the Value is Announced, the Buyer does not know the Value at the time of purchase. However, the Value, as opposed to the Announced Value, determines part of the Buyer's Points. The remaining part of the Buyer's Points are determined by the Price chosen by the Seller.

If the Buyer does not purchase the item:

Buyer's Points = 0.

Step 3: Point Earnings

After the Seller and the Buyer make their decisions, the computer program will determine the Points for each Player. Note that the Seller will always know the Value, but the Buyer will only observe the Value if the Buyer purchases the item. The Points will be totaled for the 15 Rounds in Part 1.

4. EXPERIMENT PART 3

Step 1: Seller's Move and Points

In each round, the Seller will offer an item to the Buyer and the Buyer will choose whether to purchase the item. The specific details of the decisions are shown below.

The Seller observes the Value of the item. The computer will randomly generate the Value between 0 and 180, where each number between 0 and 180 has an equal chance of being drawn. Note that the computer will randomly generate a new Value in each round and that the Values that have been drawn will not affect the Values that will be drawn in the future.

Upon observing the Value, the Seller chooses between the following:

- *Choose to Certify the Value of the item by incurring a cost of 20 (Yes or No)*

Note that the Certified Value is equal to the Value that is observed by the Seller 50% of the time and is equal to a separate Random Number that is drawn by the computer between 0 and 180 the remaining 50% of the time. In this way, the Certified Value is accurate only half of the time and the remaining 50% of the times, any number between 0 and 180 has an equal chance of being drawn by the computer. Note that the computer will randomly generate a new Random Number in each round and that the Random Numbers that have been drawn will not affect the Random Numbers that will be drawn in the future nor will it affect the Values that are drawn for the Seller (and vice versa).Also, note that the Certified Value comes at a cost of 20 which will be deducted from the Seller's Points if Certify is chosen.

After choosing whether to certify, the Seller does the following:

- *If Certify the Value is chosen, choose whether to share the Certified Value with the Buyer or choose to Announce the Value (Certify or Announce).*
    - *If sharing the Certified Value, the Buyer will be shown the Certified Value that was observed in the previous decision.*
    - *If choosing to Announce the Value of the item to the Buyer, the Seller choosesthe Announced Value (between 0 and 180 in integers).*
- *If Announce the Value is chosen without Certifying the Value in the previous decision, choose to Announce the Value of the item to the Buyer (between 0 and 180 in integers).*

Note that after observing the Certified Value, the Seller can still choose whether to use the Certified Value or to Announce a Value. The Announced Value of the item can be equal to the Value of the item, but it can also differ from the Value of the item. However, if the Seller does not Certify the Value of the item, the Seller will proceed to choose the Announced Value of the item.

After choosing between the Certified Value and the Announced Value, the Seller chooses the following:

- *Choose the Price of the item that you will offer the item to the Buyer (between 0 and 180 in decimals up to two places)*

The Seller's points in each round are equal to the following (note that the only costs are certification costs if the Seller chooses to Certify):

- If the Seller chooses to Certify and the Buyer purchases the item:
  Seller's Points = Price – 20.

  If the Seller chooses to Certify and the Buyer does not purchase the item:
  Seller's Points = -20.

- If the Seller chooses to Announce and the Buyer purchases the item:
  Seller's Points = Price.

  If the Seller chooses to Announce and the Buyer does not purchase the item:
  Seller's Points = 0.

Therefore, the Seller's Points increase with a higher Price as long as the buyer purchases. However, the Seller will also need to consider if the Buyer will purchase (discussed further below). Also, the Buyer may not know the Seller's points because it is possible for the Seller to Certify and then later choose to use the Announced Value instead.

Step 2: Buyer's Move and Points

Upon receiving either the Certified Value or the Announced Value of the item and the Price, the Buyer chooses the following:

- *Choose whether to purchase the item at the Price offered (Yes or No)*

Note that if the Seller uses the Certified Value, the Buyer observes the Certified Value that is accurate 50% of the time and is randomly drawn from 0 to 180 the remaining 50% of the time. Hence, the Buyer will not know whether the Certified Value of the item equals the Value of the item until after the purchase. The Buyer will also not know the Value of the item if the Seller chooses to Announce the Value at the time of purchase. In the latter case, the Buyer will observe the Announce Value that is chosen by the Seller and will observe the Value only after purchasing the item when the Points are determined.

The Buyer's points in each round are equal to the following:

If the Buyer purchases the item:

Buyer's Points = Value – Price.

When the Buyer purchases the item, the Buyer knows that the Certified Value is accurate 50% of the time and is randomly drawn from 0 to 180 the remaining 50% of the time. If the Value is Announced, the Buyer does not know the Value at the time of purchase. However, the Value, as opposed to the Certified Value or the Announced Value, determines part of the Buyer's Points. The remaining part of the Buyer's Points are determined by the Price chosen by the Seller.

If the Buyer does not purchase the item:

Buyer's Points = 0.

Step 3: Point Earnings

After the Seller and the Buyer make their decisions, the computer program will determine the Points for each Player. Note that the Seller will always know the Value, but the Buyer will only observe the Value if the Buyer purchases the item. The Points will be totaled for the 15 Rounds in Part 1.

5. CASH EARNINGS

Your final earnings will be the sum of your points for the 45 decision rounds (15 rounds in each part) converted at a rate of 100 points equals $1.00.

Are there any questions?